APPENDIX B

DEBRIS MODEL

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The modeling methodology described below was developed by the Mobile District, U.S. Army Corps of Engineers Emergency Management staff using actual data from Hurricanes Frederick, Hugo, and Andrew. The estimates produced by the model are predicated to have an accuracy of ± 30% (accuracy is limited due to the many variables inherit to the debris removal process). The primary factor the model utilizes to estimate storm generated debris is the total number of households in a developed urban/suburban area. Other factors utilized are cubic yards of debris generated per household per storm category, vegetative cover, commercial density, and precipitation. The household debris includes debris generated from damage to the house including contents and surrounding shrubs/trees. Vegetative cover includes all trees /shrubbery and other debris located on public rights of way. Commercial density includes debris generated by damage to businesses and industrial facilities. The majority of commercial related debris will be removed by private contractors, however disposal/reduction space is still required. The amount of precipitation generated by a storm has a direct relationship on debris quantities. Very wet storms will cause ground saturation increasing tree fall.

For planning purposes, the worse case scenario should be used, one storm category for the subject area. For actual events the winds speeds will vary and more accurate debris estimates can be determined by detailed analysis. The most accurate process, is to determine the defined areas is by using Doppler Radar (National Weather Service Broadcasts) and GIS (Geographical Information Systems) . The Doppler radar will define the storms intensity and the exact track of the "EYE" of the storm in relation to the affected area. By tracking the storm and plotting the eye path and 5 mile wide bands out from the eye, defined areas and estimated winds speeds can be determined. The wind speed of the eye wall normally determines the reported storm category with the outward or five mile bands being a lesser category. The storm then can be tracked inland until the winds speeds dissipate below hurricane strength. The areas now outlined can be divided by storm category. Once divided, coordinates can be entered into GIS to determine areas and demographic information such as population, schools, businesses required by the model to calculate debris quantities.

ESTIMATING DEBRIS QUANTITIES

Determine population (**P**) in the affected area (for example, 1990 census data for the Harrison County Ms. is 165,500). Therefore, for Harrison Co., **P** = 165,500. Population density per square
mile can also be used to determine debris estimates per square mile.

The assumption of three persons per household (**H**) is used for this model.

Known/estimated population (**P**) for a jurisdiction may be used to determine a value for **H**.

H =**P** / 3

The formula used in this model will generate debris quantity as an absolute value based on a known/estimated population or as a debris quantity per square mile based upon population density per square mile.

The model formula is as follows:

Q = **H** (**C**) (**V**) (**B**) (**S**)

where

Q is quantity of debris in cubic yards

H is the number of households

C is the storm category factor in cubic yards

V is the vegetation characteristic multiplier

B is the commercial/business/industrial use multiplier

S is the storm precipitation characteristic multiplier

C is the storm category factor. It expresses debris quantity in cubic yards (cy) per household by hurricane category and includes the house and its contents, and land foliage.

Hurricane Category	Value of **C** Factor
1	2 cy
2	8 cy
3	26 cy
4	50 cy
5	80 cy

V is the vegetation multiplier. It acts to increase the quantity of debris by adding vegetation including shrubbery and trees on public rights of way.

Vegetative Cover	Value of **V** Multiplier
Light	1.1
Medium	1.3
Heavy	1.5

B is the multiplier which takes into account areas which are not solely single-family residential, but include small retail stores, school, apartments, shopping centers and light industrial/manufacturing facilities. Built into this multiplier is the offsetting commercial insurance requirement for owner/operator salvage operations.

Commercial Density	Value of Multiplier
Light	1.0
Medium	1.2
Heavy	1.3

S is a precipitation multiplier which takes into account either a "wet" or "dry" storm event, with a "wet" storm trees will up-root generating a larger volume of storm generated debris (for category III or greater storms only).

Precipitation Characteristic	Value of Multiplier
None to Light	1.0
Medium to heavy	1.3

Example: A category 4 storm passes through Harrison County Mississippi. The area is primarily single family dwellings with some apartment complexes, schools and shopping centers. Vegetation characteristic is heavy due to the proliferation of residential landscape shrubbery and trees throughout the area. The storm is a very wet storm with rain before and continuing for a few days after the wind pass.

Q = **H** (**C**) (**V**) (**B**) (**S**)

H =**P**/3 = 165,500 / 3 = 55,167 (3 persons/household)

C = 50 (factor for a Category 4 storm)

V = 1.5 (multiplier for heavy vegetation)

B = 1.3 (multiplier for heavy commercial due to schools/stores/apartments)

S = 1.3 (multiplier for wet storm event)

then **Q** = 55,167 (50) (1.5) (1.3) (1.3) = 6,992,374 cy debris or **<u>7 Million CY</u>**

DEBRIS REDUCTION SITE REQUIREMENTS

Current Corps guidance for debris reduction (storage/handling) sites is to estimate stack heights of 10 feet with 50% usage of land area to provide for roads, safety buffers, burn pits, HTW areas etc.

1 acre (ac) = 4,840 sq yd (sy)

10 feet stack height = 3.33 yards

total volume per ac = 4,849 sy/ac (3.33 y) = 16,133 cy/ac

From the example above, the acreage required for debris reduction sites is:

7,000,000 cy / 16,133 cy/ac = 434 acres required for debris storage only, no buffers etc..

To provide for roads, buffers etc. the acreage must be increased by a factor of 2.0.

434 x 2.0 = 868 **acres (Use 860 acres)**

or, since one square mile (sm) = 640 acres

860 acres / 640 ac/sm = 1.34 square miles

If you assume a 100 acre reduction site can be cycled every 45 to 60 days or one time during the recovery period, then, 860 / 2 = 430 acres or **five 100 acre sites would be required**. The number of sites varies with size, distance from source, speed of reduction (mixed debris is slower than clean woody debris) and removal urgency. If existing landfill space is not readily available to start reducing site volumes immediately, additional sites will be required. Public owned property should be considered first, then predesignated leases with land owners as an alternative. Predesignation of sites is critical to expediting initial debris removal operations.

The Corps commonly removes approximately 70% of the total volume generated with local governments, volunteer groups, and private individuals removing the remainder. If 7 million cy is estimated, the Corps could estimate removing approximately 70% or 4.9 million cy.

The debris removed will consist of two broad categories, clean woody and construction and demolition (C&D) debris. The clean debris will come early in the removal process as residents and local governments clear yards and rights of ways. The debris removal mission can be facilitated if debris is segregated as much as possible at the origin. i.e. along the Right of Way, according to type. The public should be informed regarding debris segregation as soon as possible after the storm. The most effective process is to set time periods for removal, i.e. the first 7-10 days clean woody debris only, then followed by all other debris, segregating the metals from the non metals.

Most common hurricane generated debris will consists of the following:

30% Clean woody debris
70% Mixed C&D
of the 70% mixed C&D,

- 42% Burnable but requires sorting
- 5% Soil
- 15% Metals
- 38% Landfilled

Based on the example above, 7,000,000 cy would break down as follows:

2,100,000 cy Clean woody debris
4,900,000 cy Mixed C&D
of the 4,900,000 cy of mixed C&D,

- 2,058,000 cy is Burnable but requires sorting or landfilling
- 245,000 cy of Soil
- 735,000 cy of Metals
- 1,862,000 cy Landfilled

Burning will produce about 95% reduction. Of less environmental concern than burning is the use of chippers and/or tub grinders. The chips/mulch produced has agricultural value as well as being easily converted to pelletized fuel. Chipping and grinding reduces the debris volume on a 1 to 4 ratio (4 cy is reduced to 1 cy) of by 75%. The rate of burning versus chipping/grinding is basically equal, about 200 cy/hr. However chipping requires on-site storage and disposal of the chips/mulch.

Questions pertaining to this model should be directed to the Emergency Management Branch, Mobile District Corps of Engineers, (334) 690-2495.