PN-ACK-653
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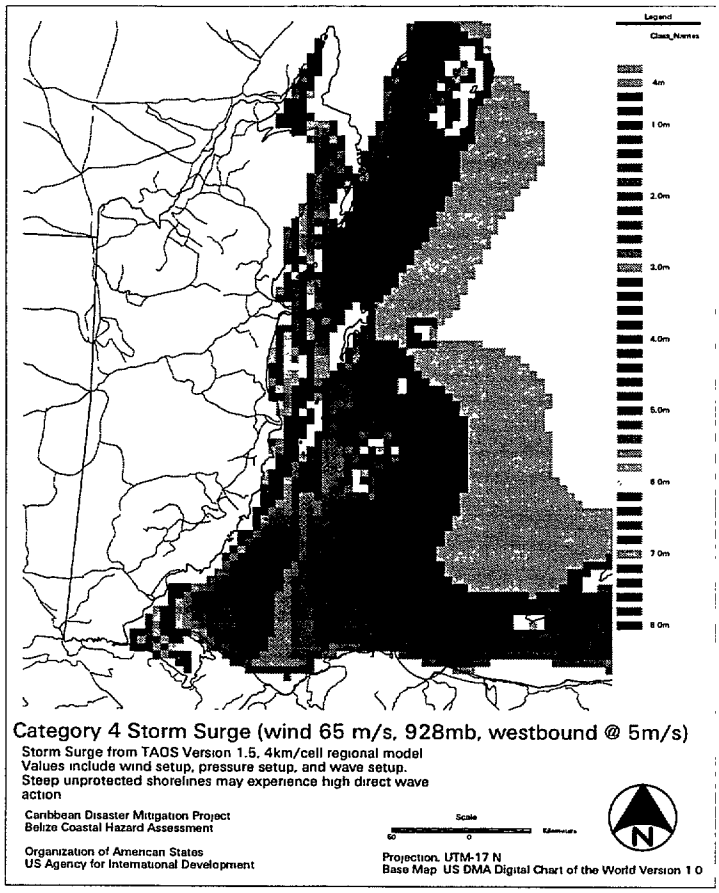
Storm Hazard Assessment for Belize

Storm Surge and Wind Hazard Maps



The Caribbean Disaster Mitigation Project

A

Storm Hazard Assessment for Belize

Storm Surge and Wind Hazard Maps

Introduction

The General Secretariat of the Organization of American States (OAS), under an agreement with the Office of Foreign Disaster Assistance of the U.S. Agency for International Development (USAID), is executing a five-year Caribbean Disaster Mitigation Project (CDMP). One component of this project is the assessment of potential hazards generated by tropical storms in terms of storm surge, coastal flooding, and extreme wind.

This report documents the "national level" assessment of the wind and coastal storm surge hazards for Belize. It consists of three parts:

1. A historical return interval analysis for five locations;
2. A series of five wind hazard maps, showing the probable surface winds for each of the five Saffir/Simpson hurricane categories; and,
3. A series of five coastal storm surge maps, one for each of the Saffir/Simpson hurricane categories.

The methods used are outlined at the beginning of each section.

Intensity and Return Time Analysis for Various Locations in Belize

Introduction

A return time analysis was conducted for five locations on the coast of Belize, as noted in Figure 1 ("Locations for Detailed Return Time Analysis"). These locations were selected to demonstrate the variability of return times along the coast.

Methodology

For each target location, historical storm tracks were extracted from the HURDAT data tape from the US National Hurricane Center. This data base covers the time period from 1886 to 1992. Each storm in the data base was processed to assess its impact on the target location using the TAOS wind model. The model outputs were analyzed and presented in the discussions which follow. Two types of data are presented. First, general statistics such as how many storms effected the location, how many years had storms, how many years had multiple storms, and how many of each category of Saffir/Simpson of storm occurred. Next an analysis of the length of time which passed between occurrences of each category of storm are presented. The maximum, minimum, and average length of time which passed between events of the stated category or greater are given. Finally, a distribution of return times is tabulated.

General Storm Tracks and Observations

Figure 2 shows the storm tracks across the Belize coastline from 1886-1992, while Figure 3 shows the relative intensities of these storms. Because of the geographic location of Belize in the Atlantic Basin, and the geometry of the Gulf of Honduras and Central America, there is a strong north/south gradient to the occurrences of storms. The northern coast of Belize is exposed to more frequent and more intense storms than the southern part. This is readily apparent by comparing the analysis for Punta Gorda and Ambergris Cay. Punta Gorda may expect a tropical storm event on average every 6 years, while Ambergris Cay may expect one to occur twice as often, every 3 years.

Locations for Detailed Return Time Analysis

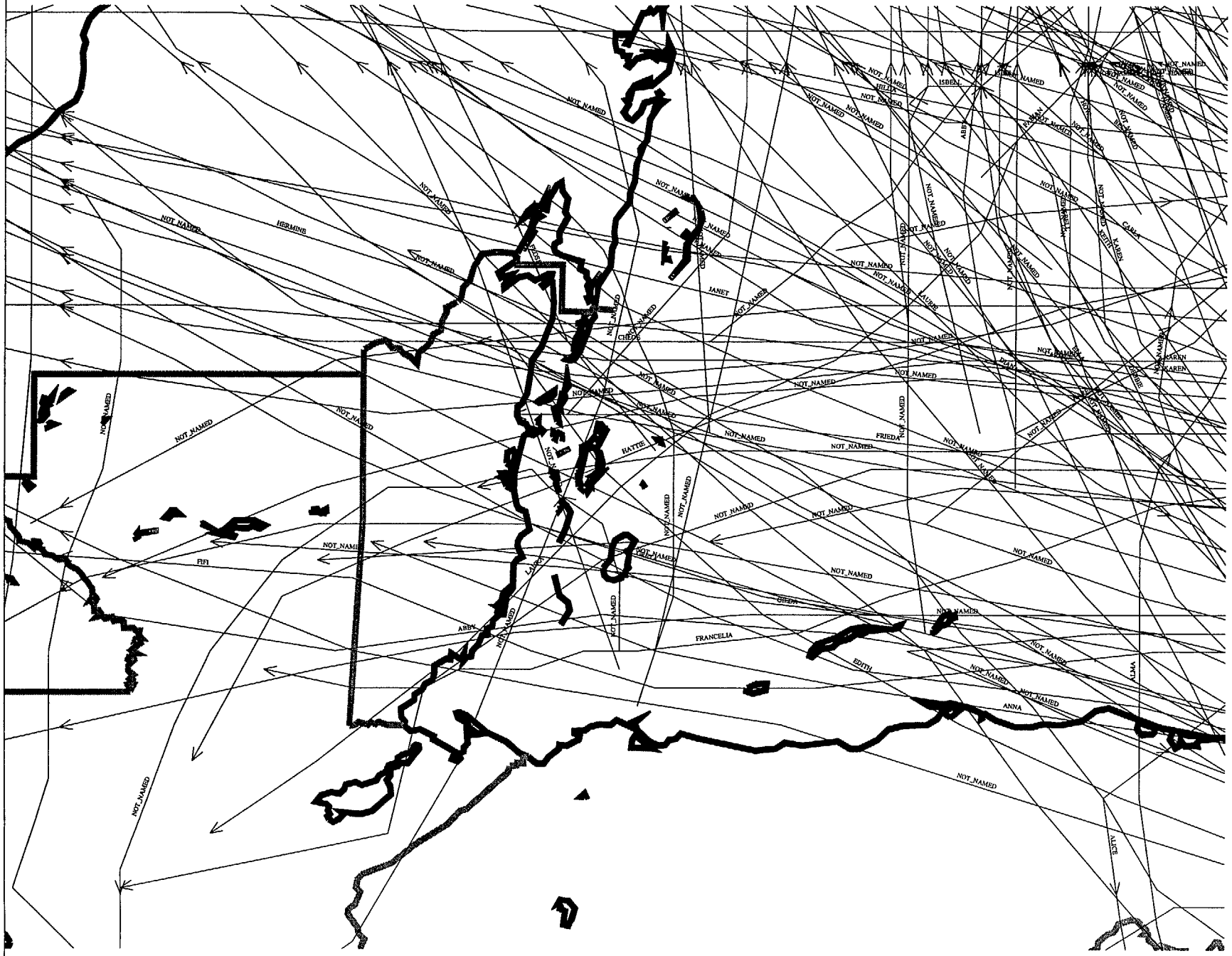
Caribbean Disaster Mitigation Project
Belize Coastal Hazard Assessment

Scale
50 0 Kilometers

Organization of American States
US Agency for International Development

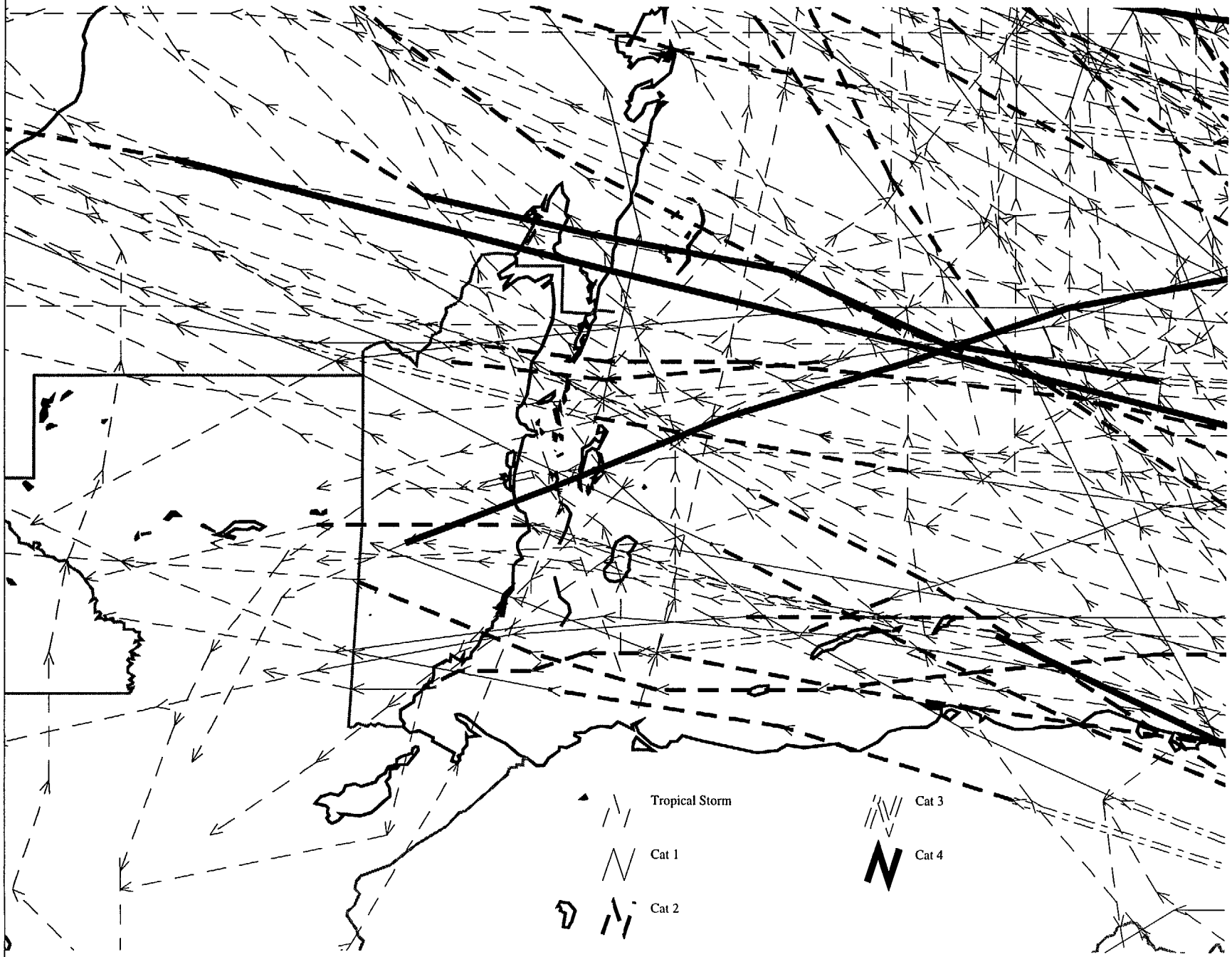
Base Map: US DMA Digital Chart of the World Version 1.0

Storms near Belize, 1886-1992



TAOS output sy ,c) 1995 Watson Technical Consulting 110 Deerwood Ct. Rincon, GA 31326 USA

Storms Effecting Belize, 1886-1992



TAOS output sy ,c) 1995 Watson Technical Consulting 110 Deerwood Ct. Rincon, GA 31326 USA

Intensity and Return Time Analysis for Punta Gorda, BZ

General Statistics

There have been 19 storm events occurring in 17 different years over the period of 1886-1992, using the HURDAT data tape. There were multiple events in 2 years.

Intensity Breakdown:

SS Cat	Number
TS	12
1	5
2	2

Return Interval Analysis

Tropical Storm or Greater

There are 15 intervals in the data base. The minimum return interval was 1 year, the maximum 26, the average 5.73 years. The distribution of return times are:

Years	Number of Intervals
1	2
2	3
3	3
4	2
5	1
8	1
9	1
13	1
26	1

Category 1 Hurricane or Greater

There are 6 intervals in the data base. The minimum return interval was 1, the maximum 15, the average 6.17 years. The distribution of return times are:

Years	Number of Intervals
1	1
4	2
5	1
8	1
15	1

Category 2 Hurricane or Greater

There was only 1 interval in the data base, of 5 years.

Intensity and Return Time Analysis for Monkey River Town, BZ

General Statistics

There have been 24 storm events occurring in 20 different years over the period of 1886-1992, using the HURDAT data tape. There were multiple events in 4 years.

Intensity Breakdown:

SS Cat	Number
TS	17
1	4
2	3

Return Interval Analysis

Tropical Storm or Greater

There are 17 intervals in the data base. The minimum return interval was 1 year, the maximum 25, the average 5.06 years. The distribution of return times are:

Years	Number of Intervals
1	4
2	4
3	2
4	2
5	1
8	1
9	1
13	1
25	1

Category 1 Hurricane or Greater

There are 6 intervals in the data base. The minimum return interval was 1, the maximum 15, the average 6.17 years. The distribution of return times are:

Years	Number of Intervals
1	1
4	2
5	1
8	1
15	1

Category 2 Hurricane or Greater

There are 2 intervals in the data base, of 4 and 5 years each.

Intensity and Return Time Analysis for Dangriga, BZ

General Statistics

There have been 37 storm events occurring in 29 different years over the period of 1886-1992, using the HURDAT data tape. There were multiple events in 8 years.

Intensity Breakdown:

SS Cat	Number
TS	25
1	8
2	1
3	2
4	1

Return Interval Analysis

Tropical Storm or Greater

There are 23 intervals in the data base. The minimum return interval was 1 year, the maximum 20, the average 3.96 years. The distribution of return times are:

Years	Number of Intervals
1	6
2	6
3	4
4	1
5	4
6	3
8	2

Category 1 Hurricane or Greater

There are 15 intervals in the data base. The minimum return interval was 2, the maximum 15, the average 6.1 years. The distribution of return times are:

Years	Number of Intervals
2	5
3	2
4	2
5	2
11	2
12	1
13	1
15	1

Category 2 Hurricane or Greater

There are 7 intervals in the data base. The minimum return interval was 2, the maximum 37, the average 12.2 years. The distribution of return times are:

Years	Number of Intervals
2	2
3	2
12	1
27	1
37	1

Category 3 Hurricane or Greater

There were 3 intervals in the data base. The minimum return interval was 2, the maximum 49, the average 26.7 years. The distribution of return times are:

Years	Number of Intervals
2	1
29	1
49	1

Intensity and Return Time Analysis for Belize City, BZ

General Statistics

There have been 39 storm events occurring in 35 different years over the period of 1886-1992, using the HURDAT data tape. There were multiple events in 4 years.

Intensity Breakdown:

SS Cat	Number
TS	28
1	6
2	2
3	2
4	1

Return Interval Analysis

Tropical Storm or Greater

There are 27 intervals in the data base. The minimum return interval was 1 year, the maximum 12, the average 3.7 years. The distribution of return times are:

Years	Number of Intervals
1	3
2	10
3	3
4	2
5	3
6	3
7	1
8	1
12	1

Category 1 Hurricane or Greater

There are 10 intervals in the data base. The minimum return interval was 2, the maximum 27, the average 12 years. The distribution of return times are:

Years	Number of Intervals
2	1
3	2
5	1
6	1
8	1
9	1
13	1
16	1
27	1

Category 2 Hurricane or Greater

There are 4 intervals in the data base. The minimum return interval was 2, the maximum 51, the average 20.75 years. The distribution of return times are:

Years	Number of Intervals
2	1
3	1
27	1
51	1

Category 3 Hurricane or Greater

There were 2 intervals in the data base. The distribution of return times are:

Years	Number of Intervals
29	1
51	1

Intensity and Return Time Analysis for Ambergris Cay, BZ

General Statistics

There have been 39 storm events occurring in 35 different years over the period of 1886-1992, using the HURDAT data tape. There were multiple events in 4 years.

Intensity Breakdown:

SS Cat	Number
TS	28
1	6
2	2
3	2
4	1

Return Interval Analysis

Tropical Storm or Greater

There are 27 intervals in the data base. The minimum return interval was 1 year, the maximum 12, the average 3.7 years. The distribution of return times are:

Years	Number of Intervals
1	3
2	10
3	3
4	2
5	3
6	3
7	1
8	1
12	1

Category 1 Hurricane or Greater

There are 10 intervals in the data base. The minimum return interval was 2, the maximum 27, the average 12 years. The distribution of return times are:

Years	Number of Intervals
2	1
3	2
5	1
6	1
8	1
9	1
13	1
16	1
27	1

Category 2 Hurricane or Greater

There are 4 intervals in the data base. The minimum return interval was 2, the maximum 51, the average 20.75 years. The distribution of return times are:

Years	Number of Intervals
2	1
3	1
27	1
51	1

Category 3 Hurricane or Greater

There were 2 intervals in the data base. The distribution of return times are:

Years	Number of Intervals
29	1
51	1

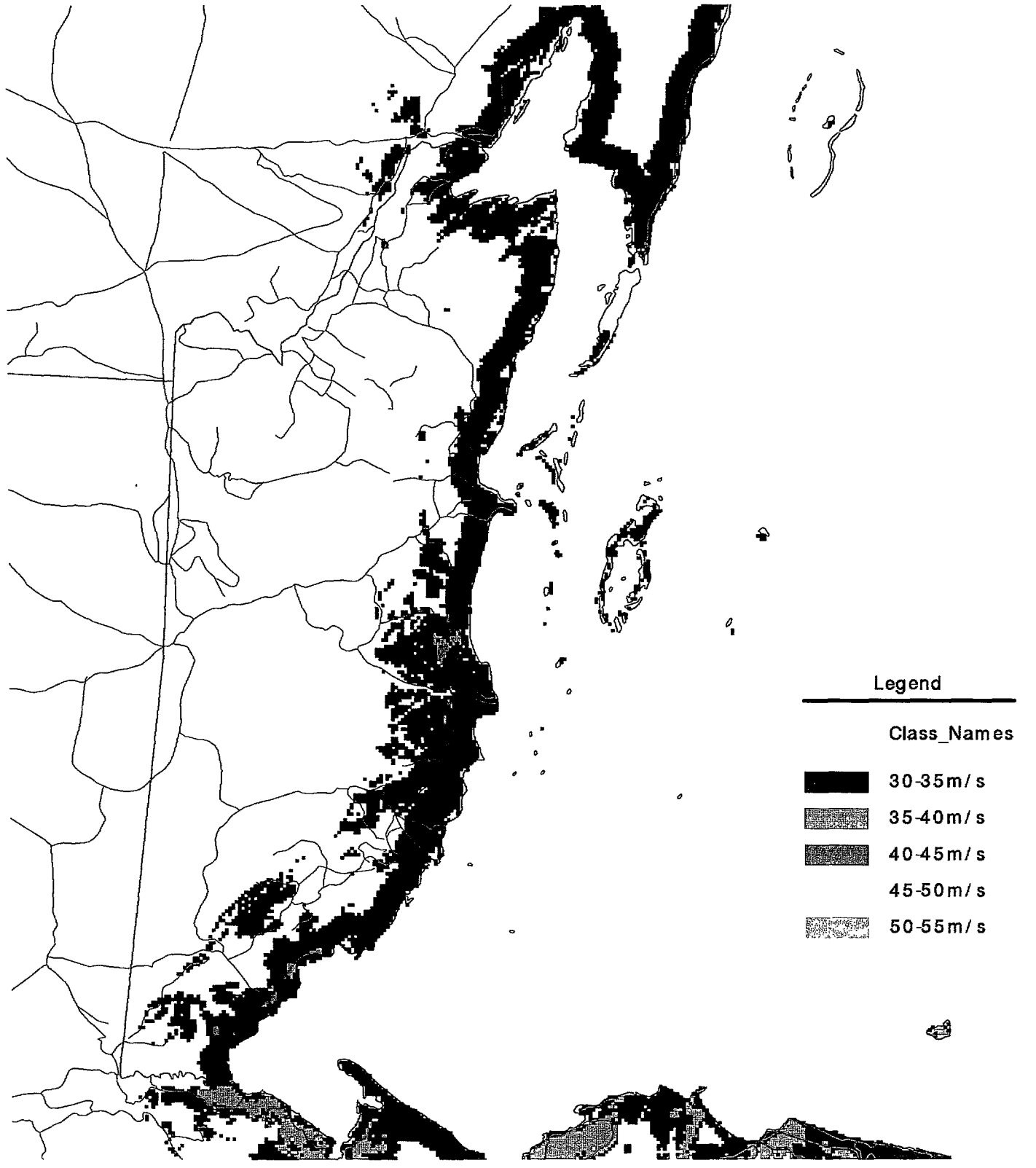
Wind Hazard Maps for Belize

Introduction

The following 6 pages depict the maximum wind speeds which may be expected during various classes of storm events. There is one map for each of the Saffir/Simpson hurricane categories. These maps are "overall maximum envelope" maps, created by running multiple tracks across the country. The tracks used are the same as those used to create the storm surge maps. They show the highest one minute average wind detected at each location. To get an approximation of the two second gust, a factor of 1.2 to 1.3 may be used. Note that as these are average winds, the higher gusts which may be encountered in some areas such as ridge lines (shown in red on the maps) are factored in. For example, if the average wind is 60 m/s, gusts of 72 to 78 m/s should be expected. To simulate decrease in strength in landfalling storms, a decay rate of 4mb/hr while over land was used. The climatalogical average forward speed of 9.5 knots (17.1kph) was used. The above combination results in a very rapid decay of tropical systems impacting Belize, much more so than for systems effecting other areas of the Atlantic basin. As a comparison, a Category 3 run was made using the regional average 2.3 mb/hr decay rate, and is included at the end of the map set.

Methodology

Surface winds were determined by modeling the effects of terrain on upper level winds. This was accomplished by using a boundary layer model and the TAOS upper level wind model. Topography was obtained from the US Defense Mapping Agency's Digital Chart of the World. Friction and land cover was determined from LANDSAT imagery provided by the Government of Belize. Winds were calculated at 1000 meter intervals, resulting in a raster GIS data base.



Wind Speeds from Category 1 Hurricane

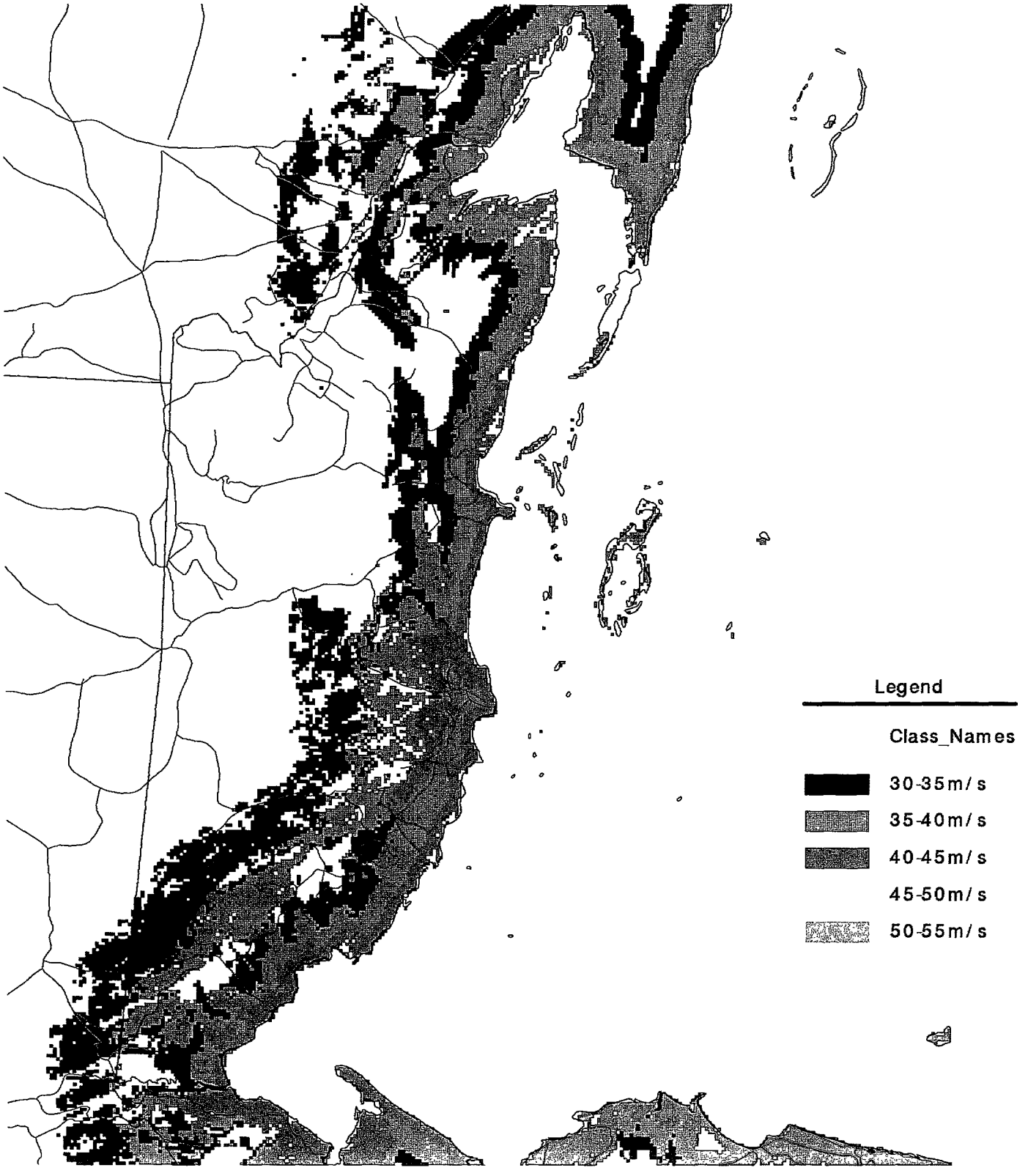
Caribbean Disaster Mitigation Project
Belize Coastal Hazard Assessment

Organization of American States
US Agency for International Development

Scale

50 0 Kilometers

Base Map: US DMA Digital Chart of the World Version 1.0



Wind Speeds from Category 2 Hurricane

Caribbean Disaster Mitigation Project
Belize Coastal Hazard Assessment

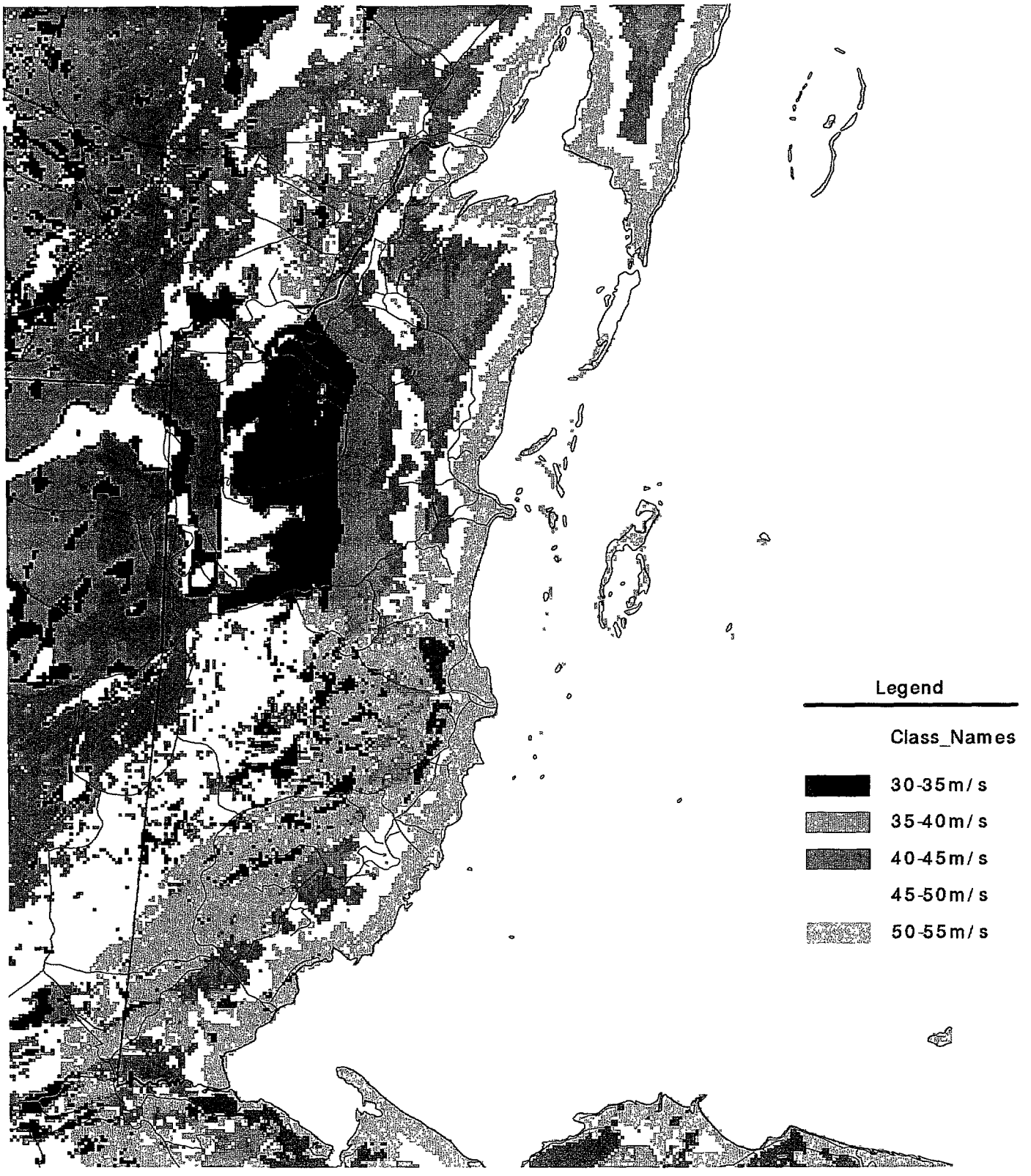
Organization of American States
US Agency for International Development

Scale

50 0 Kilometers

N

Base Map: US DMA Digital Chart of the World Version 1.0



Wind Speeds from Category 3 Hurricane, 2.3mb/hr Decay Rate

Caribbean Disaster Mitigation Project
Belize Coastal Hazard Assessment

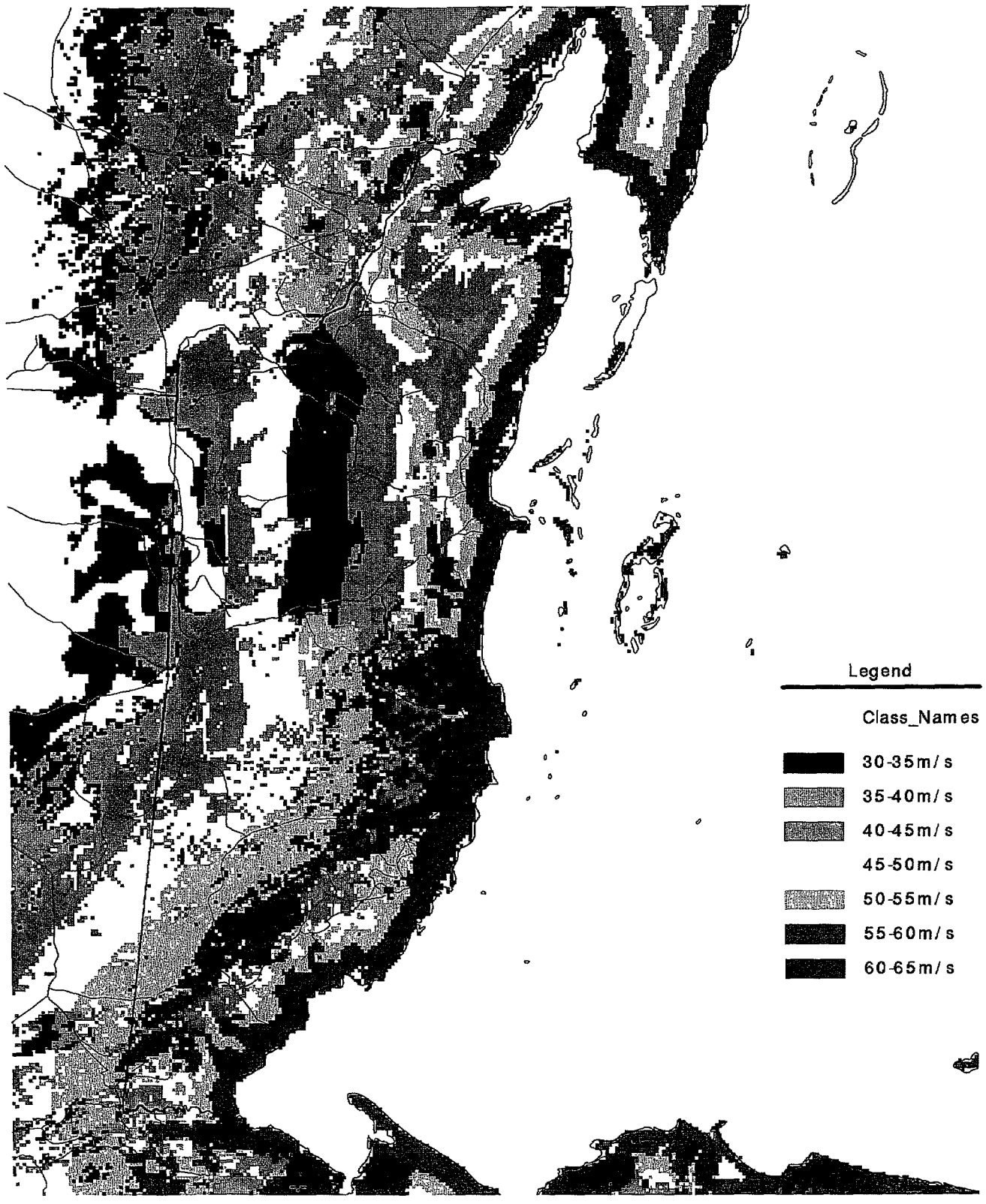
Organization of American States
US Agency for International Development

Scale

50 0 Kilometers

N

Base Map: US DMA Digital Chart of the World Version 1.0



Wind Speeds from Category 4 Hurricane

Caribbean Disaster Mitigation Project
Belize Coastal Hazard Assessment

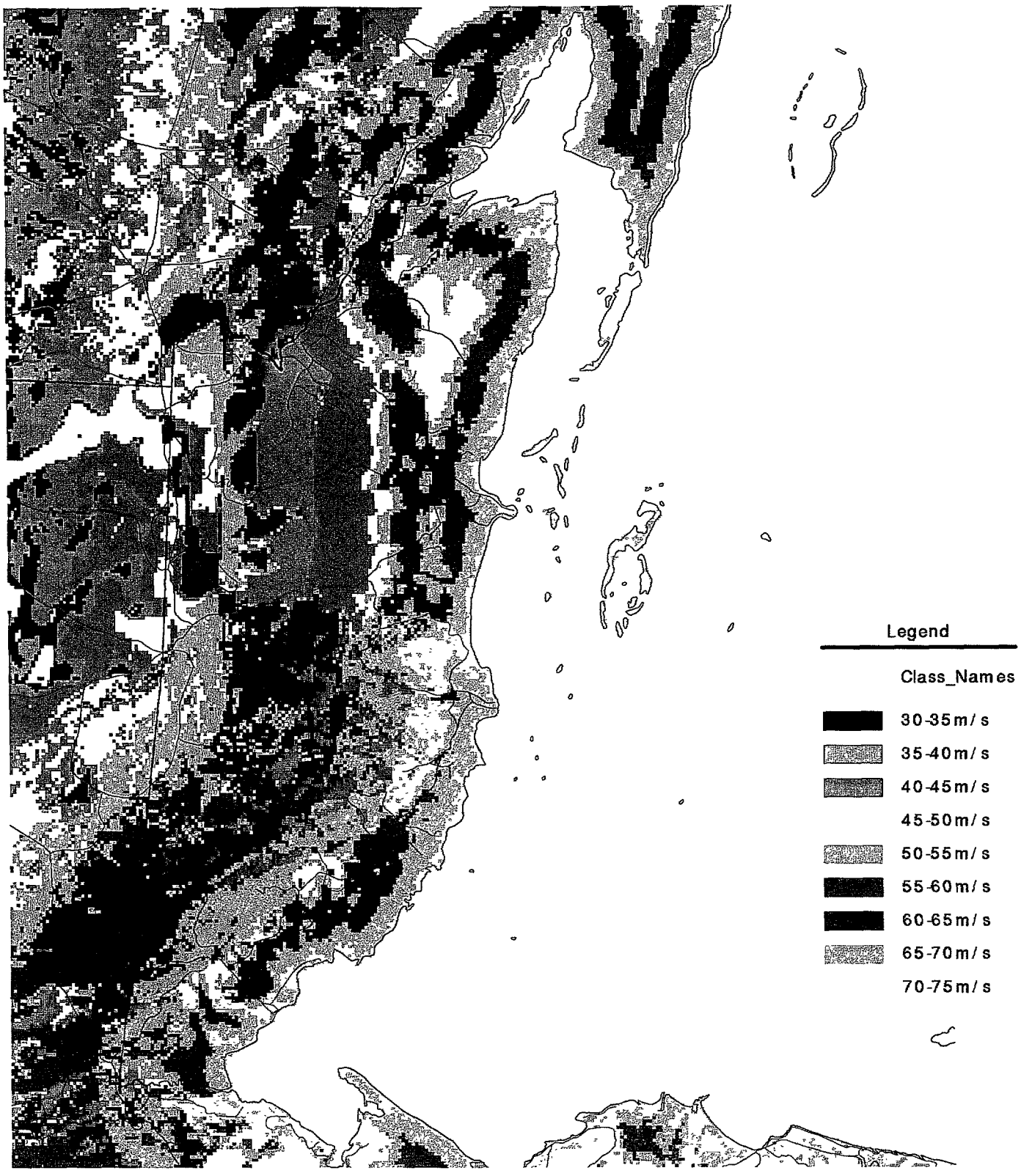
Organization of American States
US Agency for International Development

Scale

50 0 Kilometers

N

Base Map: US DMA Digital Chart of the World Version 1.0



Wind Speeds from Category 5 Hurricane

Caribbean Disaster Mitigation Project
Belize Coastal Hazard Assessment

Organization of American States
US Agency for International Development

Scale

50 0 Kilometers

N

Base Map: US DMA Digital Chart of the World Version 1.0

Coastal Storm Surge Hazard Maps for Belize

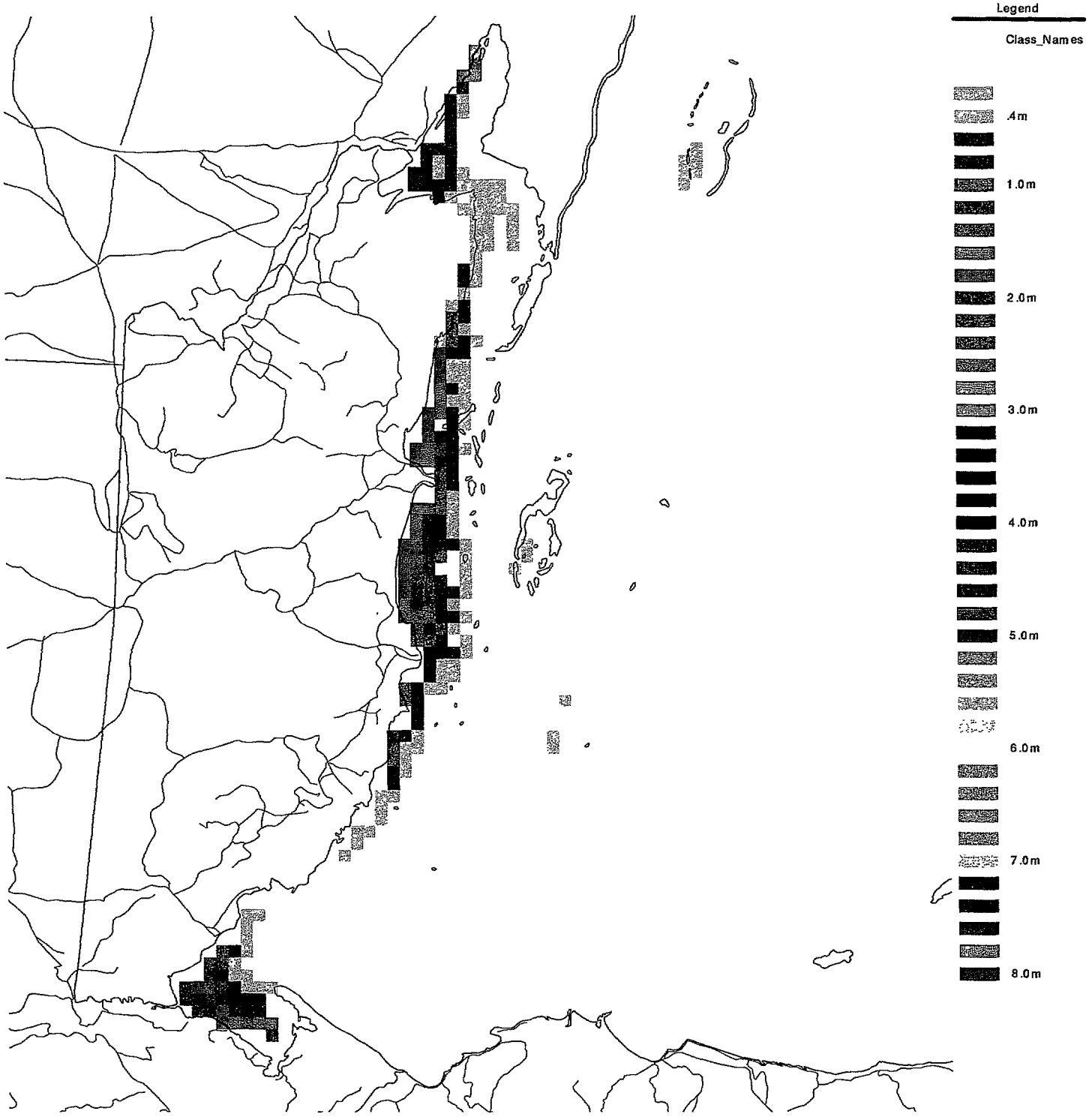
Introduction

The following 5 maps show the maximum envelope of water (MEOW) at the coast for hurricanes which may pass over Belize. They are organized according to intensity. The climatalogical average forward speed of 17.1 kph was used. Five intensity levels are used, one for each of the Saffir/Simpson storm categories.

Methodology

A set of parallel tracks was developed, spaced so that when combined the maximum water level along the shoreline for any storm of similar strength traveling in the same direction may be estimated. The TAOS 4km/cell model was used to run a model storm along each track. This results in a storm surge map for that track. The results of all of the runs for each Saffir/Simpson category are combined to create the MEOW map for that storm and forward speed.

Bathymetry and topography for the model was derived from the US Defense Mapping Agency DTM, USGS ETOPO data set, and satellite imagery provided by the government of Belize.



Category 1 Storm Surge (wind 38m/s, 985mb, westbound @5m/s)

Storm Surge from TAOS Version 1.5, 4km/cell regional model.
Values include wind setup, pressure setup, and wave setup.
Steep unprotected shorelines may experience high direct wave action.

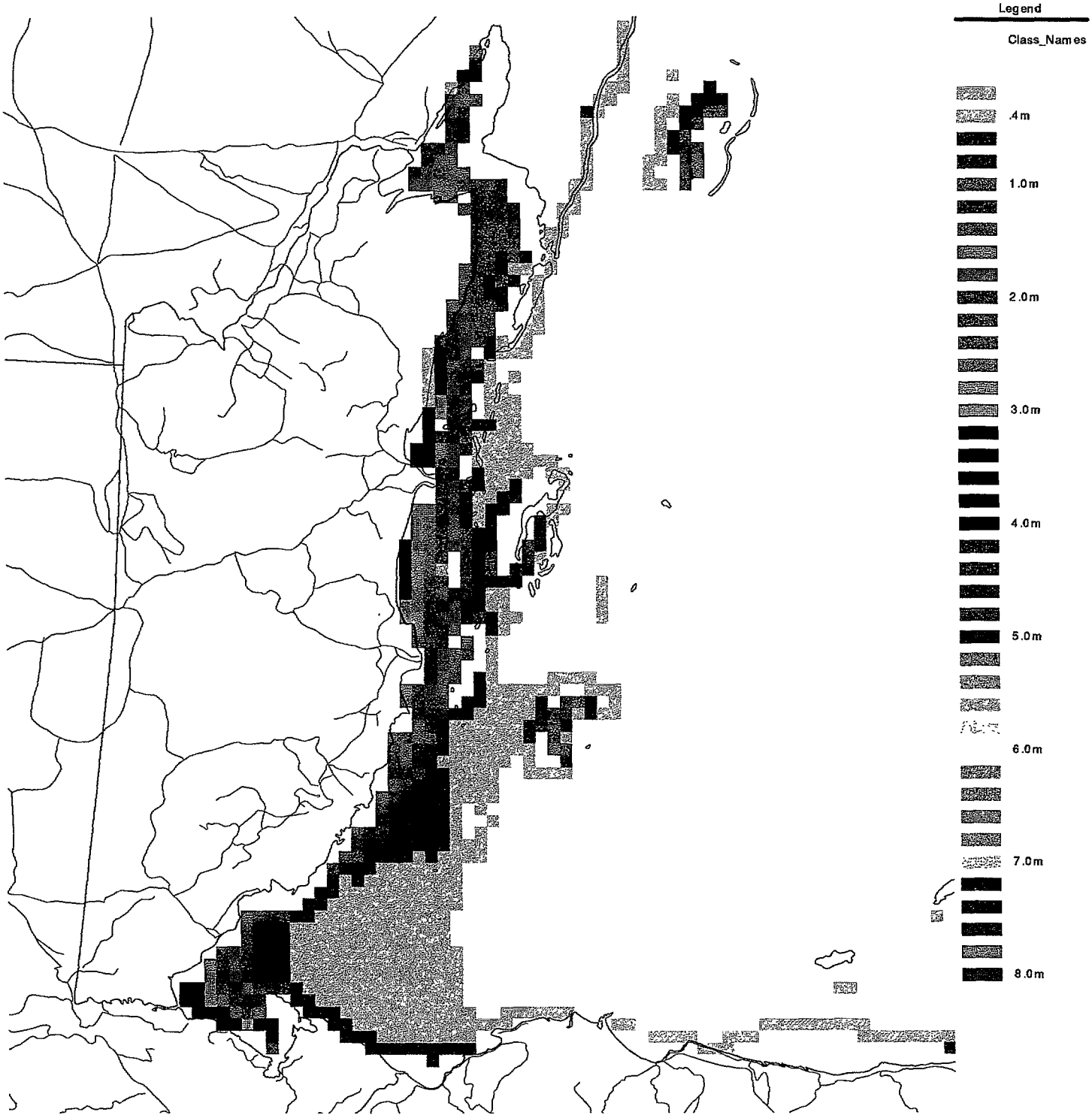
Caribbean Disaster Mitigation Project
Belize Coastal Hazard Assessment

Organization of American States
US Agency for International Development

Scale
50 0 Kilometers

N

Projection: UTM-17 N
Base Map: US DMA Digital Chart of the World Version 1.0



Category 2 Storm Surge (wind 45 m/s, 972mb, westbound @5m/s)

Storm Surge from TAOS Version 1.5, 4km/cell regional model.
Values include wind setup, pressure setup, and wave setup.
Steep unprotected shorelines may experience high direct wave action.

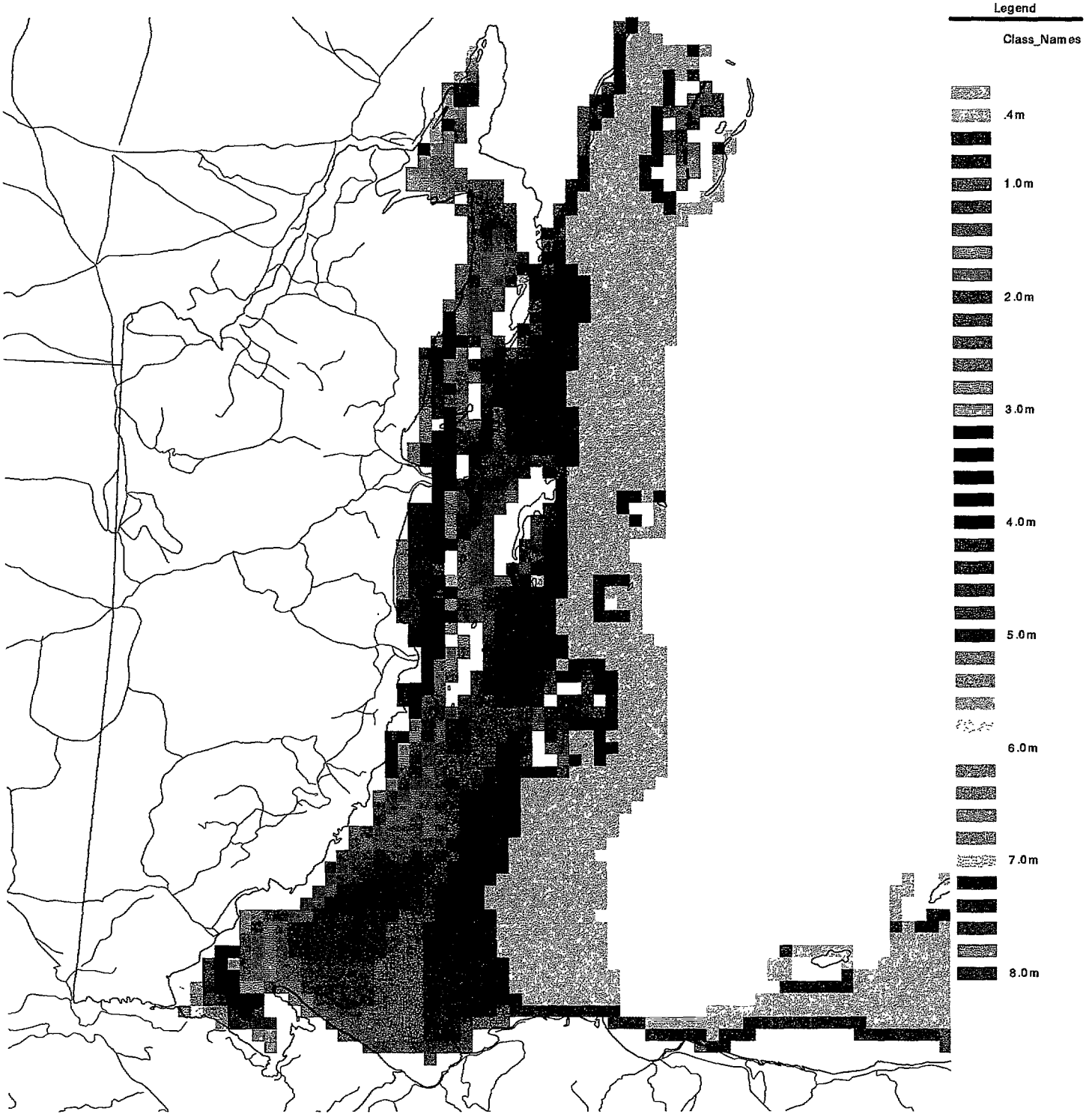
Caribbean Disaster Mitigation Project
Belize Coastal Hazard Assessment

Organization of American States
US Agency for International Development

Scale
50 0 Kilometers

N

Projection: UTM-17 N
Base Map: US DMA Digital Chart of the World Version 1.0



Category 3 Storm Surge (wind 55 m/s, 950mb, westbound @5m/s)

Storm Surge from TAOS Version 1.5, 4km/cell regional model.
Values include wind setup, pressure setup, and wave setup.
Steep unprotected shorelines may experience high direct wave action.

Caribbean Disaster Mitigation Project
Belize Coastal Hazard Assessment

Organization of American States
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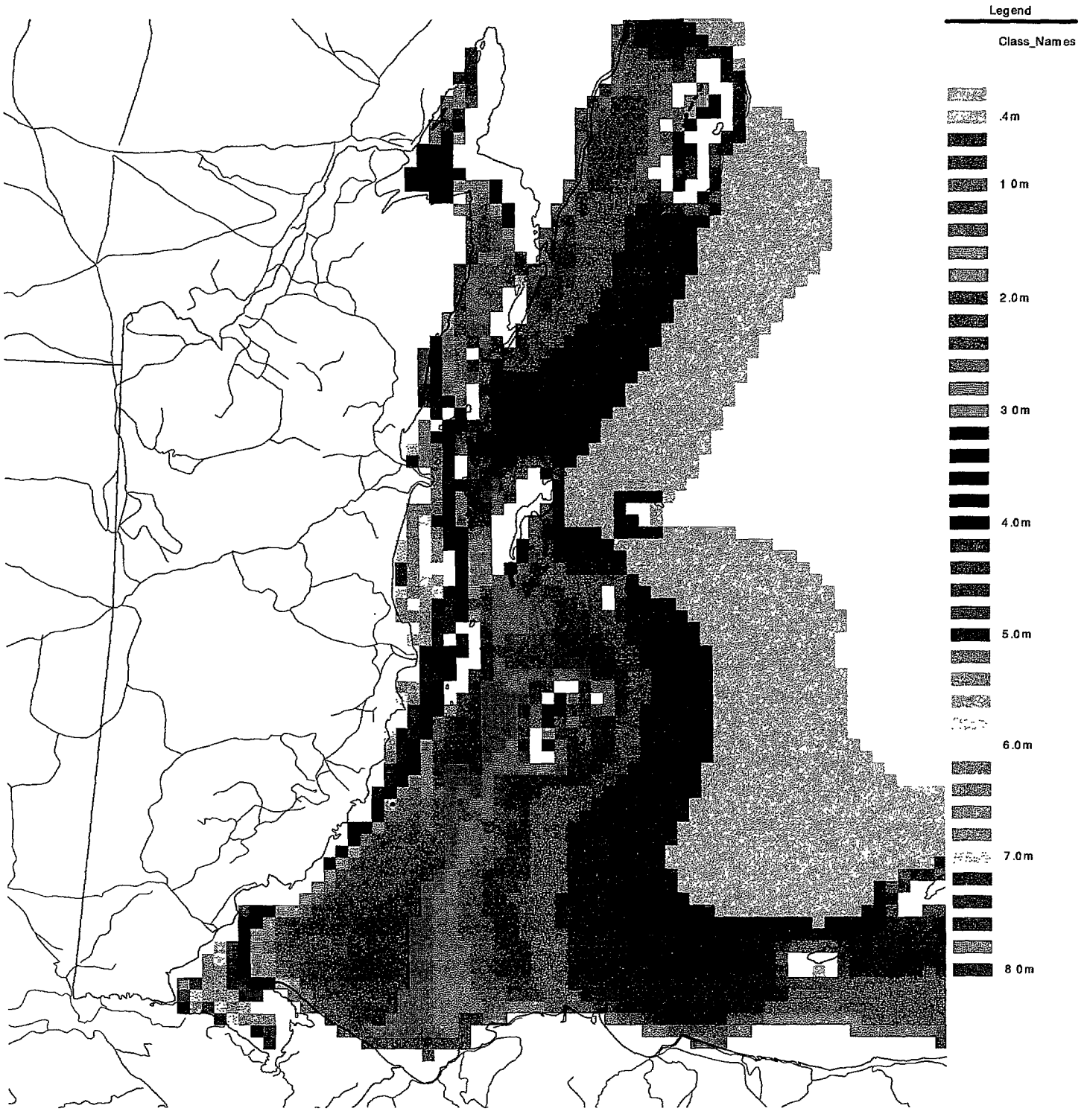
Scale
50 0 Kilometers

N

Projection: UTM-17 N
Base Map: US DMA Digital Chart of the World Version 1.0



Category 4 Storm Surge (wind 65 m/s, 928mb, westbound @5m/s)

Storm Surge from TAOS Version 1.5, 4km/cell regional model.
Values include wind setup, pressure setup, and wave setup.
Steep unprotected shorelines may experience high direct wave action.

Caribbean Disaster Mitigation Project
Belize Coastal Hazard Assessment

Organization of American States
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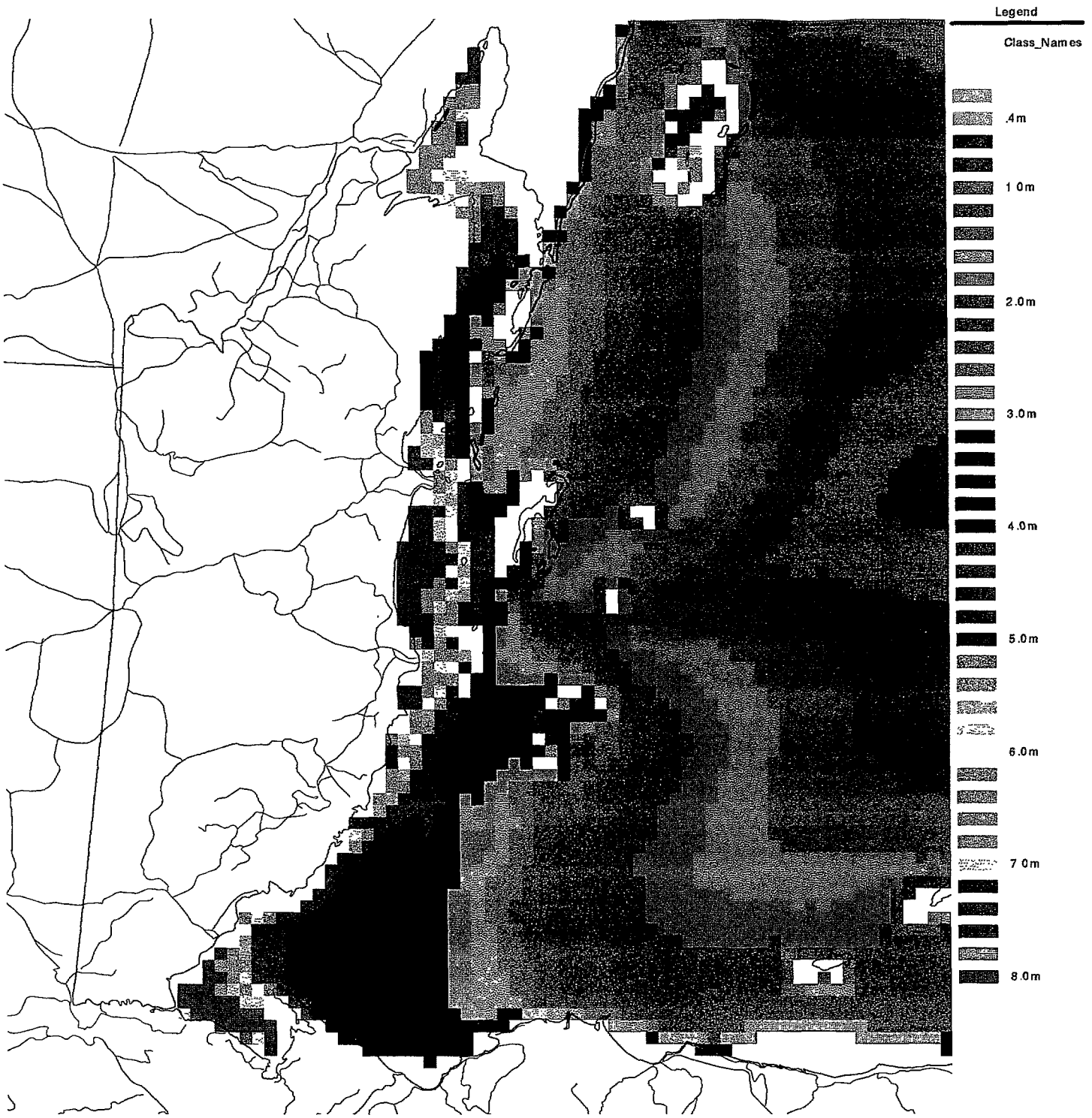
Scale
50 0 Kilometers

N

Projection: UTM-17 N
Base Map: US DMA Digital Chart of the World Version 1.0



Category 5 Storm Surge (wind 72 m/s, 910mb, westbound @5m/s)

Storm Surge from TAOS Version 1.5, 4km/cell regional model.
Values include wind setup, pressure setup, and wave setup.
Steep unprotected shorelines may experience high direct wave action.

Caribbean Disaster Mitigation Project
Belize Coastal Hazard Assessment

Organization of American States
US Agency for International Development

Scale
50 0 Kilometers

N

Projection: UTM-17 N
Base Map: US DMA Digital Chart of the World Version 1.0

CARIBBEAN DISASTER MITIGATION PROJECT

The Caribbean Disaster Mitigation Project (CDMP) is a coordinated effort to promote the adoption of natural disaster mitigation and preparedness practices by both the public and private sectors in the Caribbean region through a series of activities carried out over a five-year period. The CDMP is funded by the **USAID Office of Foreign Disaster Assistance (OFDA)** and implemented by the **Organization of American States/Unit of Sustainable Development and Environment (OAS/USDE)** for the **USAID Regional Housing & Urban Development Office in the Caribbean (RHUDO/CAR)**.

The CDMP provides a framework for collaboration with the Caribbean region to establish sustainable public and private sector mechanisms for natural disaster mitigation that will measurably lessen loss of life, reduce the potential for physical and economic damage, and shorten the disaster recovery period over the long term. Project activities vary according to location, contents and implementation strategy, but all contribute to attainment of the overall CDMP goal: a more disaster-resistant environment for the people who live, work and invest in this hazard-prone region.

Project activities include: 1) natural hazard risk audits for electrical utilities and other infrastructure systems and key lifeline facilities; 2) hazard mapping to support improved planning and location of physical development; 3) assisting the insurance industry in improving risk management for insured property; 4) assisting countries to adopt improved building standards and practices and training of builders, architects and artisans in their use; 5) stimulating community-based disaster preparedness and mitigation efforts with support of the private sector, and, 6) post disaster mitigation planning and program design.

The Project is being implemented in Caribbean countries where USAID has active assistance programs, i.e. the Dominican Republic, the Eastern Caribbean countries which are served by the Caribbean Office of Regional Assistance (CORA) of USAID, Haiti, Belize, and Jamaica. The entire region is to benefit from the project through an active dissemination of project information and methods.

The CDMP will build on past and ongoing regional initiatives in disaster preparedness and mitigation, and will promote technology transfer and institutional capacity building through direct involvement of professional associations, bankers, builders, insurance companies and reinsurers, NGO's, PVO's, community groups and government organizations in project activities.

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