Caribbean Application Document
for
ASCE 7-05 Chapter 6 Wind Loads
with references to
Chapter 1 General
and
Chapter 2 Combinations of Loads

The Standard ASCE 7 is the American Society of Civil Engineers:
"Minimum Design Loads for Buildings and Other Structures"

prepared by
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under contract to
The Pan American Health Organisation
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Contents

Caribbean Application Document for ASCE 7-05 Chapter 6 Wind Loads

Introduction

This Caribbean Application Document for ASCE 7-05 Chapter 6 (CAD:ASCE 7-05:Ch 6) does not reproduce ASCE 7-05. The user of this CAD:ASCE 7-05:Ch 6 must also have available the complete ASCE 7-05 Chapter 6. The user must also have access to Chapters 1 and 2 of ASCE 7-05.

The trend in most countries in the Caribbean is towards wind load standards based on ASCE 7. Because of this a project has been funded by the United States Agency for International Development and executed by the Pan American Health Organisation for the preparation of wind hazard information for the entire Caribbean Basin consistent with the requirements of ASCE 7-05. That project was completed early in 2008 and its results are incorporated in this CAD:ASCE 7-05:Ch 6.

The most significant adjustment to ASCE 7-05 brought about by the new wind hazard information is the direct use of ultimate wind speeds in the calculation of wind loads. The Basic Wind Speed for Category II buildings in this CAD:ASCE 7-05:Ch 6 is the 700-year return period wind. The Basic Wind Speed for Categories III and IV buildings in this CAD:ASCE 7-05:Ch 6 is the 1700-year return period wind. This differs from ASCE 7-05 which starts off with a 50-year return period Basic Wind Speed.

Principal Directive

Use the American Society of Civil Engineers standard ASCE 7-05 Chapter 6 with the following amendments – omissions, additions and rewritten clauses.

6.1 GENERAL

6.1.4.1 Main Wind-Force Resisting System. The factored wind load to be used in the design of the MWFRS for an enclosed or partially enclosed building or other structure shall not be less than 16 lb/ft2 (0.48 kN/m2) multiplied by the area of the building or structure projected onto a vertical plane normal to the assumed wind direction. The factored design wind force for open buildings and other structures shall be not less than 16 lb/ft2 (0.77 kN/m2) multiplied by the area A_f.

6.1.4.2 Components and Cladding. The design wind pressure for components and cladding of buildings shall not be less than a net pressure of 10 lb/ft2 (0.77 kN/m2) acting in either direction normal to the surface.

6.2 DEFINITIONS

HURRICANE PRONE REGIONS: Areas vulnerable to hurricanes ;in the Caribbean Basin including:

1. All islands in the Caribbean and the Turks and Caicos Islands and the Bahamas;

2. the Caribbean coastal regions of Central America and South America where the basic wind speed (700-year return period) is greater than 110 mi/h.

IMPORTANCE FACTOR, *I*: A factor that accounts for the degree of hazard to human life and damage to property. This will apply only to Category I buildings. For Categories III and IV buildings, the Importance Factor will be not be required since the Basic Wind Speed for those Categories is the 1700-year return period speed.

WIND-BORNE DEBRIS REGIONS: Areas within hurricane prone regions located:

1. Within 1 mile of the coastal mean high water line where the basic wind speed (700-year) is equal to or greater than 140 mi/h or

2. In areas where the basic wind speed (700-year) is equal to or greater than 150 mi/h.

6.3 SYMBOLS AND NOTATION

F = factored design wind force for other structures, in lb (N)

p = factored design pressure to be used in determination of wind loads for buildings, in lb/ft2 (N/m2)

pL = factored wind pressure acting on leeward face in Fig. 6-9, in lb/ft2 (N/m2)

$pnet$ = net factored design wind pressure from Eq. 6-2, in lb/ft2 (N/m2)

$pnet30$ = net factored design wind pressure for Exposure B at h = 30 ft and I = 1.0 from Fig. 6-3, in lb/ft2 (N/m2)

pp = combined net factored pressure on a parapet from Eq. 6-20, in lb/ft2 (N/m2)

ps = net factored design wind pressure from Eq. 6-1, in lb/ft2 (N/m2)

$ps30$ = simplified factored design wind pressure for Exposure B at h = 30 ft and I = 1.0 from Fig. 6-2, in lb/ft2 (N/m2)

pW = factored wind pressure acting on windward face in Fig. 6-9, in lb/ft2 (N/m2)

q = factored velocity pressure, in lb/ft2 (N/m2)

qh = factored velocity pressure evaluated at height $z = h$, in lb/ft2 (N/m2)

qi = factored velocity pressure for internal pressure determination, in lb/ft2 (N/m2)

qp = factored velocity pressure at top of parapet, in lb/ft2 (N/m2)

qz = factored velocity pressure evaluated at height z above ground, in lb/ft2 (N/m2)

V_{700} = basic wind speed (700-year) obtained from Fig. 6-1a, in mi/h (m/s). The basic wind speed corresponds to a 3-s gust speed at 33 ft (10 m) above ground in exposure Category C

V_{1700} = basic wind speed (1700-year) obtained from Fig. 6-1b, in mi/h (m/s). The basic wind speed corresponds to a 3-s gust speed at 33 ft (10 m) above ground in exposure Category C

6.4 METHOD 1—SIMPLIFIED PROCEDURE

6.4.2.1.1 Minimum Pressures. The load effects of the design wind pressures from Section 6.4.2.1 shall not be less than the minimum load case from Section 6.1.4.1 assuming the factored pressures, *ps* , for zones A, B, C, and D all equal to +16 psf, while assuming zones E, F, G, and H all equal to 0 psf.

6.4.2.2.1 Minimum Pressures. The factored positive design wind pressures, *pnet* , from Section 6.4.2.2 shall not be less than +16 psf, and the factored negative design wind pressures, *pnet* , from Section 6.4.2.2 shall not be less than -16 psf.

6.5 METHOD 2—ANALYTICAL PROCEDURE

6.5.3 Design Procedure.

1. The *basic wind speeds* V_{700} *and* V_{1700} and *wind directionality factor Kd* shall be determined in accordance with Section 6.5.4.

6.5.4 Basic Wind Speed. The basic wind speeds, V_{700} and V_{1700}, used in the determination of design wind loads on buildings and other structures shall be as given in Fig. 6-1a and 6-1b except as provided in Sections 6.5.4.1 and 6.5.4.2. The wind shall be assumed to come from any horizontal direction.

6.5.4.1 Special Wind Regions. The basic wind speed shall be increased where records or experience indicate that the wind speeds are higher than those reflected in Fig. 6-1a and 6-1b. Mountainous terrain, gorges, and special regions shall be examined for unusual wind conditions. The authority having jurisdiction shall, if necessary, adjust the values given in Fig. 6-1a and 6-1b to account for higher local wind speeds. Such adjustment shall be based on meteorological information and an estimate of the basic wind speed obtained in accordance with the provisions of Section 6.5.4.2.

~~**6.5.4.2 Estimation of Basic Wind Speeds from Regional Climatic Data.** In areas outside hurricane-prone regions, regional climatic data shall only be used in lieu of the basic wind speeds given in Fig. 6-1 when (1) approved extreme-value statistical-analysis procedures have been employed in reducing the data; and (2) the length of record, sampling error, averaging time, anemometer height, data quality, and terrain exposure of the anemometer have been taken into account. Reduction in basic wind speed below that of Fig. 6-1 shall be permitted.~~

~~In hurricane-prone regions, wind speeds derived from simulation techniques shall only be used in lieu of the basic wind speeds given in Fig. 6-1 when (1) approved simulation and extreme value statistical analysis procedures are used (the use of regional wind speed data obtained from anemometers is not permitted to define the hurricane wind-speed risk along the Gulf and Atlantic coasts, the Caribbean, or Hawaii) and (2) the design wind speeds resulting from the study shall not be less than the resulting 500-year return period wind speed divided by ã1.5.~~

~~In areas outside hurricane-prone regions, when the basic wind speed is estimated from regional climatic data, the basic wind speed shall be not less than the wind speed associated with an annual probability of 0.02 (50-year mean recurrence interval), and the estimate shall be adjusted for equivalence to a 3-s gust wind speed at 33 ft (10 m) above ground in exposure Category C. The data analysis shall be performed in accordance with this chapter.~~

6.5.6.2 Surface Roughness Categories.

~~Surface Roughness D: Flat, unobstructed areas and water surfaces outside hurricane prone regions. This category includes smooth mud flats, salt flats, and unbroken ice.~~

6.5.6.3 Exposure Categories

Exposure C: Exposure C shall apply for all cases where Exposure B does not apply.

6.5.7.1 Wind Speed-Up over Hills, Ridges, and Escarpments.

5. *H* is greater than or equal to 15 ft (4.5 m) for Exposures C and 60 ft (18 m) for Exposure B.

6.5.10 Factored Velocity Pressure. Factored Velocity pressure, qz, evaluated at height z shall be calculated by the following equations:

$qz = 0.00256KzKzt\ KdV_{700}^2\ I$ (lb/ft2) (6-15a) for Category I buildings

$qz = 0.00256KzKzt\ KdV_{700}^2$ (lb/ft2) (6-15b) for Category II buildings

$qz = 0.00256KzKzt\ KdV_{1700}^2$ (lb/ft2) (6-15c) for Categories III and IV buildings

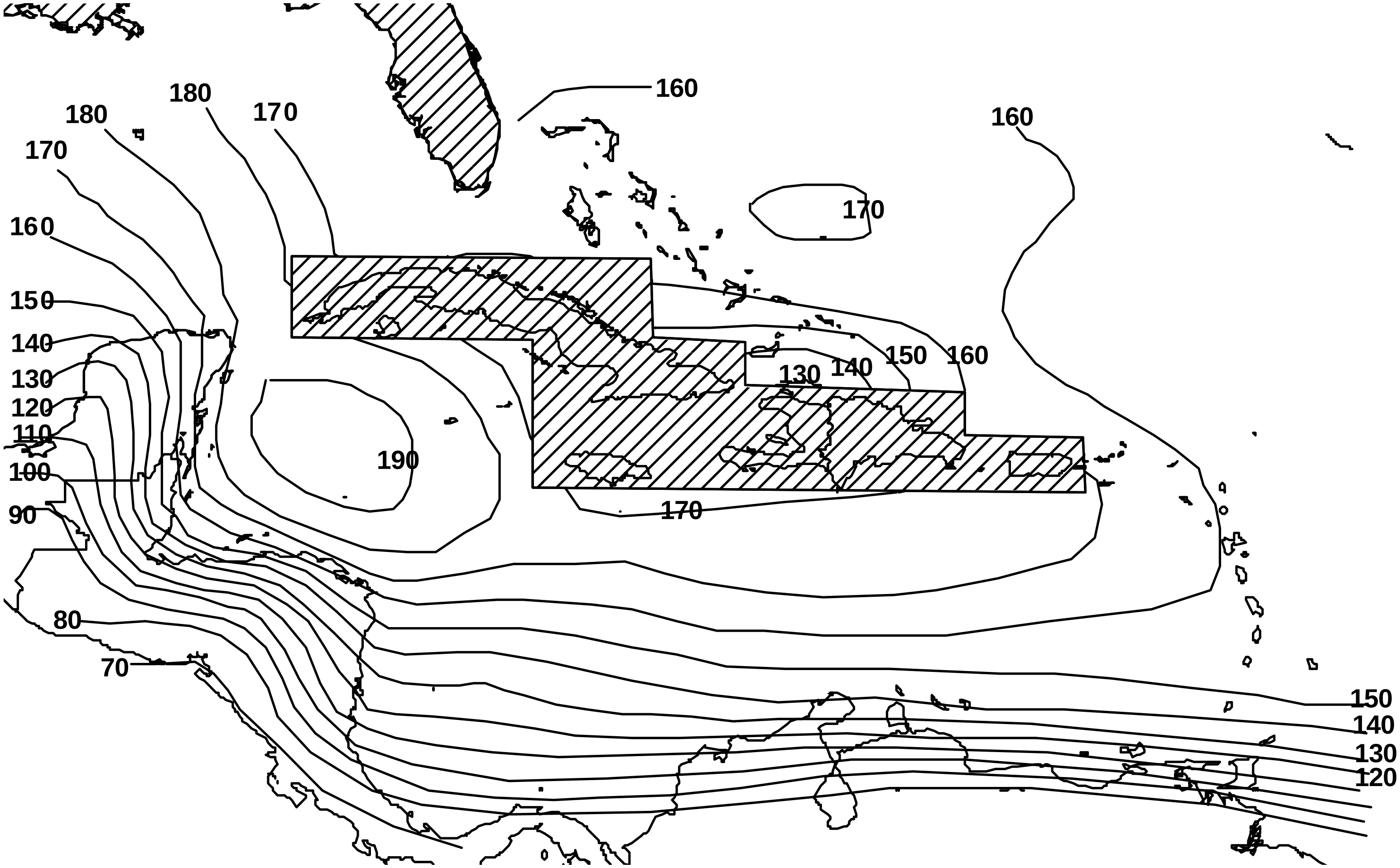
[In SI: $qz = 0.613KzKzt\ KdV2\ I$ (N/m2); V in m/s]

FIGURE 6-1 BASIC WIND SPEED

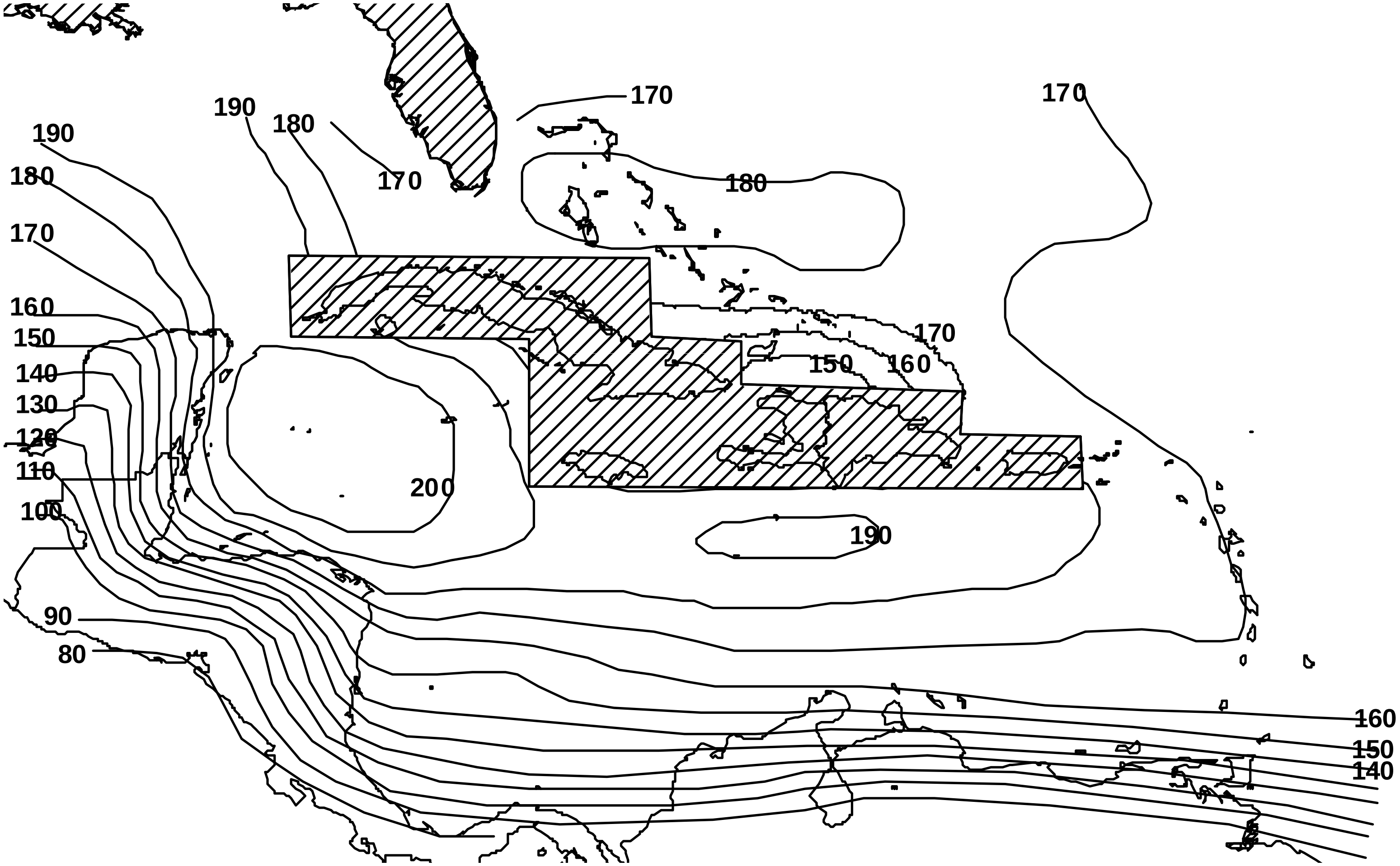
The hurricane hazard maps are presented in the following Figures and Table. The Figures present contour maps of open terrain wind speeds for the entire Caribbean basin (except for the Greater Antilles, which are given in separate Figures).

Wind speeds at representative locations on the populated islands are summarized in accompanying Table.

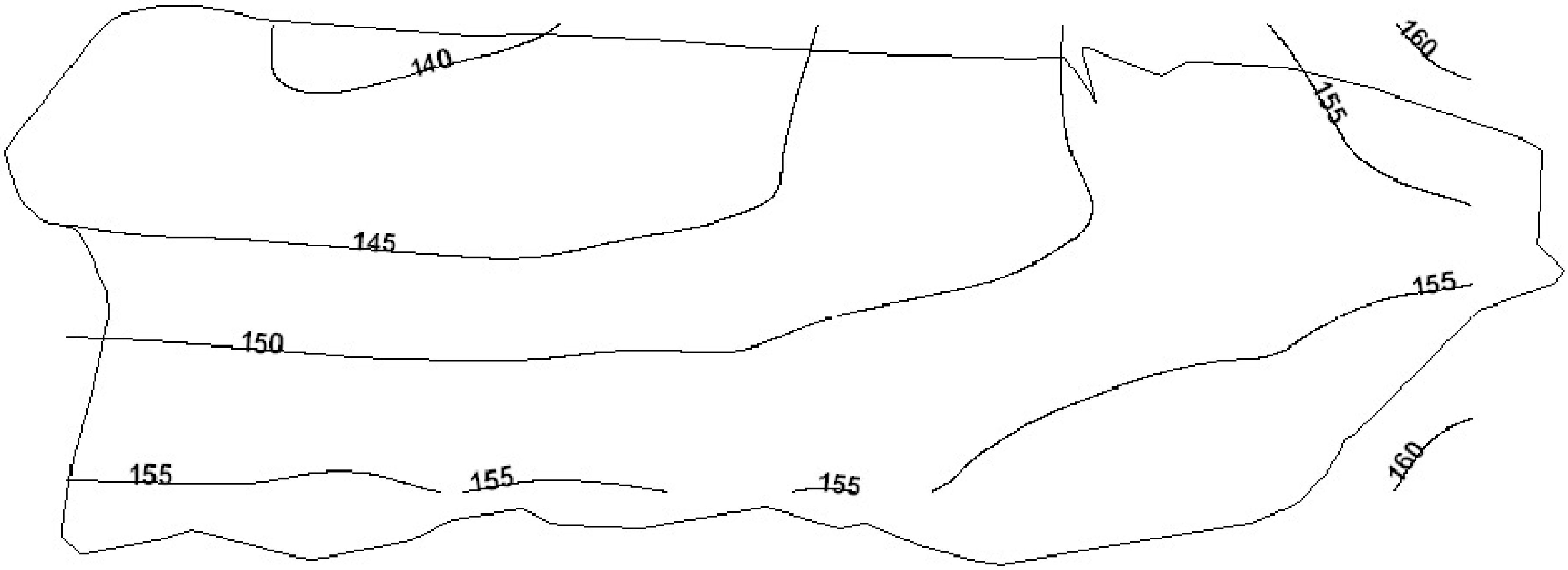
700 Year Wind Speeds for Caribbean



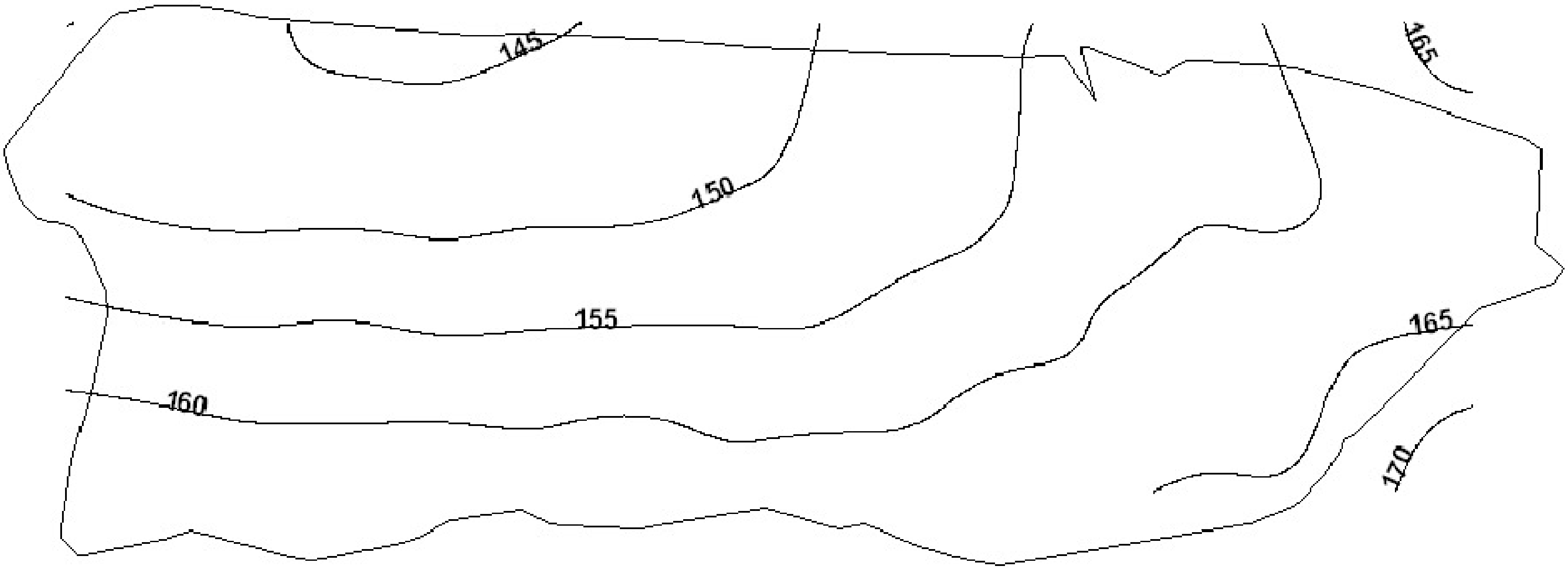
1700 Year Wind Speeds for Caribbean



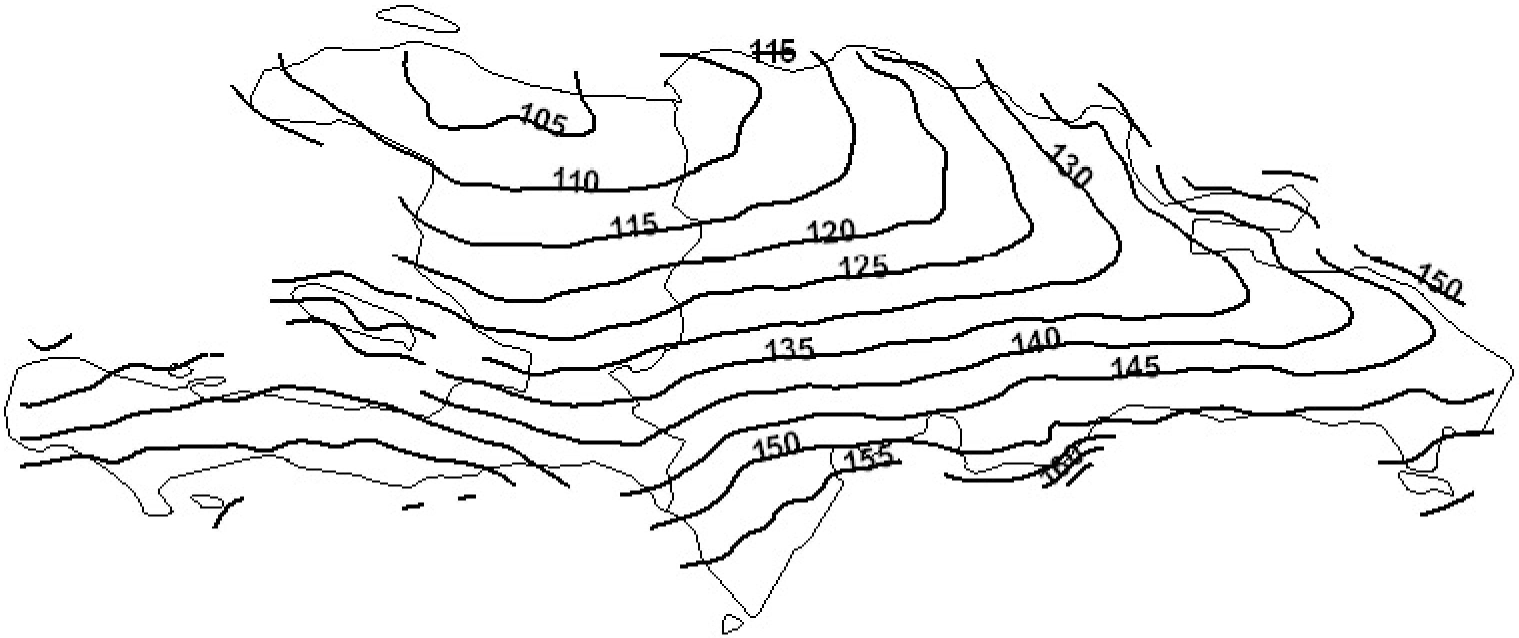
700 year Return Period Wind Speeds for Puerto Rico



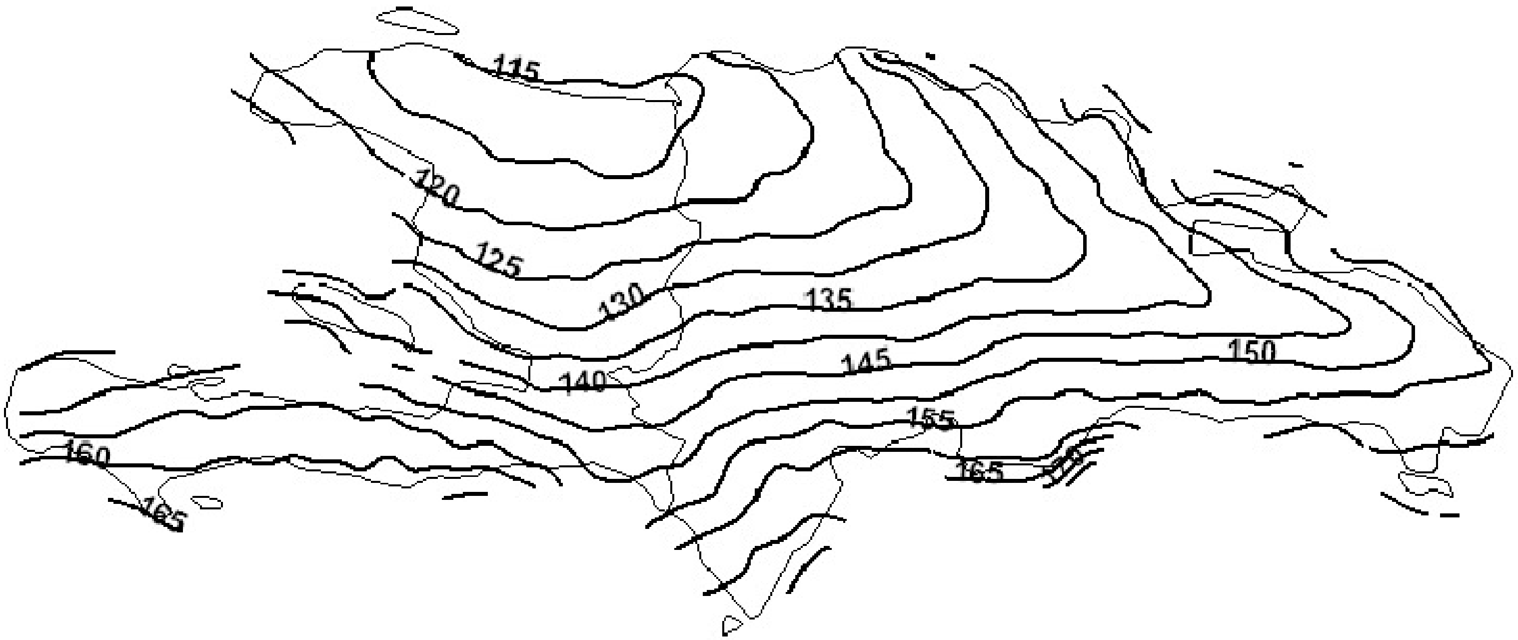
1700 year Return Period Wind Speeds for Puerto Rico



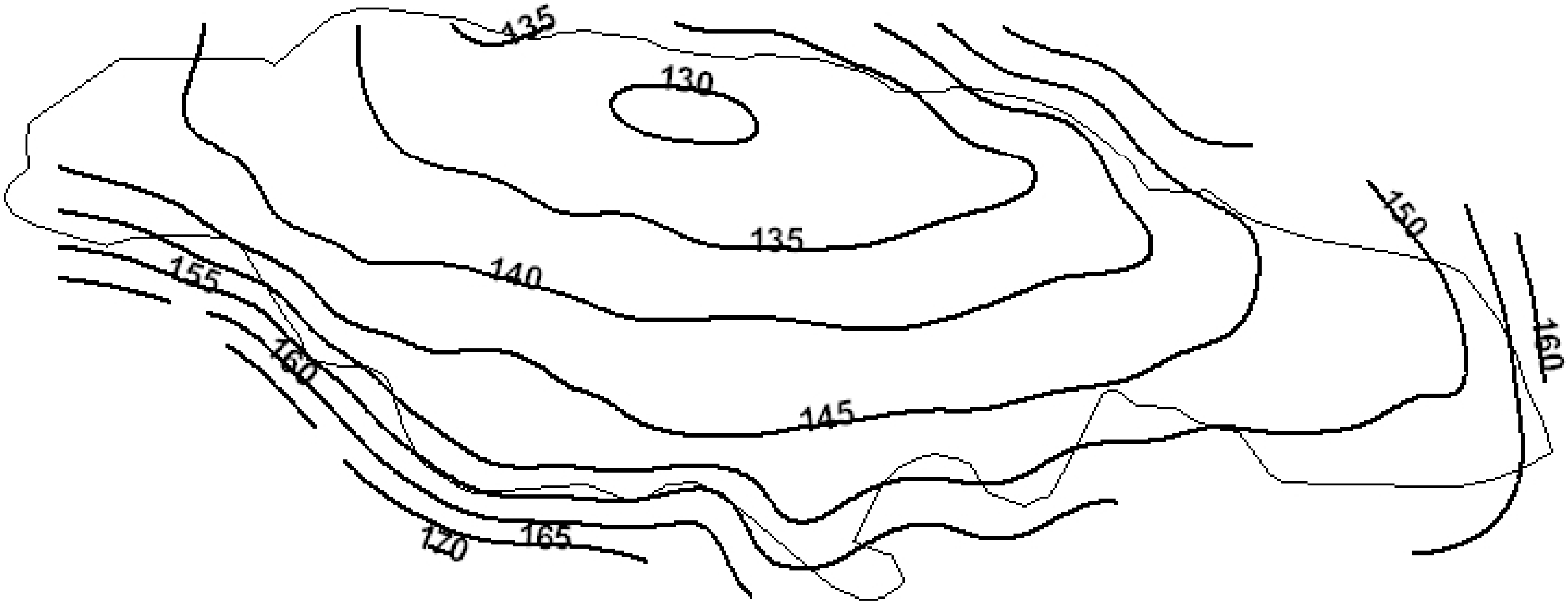
700 Year Return Period Wind Speeds for the Island of Hispaniola



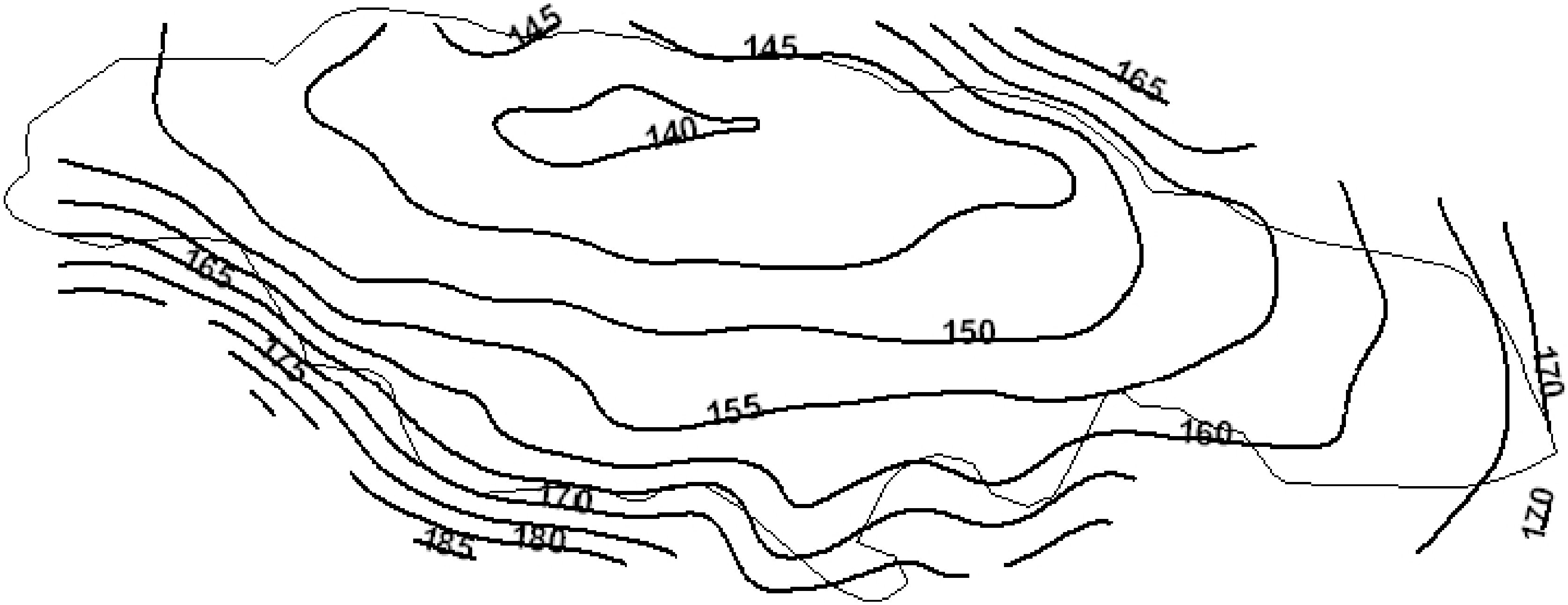
1700 Year Return Period Wind Speeds for the Island of Hispaniola



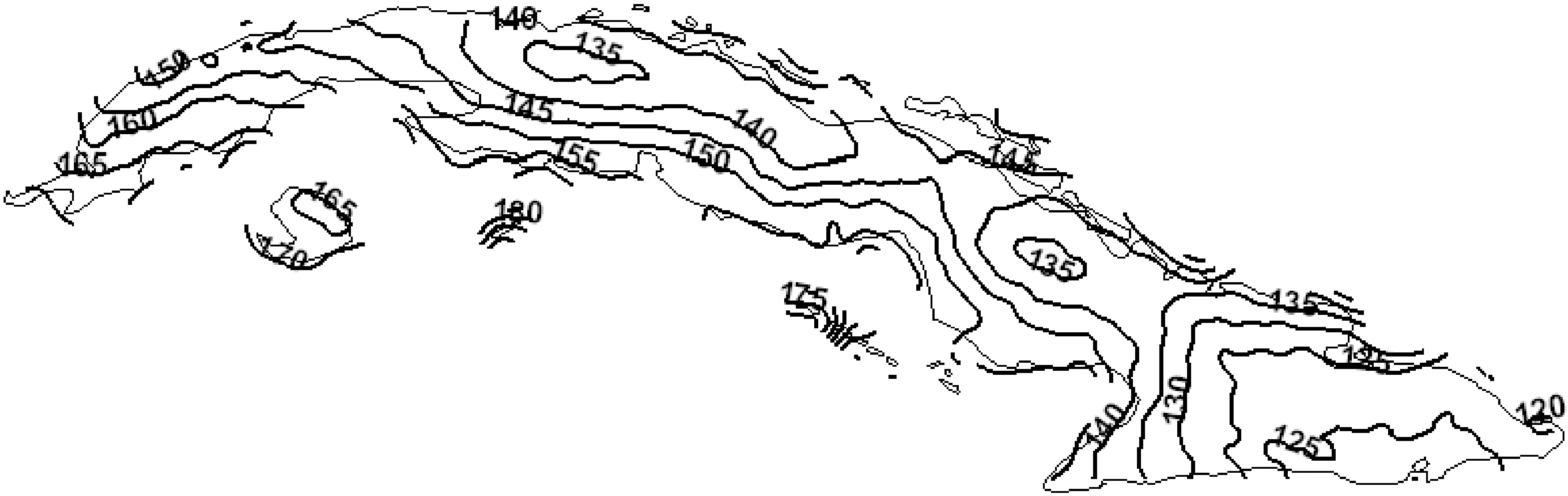
700 year Return Period Wind Speeds for Jamaica



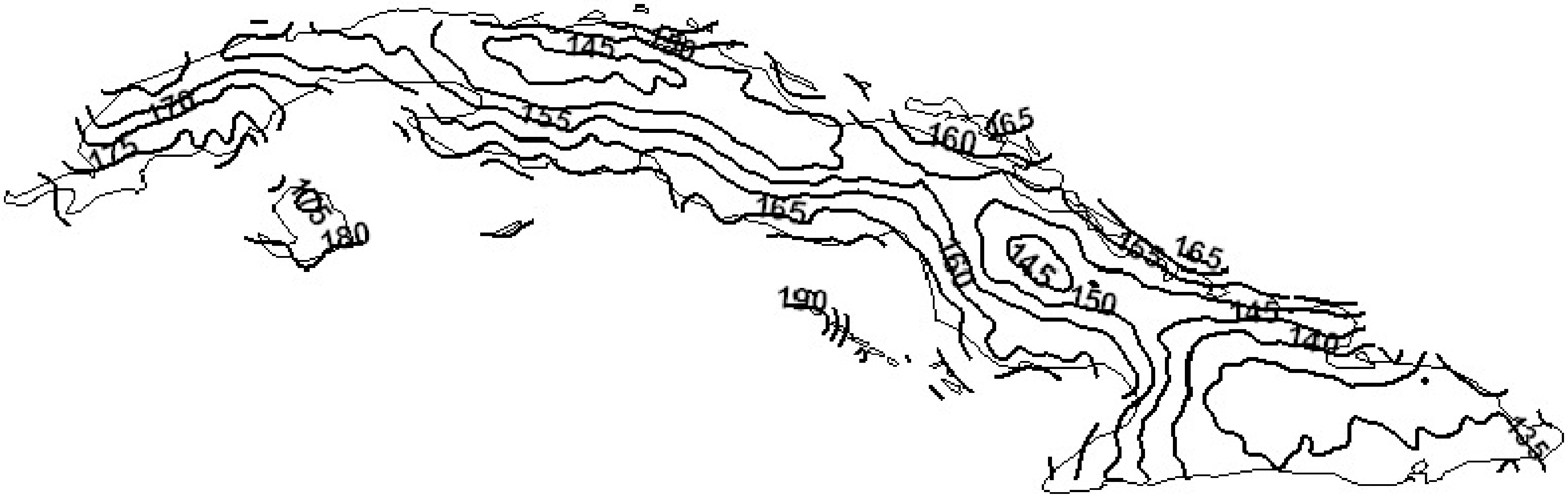
1700 year Return Period Wind Speeds for Jamaica



700 Year Return Period Wind Speeds for Cuba



1700 Year Return Period Wind Speeds for Cuba



Basic wind speeds for selected locations

Location	Return period (years)		Return period (years)	
	700	1700	700	1700
	miles per hour		metres per second	
Trinidad (S)	82	102	37	46
Trinidad (N)	136	156	61	70
Isla Margarita	100	128	45	57
Grenada	154	168	69	75
Bonaire	149	156	67	70
Curacao	147	168	66	75
Aruba	146	162	65	72
Barbados	152	169	68	76
Saint Vincent	155	171	69	76
Saint Lucia	155	172	69	77
Martinique	159	171	71	76
Dominica	159	172	71	77
Guadeloupe	157	168	70	75
Montserrat	164	172	73	77
St. Kitts and Nevis	163	170	73	76
Antigua and Barbuda	160	168	72	75
Saint Martin/Sint Maarten	168	178	75	80
Anguilla	166	176	74	79
US Virgin Islands	167	176	75	79
British Virgin Islands	169	180	76	80
Grand Cayman	187	200	84	89
Little Cayman/Cayman Brac	178	197	80	88
Turks & Caicos (Grand Turk)	150	162	67	72
Turks & Caicos (Providenciales)	155	170	69	76
Eleuthera	165	180	74	80
Andros	162	180	72	80
New Providence (Nassau)	163	180	73	80
Great Abaco	162	178	72	80
Grand Bahama (Freeport)	161	175	72	78
Belmopan	165	177	74	79

Wind Hazard Table

Importance Factor, I (Wind Loads)
Table 6-1

The Importance Factor for Category I buildings is 0.77 applied to the V_{700} load cases.

No Importance Factors are applied for Categories II, III and IV buildings since for Category II buildings I is already included in V_{700} and for Categories III and IV buildings I is already included in V_{1700}.

Terrain Exposure Constants
Table 6-2

Omit Exposure D

Velocity Pressure Exposure Coefficients, Kh and Kz
Table 6-3

Omit Exposure D

Caribbean Application Document for ASCE 7-05 Chapter 1 General

Table 1-1

Nature of Occupancy	**Occupancy Category**
Buildings and other structures that represent a low hazard to human life in the event of failure, including, but not limited to: • Agricultural facilities • Certain temporary facilities • Minor storage facilities	I
All buildings and other structures except those listed in Occupancy Categories I, III, and IV	II
Buildings and other structures that represent a substantial hazard to human life in the event of failure, including, but not limited to: • Buildings and other structures where more than 300 people congregate in one area • Buildings and other structures with daycare facilities with a capacity greater than 150 • Buildings and other structures with elementary school or secondary school facilities with a capacity greater than 250 • Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities • Health care facilities with a capacity of 50 or more resident patients, but not having surgery or emergency treatment facilities • Jails and detention facilities Buildings and other structures, not included in Occupancy Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure, including, but not limited to: • Power generating stations*a* • Water treatment facilities • Sewage treatment facilities • Telecommunication centers Buildings and other structures not included in Occupancy Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released. Buildings and other structures containing toxic or explosive substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the toxic or explosive substances does not pose a threat to the public.	III
Buildings and other structures designated as essential facilities, including, but not limited to: • Hospitals and other health care facilities having surgery or emergency treatment facilities • Fire, rescue, ambulance, and police stations and emergency vehicle garages • Designated earthquake, hurricane, or other emergency shelters • Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response • Power generating stations and other public utility facilities required in an emergency • Ancillary structures (including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operation of Occupancy Category IV structures during an emergency • Aviation control towers, air traffic control centers, and emergency aircraft hangars • Water storage facilities and pump structures required to maintain water pressure for fire suppression • Buildings and other structures having critical national defense functions Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing highly toxic substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction. Buildings and other structures containing highly toxic substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the highly toxic substances does not pose a threat to the public. This reduced classification shall not be permitted if the buildings or other structures also function as essential facilities.	IV

ASCE 7-05 Chapter 2 Combinations of Loads

The following load combinations shall be used.

Factored loads using strength design

1: $1.4(D + F)$
2: $1.2(D + F + T) + 1.6(L + H) + 0.5(Lr \text{ or } S \text{ or } R)$
~~3: $1.2D + 1.6(Lr \text{ or } S \text{ or } R) + (L \text{ or } 0.8W)$~~
3a: $1.2D + 1.6(Lr \text{ or } R) + (L \text{ or } 0.8W700/1.6)$
~~4: $1.2D + 1.6W + L + 0.5(Lr \text{ or } S \text{ or } R)$~~
4a: $1.2D + 1.0W700 + L + 0.5(Lr \text{ or } R)$
5: $1.2D + 1.0E + L + 0.2S$
~~6: $0.9D + 1.6W + 1.6H$~~
6a: $0.9D + 1.0W700 + 1.6H$
7: $0.9D + 1.0E + 1.6H$

Nominal loads using allowable stress design

1: $D + F$
2: $D + H + F + L + T$
3: $D + H + F + (Lr \text{ or } S \text{ or } R)$
4: $D + H + F + 0.75(L + T) + 0.75(Lr \text{ or } S \text{ or } R)$
~~5: $D + H + F + (W \text{ or } 0.7E)$~~
5a: $D + H + F + (W700/1.6 \text{ or } 0.7E)$
~~6: $D+H+F+0.75(W \text{ or } 0.7E)+0.75L+0.75(Lr \text{ or } S \text{ or } R)$~~
6a: $D+H+F+0.75(W700/1.6 \text{ or } 0.7E)+0.75L+0.75(Lr \text{ or } R)$
~~7: $0.6D + W + H$~~
7a: $0.6D + W700/1.6 + H$
8: $0.6D + 0.7E + H$

The New Caribbean Basin Wind Hazard Maps (commentary)

by **Tony Gibbs** BSc DCT(Leeds) FICE FIStructE FASCE FconsE FRSA FRICS

October 2008

Why were new wind hazard maps prepared? Here are some of the reasons:

- The only pan-Caribbean wind hazard maps ever produced for application in the design of structures were in 1969 (Caribbean Meteorological Institute – H C Shellard), 1981&1984 Caribbean Meteorological Institute – B Rocheford), 1985 (University of Western Ontario Boundary Layer Wind Tunnel Laboratory – Davenport, Surry, Georgiou).
- Since 1985 the region has collected another 23 years of relatively reliable data. The incorporation of these data should serve to improve the quality of currently-available wind hazard information.
- There have been developments in the science and technology related to the long-term forecasting of hurricane activity in the North Atlantic (including the Caribbean).
- The past 13 years of higher-than-normal hurricane activity in the North Atlantic has led to the questioning of wind design criteria incorporated in the present standards in the Caribbean.
- This, in turn, has led to uninformed and unreasonable and counterproductive decisions on appropriate basic (and therefore design) wind speeds for some Caribbean projects and in some Caribbean countries.
- The subject project includes the Caribbean coastlines of South and Central American countries. In several of these cases there were no previously available wind hazard guidance for structural design purposes. The new maps plug those gaps.
- The phenomenon of hurricane activity in the Caribbean is best dealt with regionally and not in a country-by-country manner.

What use will be made of the results of the proposed project? Here are some answers:

- New regional standards are currently being prepared in a project funded by the Caribbean Development Bank (CDB) and executed by the Caribbean Regional Organisation for Standards and Quality (CROSQ). These will replace the Caribbean Uniform Building Code (CUBiC). The CDB-CROSQ project does not include new wind hazard maps for the target region. These new Caribbean Basin maps have been prepared to be consistent with the CDB-CROSQ intension to base the new standards project on the USA "International" codes which reference the wind load provisions of the American Society of Civil Engineers (ASCE 7 Chapters 2 and 6). Thus the results of this wind hazard mapping project could be plugged directly into the new CDB-CROSQ standards.

- Those Caribbean countries which, for whatever reason, are developing their own standards and not participating in the CDB-CROSQ project will also require wind hazard information. This wind hazard mapping project will provide wind hazard information which could readily be represented in forms designed to fit directly into standards documents with different approaches.
- Engineers in all Caribbean countries are designing projects every day which must resist the wind. Confidence in the wind hazard information is important to designers. Clients sometimes wish to specify the levels of safety of their facilities. Insurance providers sometimes wish to know the risks they underwrite. This depends critically on the quality of hazard information. Financing institutions sometimes wish to specify wind design criteria for their projects. There is, in summary, an immediate and palpable need for wind hazard information based on up-to-date meteorological records and methodologies recognised by consensus in the scientific community.

The agencies and main personnel responsible for the new maps are:

- Principal researcher – Applied Research Associates (Peter Vickery)
- Regional coordinator – Tony Gibbs (CEP International Ltd)
- Executing agency – Pan American Health Organisation (PAHO) (Dana van Alphen)
- Funding agency – United States Agency for International Development (Tim Callaghan and Julie Leonard)

The open process adopted in his project is exemplified by:

- The Caribbean Basin Wind Hazard Maps project has prepared a series of overall, regional, wind-hazard maps using uniform, state-of-the-art approaches covering all of the Caribbean islands and the Caribbean coastal areas of South and Central America. The project was executed in consultation with interest groups throughout the target region.

- An interim, information meeting was held at PAHO in Barbados on 01 October 2007. Meteorologists, engineers, architects, emergency managers, standards personnel and funding agency personnel from the wider Caribbean were invited (and were funded) to attend.
- At that meeting the principal researcher, Dr Peter Vickery of Applied Research Associates (ARA) described the methodology for developing the maps; presented the interim results available at the time of the meeting; received comments from participants and answered their questions; discussed what systems need to be put in place to improve knowledge of the wind hazard in the Caribbean region and outlined the further work to finalise the mapping exercise.

There are web sites presenting the results of the project including:

http://www.paho.org/english/dd/ped/caribbeanwindhazardmaps.htm
and
http://www.istructe.org/BRANCH/CARIBBEAN/news/article.asp?NID=370&Name=CARIBBEAN&BID=30

The sites contain:

- the 20 wind hazard maps;
- Peter Vickery's paper describing the methodology;
- Tony Gibbs's presentation of the CBWHM project to recent conferences;
- Peter Vickery's presentation of the CBWHM project to the 2008 National Hurricane Conference.

DESIGN WIND SPEEDS

taken from
Development of Design Wind Speed Maps for the Caribbean for Application with the Wind Load Provisions of ASCE 7, February 12 2008 by P. J. Vickery and D. Wadhera

The hurricane simulation model described in section 2 was used to develop estimates of peak gust wind speeds as a function of return period in the Caribbean. All speeds are produced as values associated with a 3 second gust wind speed at a height of 10 m in flat open terrain. The wind speeds can be used in conjunction with the methods outlined in Chapters 2 and 6 of ASCE editions 7-98 and later for the purposes of estimating design wind pressures. As will be discussed in more detail below, the basic wind speed to be used in the design of Category II structures is the 700-year wind speed divided by $\sqrt{1.6}$. For Category III and IV structures, the wind speed to be used is the 1,700-year wind speed divided by $\sqrt{1.6}$. The use of 1,700-year wind speed divided by $\sqrt{1.6}$ replaces the need to use the 700 year values with an importance factor of 1.15 as given in ASCE 7-98 and later. For buildings located near the coast, the wind speeds presented herein should be used with the procedures given in ASCE 7 including the use of Exposure D. The use of exposure D is required because of the limit in the sea surface drag coefficient. The following sections discuss the development of the wind speed maps and the use of the resulting wind speeds in conjunction with the wind load provisions as given in ASCE 7-98 and later.

3.1 Design Wind Speed Maps

Predictions of wind speed as a function of return period at any point in the Caribbean are obtained using the hurricane simulation model described in Section 2 using a 100,000 year simulation of hurricanes. Upon completion of the 100,000-year simulation, the wind speed data are rank ordered and then used to define the wind speed probability distribution, *P(v>V)*, conditional on a storm having passed within 250 km of the site and producing a peak gust wind speed of at least 20 mph. The wind speed associated with a given exceedance probability is obtained by interpolating from the rank ordered wind speed data. The probability that the tropical cyclone wind speed (independent of direction) is exceeded during time period *t* is,

$$P_t(v > V) = 1 - \sum_{x=0}^{\infty} P(v < V \mid x)\, p_t(x) \qquad \text{(3-1)}$$

where $P(v < V \mid x)$ is the probability that the velocity v is less than V given that x storms occur, and $p_t(x)$ is the probability of x storms occurring during time period t. From Equation 3-1, with $p_t(x)$ defined as having a Poisson distribution and defining t as one year, the annual probability of exceeding a given wind speed is,

$$P_a(v > V) = 1 - \exp[-\lambda P(v > V)] \qquad \text{(3-2)}$$

where λ (annual occurrence rate) represents the average annual number of storms approaching within 250 km of the site and producing a minimum 20 mph peak gust wind speed, and $P(v > V)$ is the probability that the velocity v is greater than V given the occurrence of any one storm.

In order to develop wind speed contours for use in the Caribbean basin, we performed two separate simulations for:

(i) Developing a contour map of open terrain wind speeds valid for locations near the coast (i.e. small islands) generated on a 1 degree square grid encompassing the entire Caribbean basin. Each location on the 1 degree grid is treated as an "island" with a distance of 1 km to the water in all directions, thus the predicted wind speeds are representative of open terrain values for a near coast location.

(ii) Developing contour maps of wind speeds on the larger islands of the Greater Antilles (Cuba, Hispaniola, Jamaica and Puerto Rico) developed on a 10 km grid. Each grid point contains information on the distance to the coast for all (36) directions.

Wind speeds were predicted for return periods of 50, 100, 700 and 1,700 years. The 700 and 1,700 year values were computed to provide wind speeds consistent with the return periods currently implied in ASCE 7-98 and later. Appendix B provides background information as the rationale behind the selection of return periods of 700 and 1,700 years.

At each location the effect of wind field modelling uncertainty was included. The inclusion of the wind field modelling uncertainty results in an increase in the predicted wind speeds compared to the case where wind field model uncertainty is not included. The magnitude of the increased wind speeds increases with increasing return period, where the 50-, 100-, 700- and 1,700-year return period wind speeds are, on average about 1%, 2%, 4% and 5%, respectively, higher than those obtained without considering uncertainty.

The resulting hurricane hazard maps are presented in Figures 3-1 through 3-8. Figures 3-1 through 3-4 present contour maps of open terrain wind speeds for the entire Caribbean basin (except for the Greater Antilles, which are given separately in Figures 3-5 through 3-8). Apparent discontinuities between the basin contours (Figures 3-1 through 3-4) and the Greater Antilles Island contours (Figures 3-5 through 3-6) may exist because of the grid resolutions used to develop the two sets of contours (~10 km for the Greater Antilles Islands vs. ~ 100 km for the basin). An additional potential source of discontinuities is associated with the modelling of the distance to the coast, where actual distances varying with direction are used in the 10 km grid for the islands, and a simplified 1 km distance for all directions is used for the basin contours.

Wind speeds at representative locations on the populated islands are summarized in Table 3-1. Each of these island locations are treated as point locations with a distance of 1 km to the water in all directions, thus the predicted wind speeds are representative of open terrain values for a near coast location, and are consistent with the wind speeds used to develop the contours given in Figures 3-1 through 3-4.

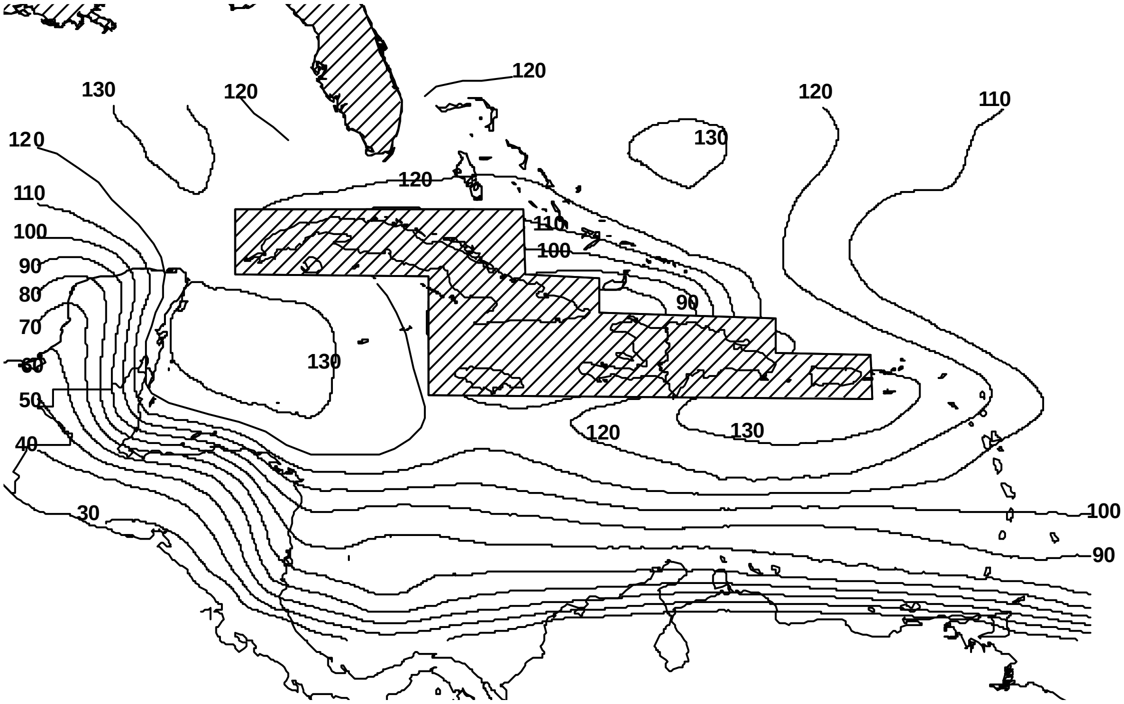


Figure 3-1. Contours or predicted 50 year return period peak gust wind speeds (mph) at a height of 10m in flat open terrain (ASCE 7 Exposure C).

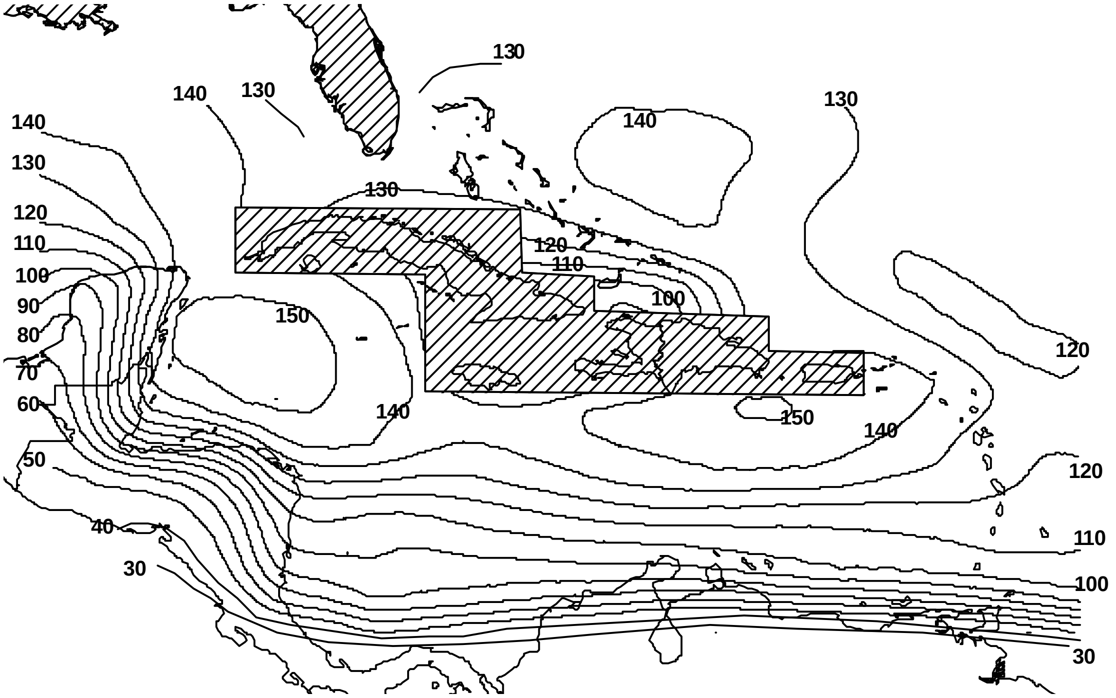


Figure 3-2. Contours or predicted 100 year return period peak gust wind speeds (mph) at a height of 10m in flat open terrain (ASCE 7 Exposure C).

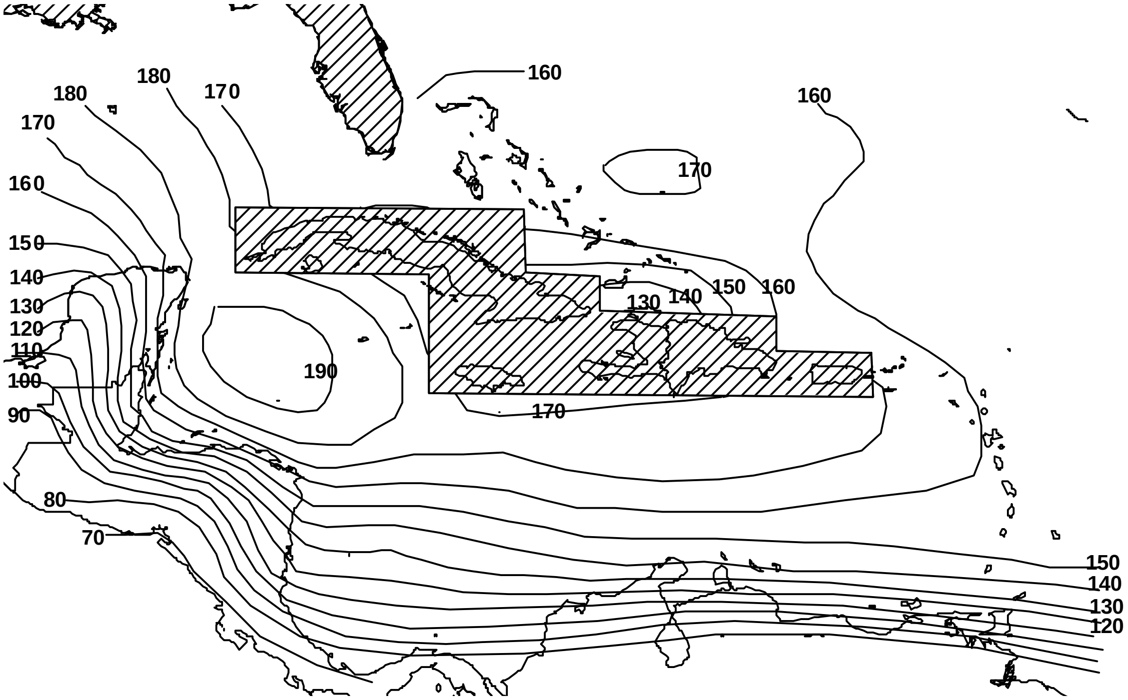


Figure 3-3. Contours or predicted 700 year return period peak gust wind speeds (mph) at a height of 10m in flat open terrain (ASCE 7 Exposure C).

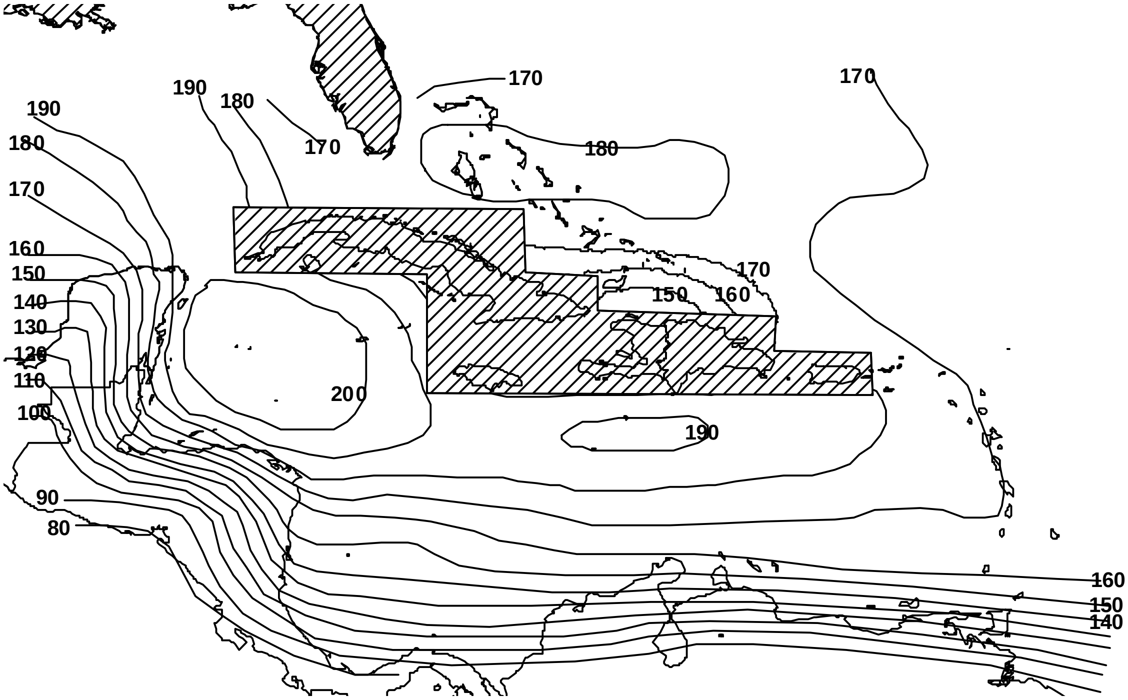


Figure 3-4. Contours or predicted 1,700 year return period peak gust wind speeds (mph) at a height of 10m in flat open terrain (ASCE 7 Exposure C).

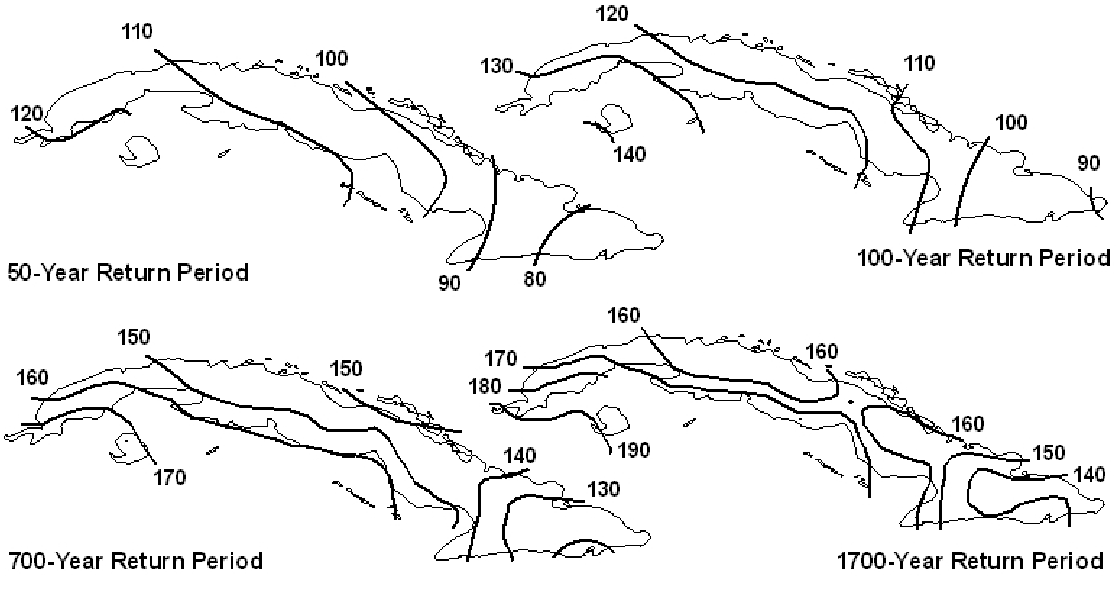


Figure 3-5. Contours of period peak gust wind speeds (mph) at a height of 10m in flat open terrain for various return periods for Cuba (ASCE 7 Exposure C).

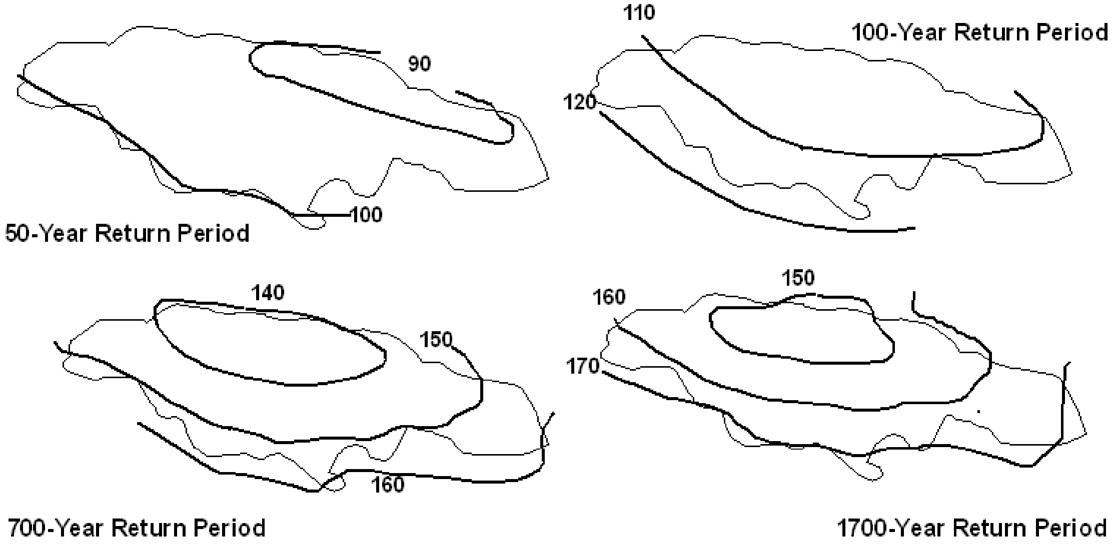


Figure 3-6. Contours of period peak gust wind speeds (mph) at a height of 10m in flat open terrain for various return periods for Jamaica (ASCE 7 Exposure C).

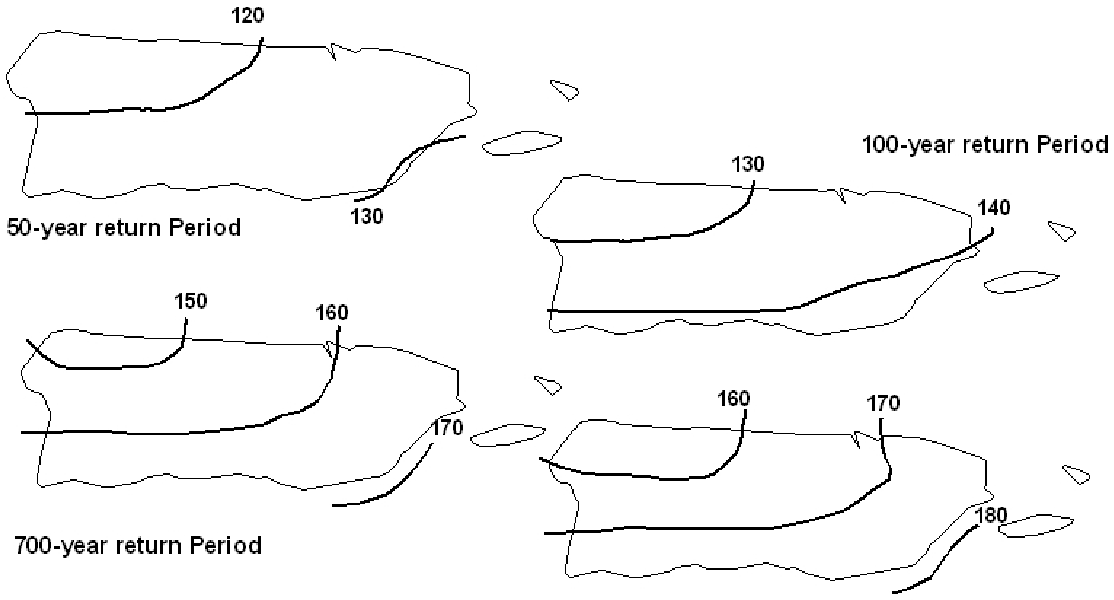


Figure 3-7. Contours of period peak gust wind speeds (mph) at a height of 10m in flat open terrain for various return periods for Puerto Rico (ASCE 7 Exposure C).

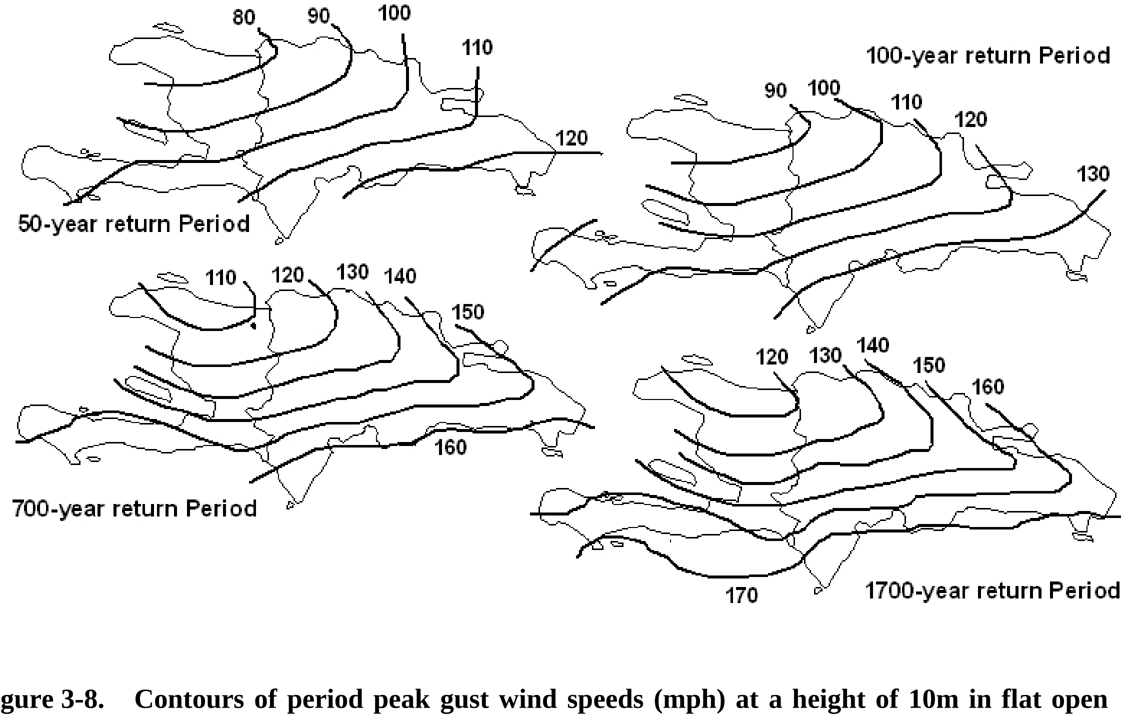


Figure 3-8. Contours of period peak gust wind speeds (mph) at a height of 10m in flat open terrain for various return periods for the island of Hispaniola(ASCE 7 Exposure C).

Table 3-1 Peak gust wind speeds (mph) in flat open terrain (ASCE 7 Exposure C) as a function of return period for selected locations in the Caribbean

Location	Lat	Long	Return Period (years)

			50	**100**	**700**	**1700**
Trinidad (S)	10.03	61.33	19	32	82	102
Trinidad (N)	11.20	61.33	61	85	136	156
Isla Margarita	10.50	64.17	24	42	100	128
Grenada	12.12	61.67	85	107	154	168
Bonaire	12.25	68.28	77	101	149	156
Curacao	12.17	69.55	73	96	147	168
Aruba	12.53	70.03	77	100	146	162
Barbados	13.08	59.50	92	112	152	169
Saint Vincent	13.17	61.17	93	111	155	171
Saint Lucia	14.03	60.97	101	119	155	172
Martinique	14.60	61.03	104	121	159	171
Dominica	15.42	61.33	106	124	159	172
Guadeloupe	16.00	61.73	110	126	157	168
Montserrat	16.75	62.70	120	135	164	172
St. Kitts and Nevis	17.33	62.75	125	138	163	170
Antigua and Barbuda	17.33	61.80	121	134	160	168
Saint Martin/Sint Maarten	17.98	63.17	129	141	168	178
Anguilla	18.25	63.17	127	140	166	176
US Virgin Islands	18.35	64.93	130	143	167	176
British Virgin Islands	18.45	64.62	128	141	169	180
Grand Cayman	19.33	81.40	128	147	187	200
Little Cayman/Cayman Brac	19.72	79.82	118	136	178	197

3.2 Use of Wind Speeds with ASCE 7 Wind Loading Criteria

The wind speeds presented herein can be used with the wind loading requirements given in ASCE 7 (ASCE 7-98 and later) to compute wind loads for the design of buildings and structures as described in the following section. The velocity pressure, q_z (psf), given in ASCE 7 is defined as:

$$q_z = 0.00256 K_z K_{zt} K_d V^2 I \tag{3-3}$$

where K_d is a wind directionality factor, K_{zt} is a height dependent topographic factor, K_z is a velocity pressure exposure coefficient, V is the basic design wind speed (*not the 50 year return period wind speed*) and has the units of mph, and I is an importance factor. Again, the units of q_z are pounds per square foot and the units of the wind speed are miles per hour. The wind speed information presented herein can be used to define the basic wind speed, V and the importance factor, I. The importance factor, I is approximately equal to the square of the ratio of the 100 year return period wind speed in a non-hurricane prone region divided by the 50 year return period wind speed in the non-hurricane prone regions of the United States.

As discussed in the commentaries of ASCE 7-98, ASCE 7-02 and ASCE 7-05, and Appendix B of this report, the basic wind speed used in ASCE 7 is the 500-year return period wind speed divided by $\sqrt{1.5}$. In the non-hurricane prone region of the US, the resulting basic wind speed is a 50-year return period value. In the hurricane prone regions of the continental United States the return period associated with the basic wind speed varies with location, but is typically in the range of 70 to 100 years.

Here, the basic wind speed is the 700-year return period wind speed divided by $\sqrt{1.6}$, which yields a design wind speed that is consistent with the intent of the developers of the ASCE 7 wind speed map. Thus the wind speed to be used in Equation 3-3 and subsequently the wind load calculations given in ASCE 7 is

$$V = V_{700} / \sqrt{1.6}$$

Appendix B provides information as to the reason for using a 700-year return period wind speed divided by $\sqrt{1.6}$, as compared to the 500 year return period wind speed divided by $\sqrt{1.5}$ as presented in ASCE 7-98 through ASCE 7-05. Appendix B also provides the rationale for replacing the $V^2 I$ term (where I =1.15) in Equation 3-3 with $(V_{1700} / \sqrt{1.6})^2$ for the design of Category III and IV structures.

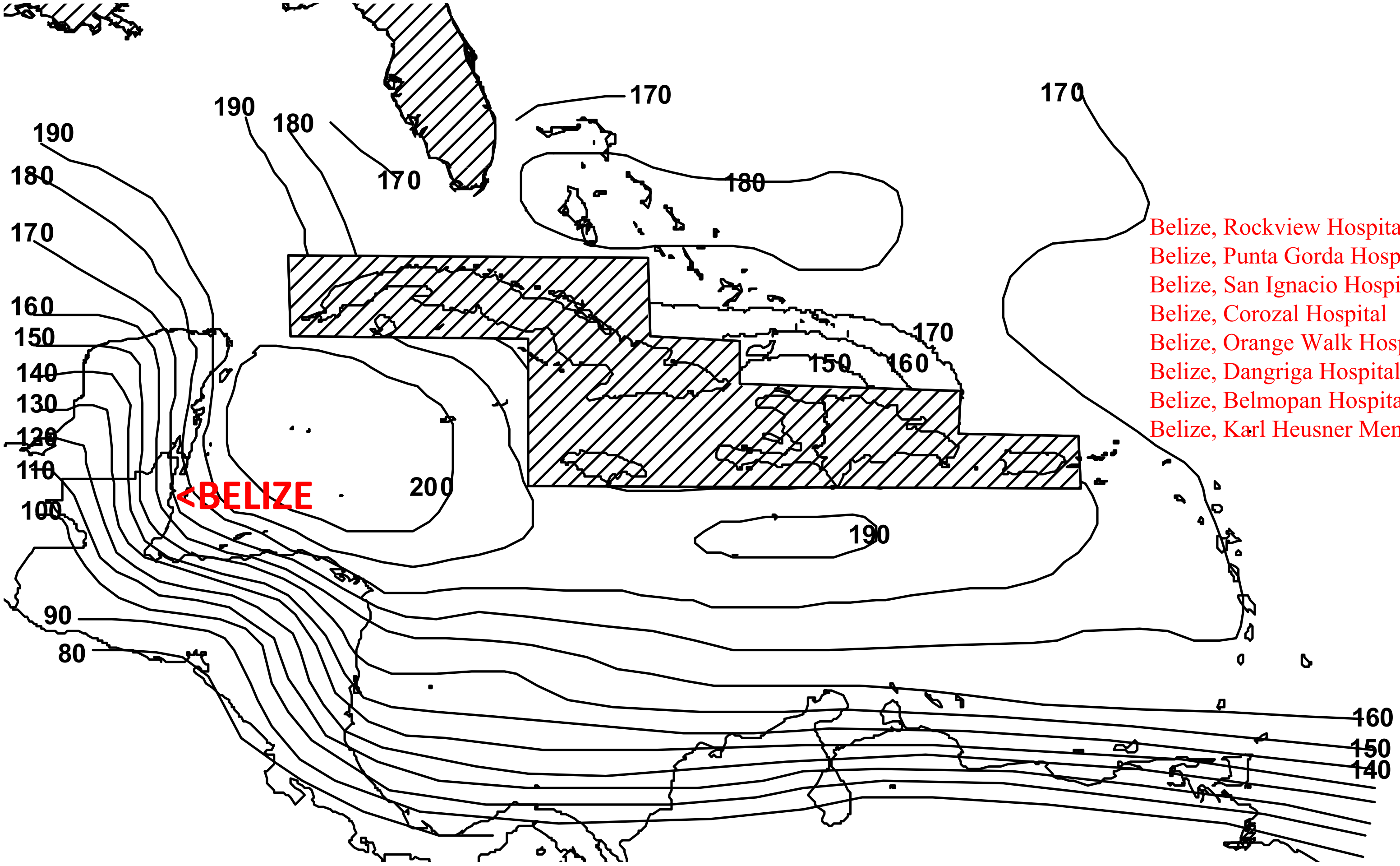
Locations of Hospitals
in the
Commonwealth Caribbean
related to the
Wind Hazard for Structural Design

compiled by

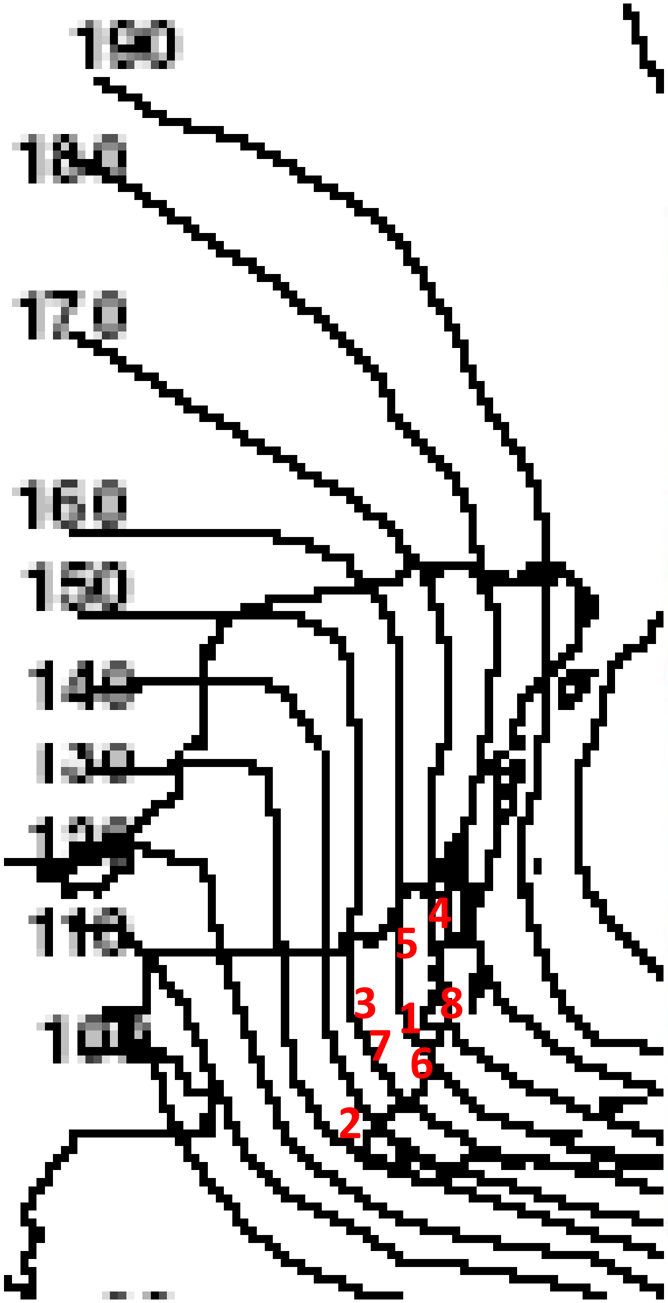
David Taylor and Tony Gibbs

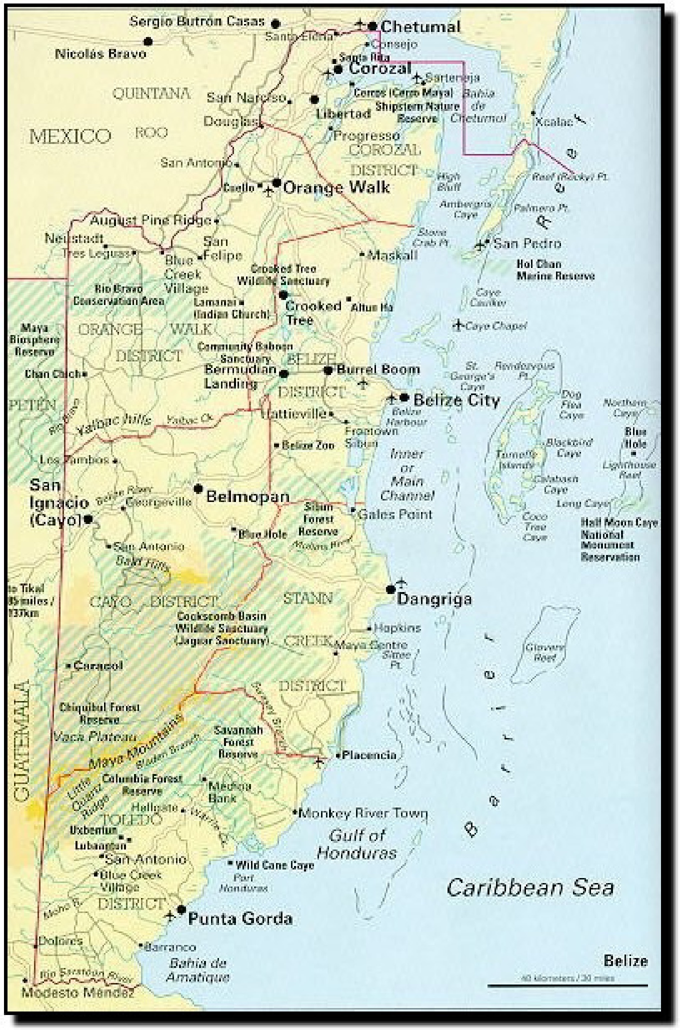
November 2008

1700 Year Wind Speeds for Caribbean



Belize, Rockview Hospital
Belize, Punta Gorda Hospital
Belize, San Ignacio Hospital
Belize, Corozal Hospital
Belize, Orange Walk Hospital
Belize, Dangriga Hospital
Belize, Belmopan Hospital
Belize, Karl Heusner Memorial Hospital

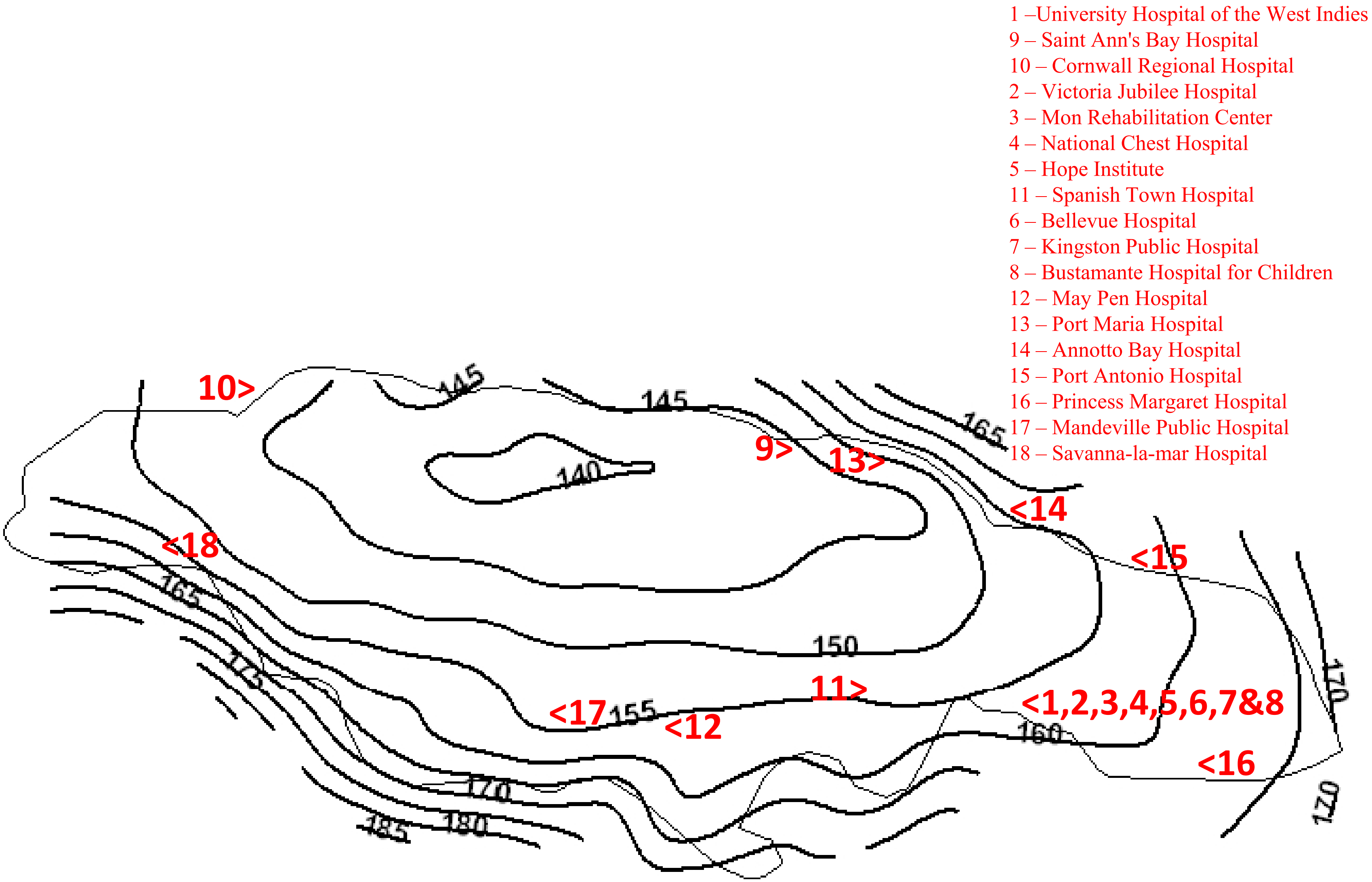




1 – Rockview Hospital
2 – Punta Gorda Hospital
3 – San Ignacio Hospital
4 – Corozal Hospital
5 – Orange Walk Hospital
6 – Dangriga Hospital
7 – Belmopan Hospital
8 – Belize, Karl Heusner Memorial Hospital

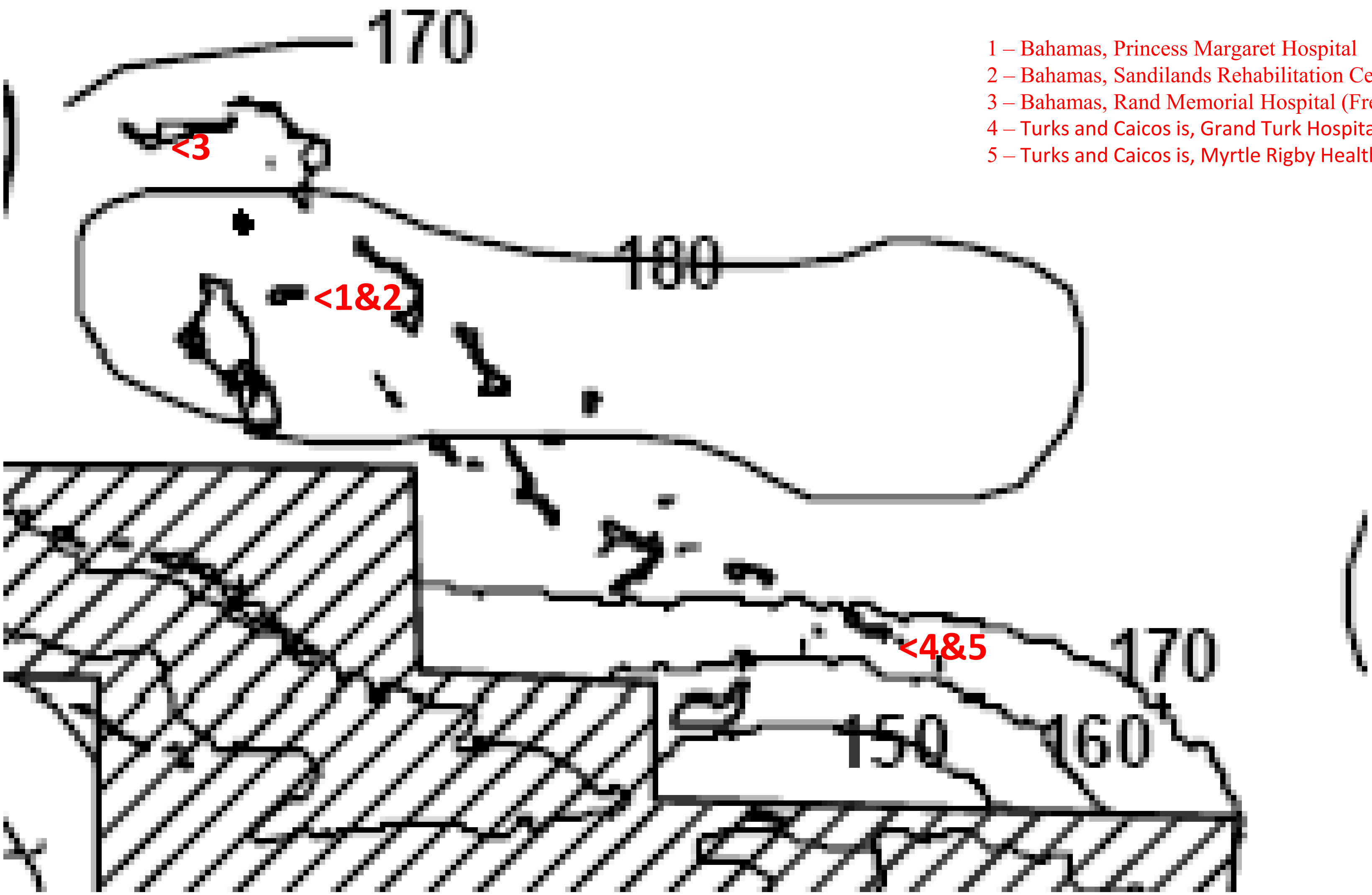
Belize

1700 year Return Period Wind Speeds for Jamaica



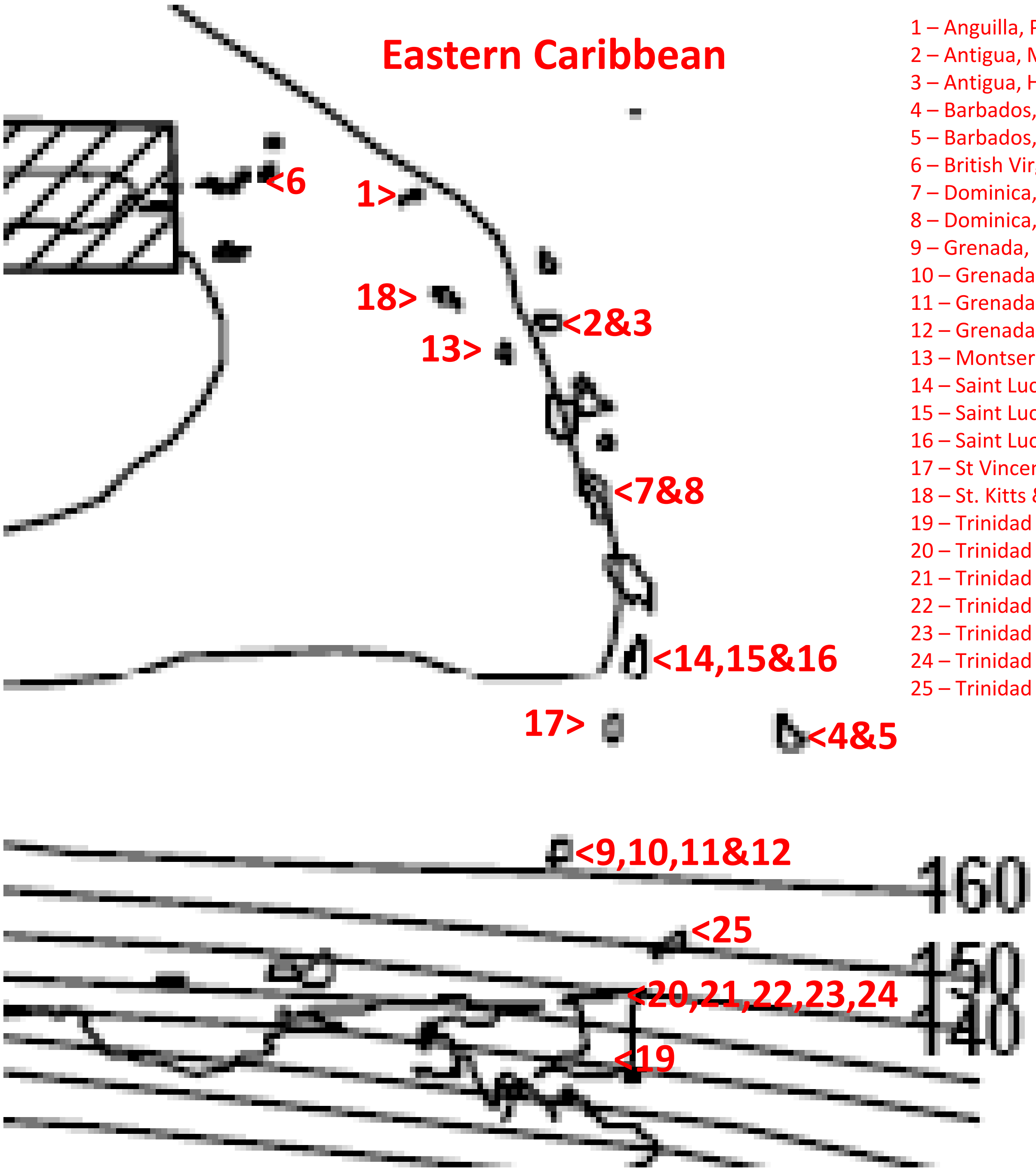
1 –University Hospital of the West Indies
9 – Saint Ann's Bay Hospital
10 – Cornwall Regional Hospital
2 – Victoria Jubilee Hospital
3 – Mon Rehabilitation Center
4 – National Chest Hospital
5 – Hope Institute
11 – Spanish Town Hospital
6 – Bellevue Hospital
7 – Kingston Public Hospital
8 – Bustamante Hospital for Children
12 – May Pen Hospital
13 – Port Maria Hospital
14 – Annotto Bay Hospital
15 – Port Antonio Hospital
16 – Princess Margaret Hospital
17 – Mandeville Public Hospital
18 – Savanna-la-mar Hospital

Bahamas and Turks & Caicos Islands



1 – Bahamas, Princess Margaret Hospital
2 – Bahamas, Sandilands Rehabilitation Centre
3 – Bahamas, Rand Memorial Hospital (Freeport)
4 – Turks and Caicos is, Grand Turk Hospital
5 – Turks and Caicos is, Myrtle Rigby Health Complex

Eastern Caribbean



1 – Anguilla, Princess Alexandra Hospital
2 – Antigua, Mental Hospital
3 – Antigua, Holberton Hospital
4 – Barbados, Queen Elizabeth Hospital
5 – Barbados, Psychiatric Hospital
6 – British Virgin Islands, Peebles Hospital
7 – Dominica, Princess Margaret Hospital
8 – Dominica, Portsmouth Hospital
9 – Grenada, Princess Royal Hospital
10 – Grenada, Mt Gay Hospital
11 – Grenada, Princess Alice Hospital
12 – Grenada, General Hospital
13 – Montserrat, Glendon Hospital
14 – Saint Lucia, Saint Jude Hospital
15 – Saint Lucia, Golden Hope Hospital
16 – Saint Lucia, Victoria Hospital
17 – St Vincent & Grenadines, Kingstown General
18 – St. Kitts & Nevis, J N France General Hospital
19 – Trinidad and Tobago, San Fernando General
20 – Trinidad and Tobago, Saint Ann's Psychiatric
21 – Trinidad and Tobago, Mount Hope Maternity
22 – Trinidad and Tobago, Mount Hope Hospital
23 – Trinidad and Tobago, Port of Spain General
24 – Trinidad and Tobago, Sangre Grande County
25 – Trinidad and Tobago, Tobago Regional Hospital