

Hazard mitigation planning utilizing the HAZUS-MH Flood Model and Hurricane Wind Model

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ABSTRACT

This study uses FEMA's new flood model software, HAZUS-MH (Multi-Hazard), to assess the socioeconomic damages following floods. HAZUS-MH provides dollar figures for land use planners, flood managers, and emergency planners to utilize in their pre- and post-disaster planning of the economical, social, and environmental consequences of flooding. HAZUS-MH estimates financial losses resulting from a 100-year flood by analyzing the potential direct and indirect economic damages that could occur in a local jurisdiction. HAZUS-MH Flood Model and Hurricane Wind Model was used to estimate losses in the Parish of East Baton Rouge, Louisiana, as part of the jurisdiction's hazard mitigation planning process. Depth grid maps and flood loss maps are explained and displayed to show the results of the flood hazard and loss analysis. The article evaluates HAZUS-MH against the criteria of quality, timeliness, and completeness. The different levels of HAZUS-MH are explained within the context of accuracy. The article also explains how geographic information system (GIS) data layers can be made available to public officials by use of a free downloadable GIS data reader.

INTRODUCTION

Causing an average of \$5 billion in damage each year, floods are the most chronic and costly natural hazard in the United States.¹ Despite advances in flood science and progress in the implementation of federal hazard reduction policies, financial damage from flooding continues to escalate.² The Worldwatch

Institute determined that floods are responsible for half of all deaths worldwide from natural disasters. Between 1985 and 1999 economic losses from flooding accounted for roughly 28 percent of total global economic losses.³ Although North America suffered a relatively low percentage, (only 1 percent) of the world's natural disaster-related deaths for this interim, flood

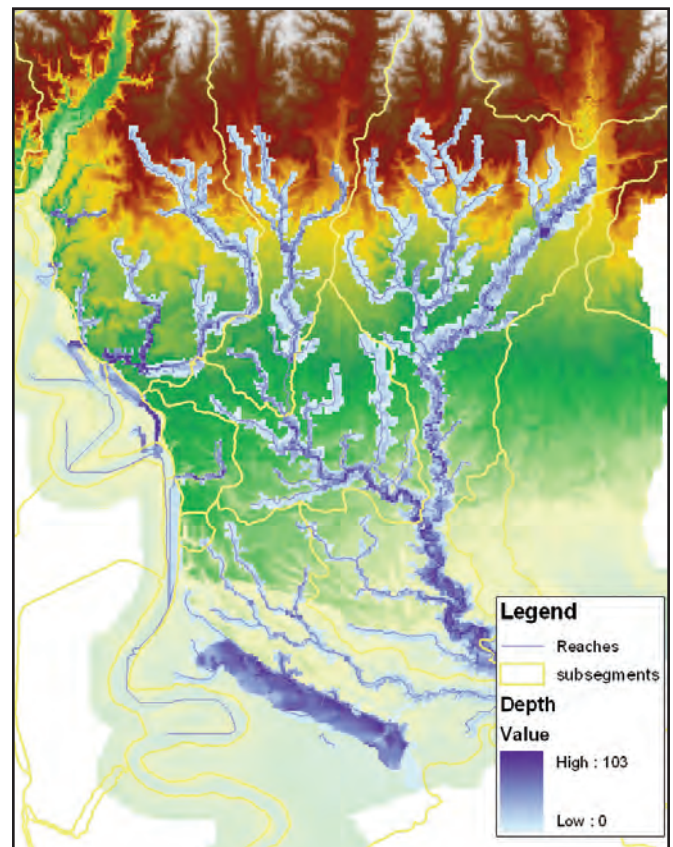


Figure 1: East Baton Rouge Parish with HAZUS-MH flood estimates.

damage amounted to 33 percent of global economic losses from all types of natural disasters. The statistics suggest that reducing losses from floods is a major concern in North America.

Emergency management has utilized hazard maps for some time to clarify the nature and extent of flooding and wind hazards. The Tennessee Valley Authority (TVA) and the US Army Corps of Engineers (USACE) were early leaders in the initiative to characterize the nature of floods and understand their impact. Congress authorized the National Flood Insurance Program in 1968 with the enactment of the National Flood Insurance Act, which was administered by the US Department of Housing and Urban Development (HUD).⁴ Flood insurance rate maps (FIRMs) provide a visible illustration of the geographic extent of flooding. By showing base elevation requirements, FIRMs make further information available on the hazard. The FIRMs, however, do not provide emergency managers with information necessary for estimating the social, economic, or environmental impact of a flood hazard.

In January 2004, FEMA released HAZUS-MH (Multi-Hazard), a new emergency planning and response software package. The HAZUS-MH mapping and modeling software utilizes the power of geographic information systems (GIS) and hazard modeling to estimate associated social and economic losses as well as characterize the nature and extent of flood, wind, and coastal hazards. This paper provides an illustration of how a local community used HAZUS-MH to assess and reduce the direct and indirect social, economic, and environmental losses from flood hazards.

The latest version of HAZUS-MH extends natural hazard modeling from a single focus on earthquake hazards to a multihazard analysis system including earthquake, flood, and wind hazards. HAZUS-MH helps emergency managers to determine the potential damage from inland and coastal flooding, hurricane winds, earthquakes, and chemical hazards.⁵ Local, state, and federal officials can improve community emergency preparedness, response, recovery, and mitigation activities by enhancing the ability to characterize the economic and social consequences from flood, wind, and coastal hazards.⁶

Officials at all levels of government have long recognized the need to more accurately estimate the escalating costs associated with natural hazards.⁴ The Hazard Mitigation Act of 2000 requires that local jurisdictions complete a comprehensive analysis as a part of their hazard mitigation plan in order to qualify for FEMA mitigation funds. HAZUS-MH provides needed tools to estimate the adverse economic impact of a flood, wind, or coastal hazard in a community.

USING HAZUS-MH IN HAZARD MITIGATION PLANNING

The East Baton Rouge Parish Office of Emergency Preparedness contracted with Shaw Environmental & Infrastructure, Inc. (Shaw E & I) to help prepare the hazards mitigation plan for the jurisdiction. Representatives from Shaw E & I, the East Baton Rouge Office of Emergency Management and Homeland Security, Public Works, and the Parish Planning Department formed the hazard mitigation team. After the contractor elected HAZUS-MH as the best tool to estimate flood and wind hazards, the mitigation team asked the Risk Assessment Lab at Louisiana State University to run the flood and wind utilities in HAZUS-MH.

HAZUS-MH was used to characterize the major water features in the jurisdiction. Figure 1 provides a view of the seven major drainage areas in the parish and their 100-year flooding tributaries.

Completing a hydrologic and hydraulic analysis for each of the seven drainage areas was the first step in characterizing flood hazards and losses from flood hazards in Baton Rouge. The output of these analyses was a depth grid reflecting the 100-year flood hazard for each drainage area.

Figures 2 and 3 illustrate the flood modeling outputs in HAZUS-MH. Figure 2 shows a flood depth grid for a 100-year flood hazard. The depth grid reflects the difference between the ground elevation and the height of the floodwater for a 100-year flooding event. Each grid cell represents the depth of the floodwater. Although HAZUS-MH provides specific calculations for the height of the water in the grid cell, the visual display reflects a range of values rather than the specific cell depth values.

Once the depth grid was created, HAZUS-MH calculated damage estimates using the program's damage

estimate capabilities. One product of the analysis is a total damage estimate by occupancy for residential, commercial, industrial, agricultural, religious buildings, education buildings, and government buildings for each of the seven drainage areas. These calculations include damage to buildings and building contents possibly affected by the hazard. A sample damage estimate report for the northwest drainage basin is shown in Figure 3. The damage estimates for both structures and building contents are summed for each of the seven drainage areas for use in the hazard mitigation plan.

HAZUS-MH ANALYSIS

HAZUS-MH Flood Model provides basic and advanced analysis for flood hazards and their impacts. The basic analysis uses USGS Digital Elevation Model (DEM) surface grids and discharge frequency values from either the National Flood Frequency Program or, when available, USGS gauge stations. The advanced analysis uses either USGS DEM surface grids or higher resolution DEMs from Light Detection and Ranging (LIDAR).

Advanced flood modeling in HAZUS-MH utilizes hydraulic analysis from the USGS Hydrologic Engineering Center River Analysis System (HEC-RAS). As required for a basic analysis, users conducting an advanced analysis must identify a flood study area and obtain a USGS DEM for the area. A USGS Web site link within HAZUS-MH provides the pathway to a USGS mosaic of 30-meter DEMs and 10-meter quads specific to the study area. The mosaic is in a GRID file format and reflects the surface elevations throughout the study region.

Outputs from the advanced analysis using HEC-RAS are the same as the basic analysis; the depth grid, however, is determined from an engineering hydraulic analysis rather than the general statistical discharge estimates reflected in the National Flood Frequency Program (NNF) or values from the USGS HEC-RAS. Depth is determined for a specific flooding event by comparing the flood elevation along a water feature with the land surface elevations as denoted in the GRID file. Flood elevations for specific cross sections of the water feature are determined using HEC-RAS.

The initial input into the East Baton Rouge Hazard Mitigation Program was a HAZUS-MH basic

flood analysis. This type of general analysis renders a foundation for an assessment of the nature and extent of flooding in a study area. The damage calculations reflected in the basic flood analysis help form a general comparison among regions in the study area. Because the parish was divided into seven major drainage areas, the estimated losses to structures and their contents may be compared among drainage areas. This analysis establishes a baseline for prioritizing future analyses using the advanced features of HAZUS-MH and HEC-RAS. East Baton Rouge Parish anticipates utilizing advanced flood analysis capabilities of HAZUS-MH by incorporating previous HEC-RAS into the program. Time constraints are a limiting factor because setting up each HEC-RAS study area requires geo-referencing the cross sections of peak water elevations.

GIS OUTPUTS TO HAZUS-MH USERS

It is important that many local offices and units understand the nature and extent of flooding and wind hazards. ArcGIS increases understanding by providing a tool to share map layers to anyone interested in viewing the HAZUS-MH study results. Having the capability to share many mapping layers from HAZUS-MH allows others associated with hazard mitigation to examine the risks and view the estimated losses such as flood depth grids, DEMs, high-resolution photos, streets, water features, critical infrastructures (schools, shelters, bridges, and government buildings), and political boundaries. Figure 4 provides an example of the format of the ArcReader mapping program.

Critical map layers from HAZUS-MH are saved using ArcGIS Map Publisher and are opened in ArcReader. The data layers are then ready to be viewed by local officials (e.g., public works officials, engineering, public safety, fire, police and emergency medical, planning, city management, elected officials, and members of the public). The ability to use the ArcReader software to share HAZUS-MH GIS layers with many local departments is an essential component for the preparation of a local hazard mitigation plan. Figure 4 shows a sample screen in ArcReader with the East Baton Rouge HAZUS-MH layers.

USING HAZUS-MH FOR RISK ASSESSMENT

FEMA developed HAZUS-MH as a tool to examine the vulnerability of local communities to hazards. The model mapping program was evaluated by examining the quality, timeliness, and completeness characteristics. Using these criteria provides a framework to evaluate the use of HAZUS-MH in examining the vulnerability of a local community.

ASSESSMENT OF THE MODEL

The HAZUS-MH documentation states that a Level 1 basic analysis is a generalization of the flood hazard in a local jurisdiction. The hydraulic analysis is not specific to each part of the study area but is derived from the NFF. USGS regression equations and gauge records are used to determine discharge frequency curves. The depth grid, which is the output from the HAZUS-MH basic flood analysis, is a much more detailed illustration of flood range depths than what is viewed on a FIRM. Level 1 analysis is the simplest type of analysis requiring minimum input by the user. However, the flood estimates are crude and are only appropriate for initial loss estimates to determine where more detailed analyses are warranted. Some refer to this type of analysis as screening. Further studies using the HAZUS-MH advanced analysis is required for specific decision making at the local level.

The results from HAZUS-MH are formatted for decision makers in several forms. The reports generated by HAZUS-MH are explicit and easy to read. However, the user is required to complete the hydraulic analysis on major water features in the study area and then calculate the economic losses for each of these water features. Researchers found this stipulation to be problematic in capturing all of East Baton Rouge Parish at one time because they had to run hydraulic analysis for each study region. Additionally, researchers were unable to generate one damage assessment report of the entire study region for use in the hazard mitigation plan. Despite this one limitation, the researchers found that the program did present information in an orderly arrangement and in a form that assists the decision maker in hazard mitigation.

Concerning the question of information overload, the researchers observed that HAZUS-MH provides the user with extensive outputs relating to economic

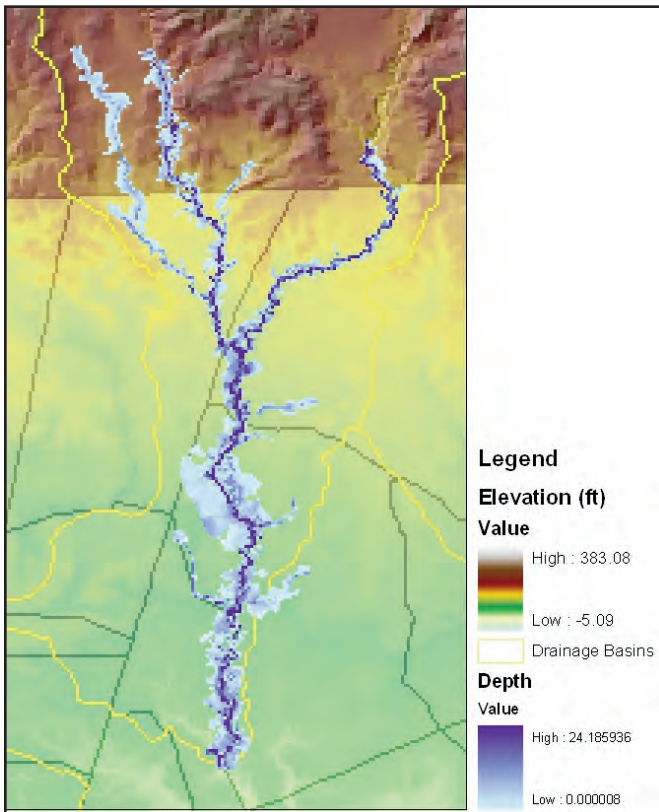


Figure 2. Comite drainage boundary for a 100-year flood.

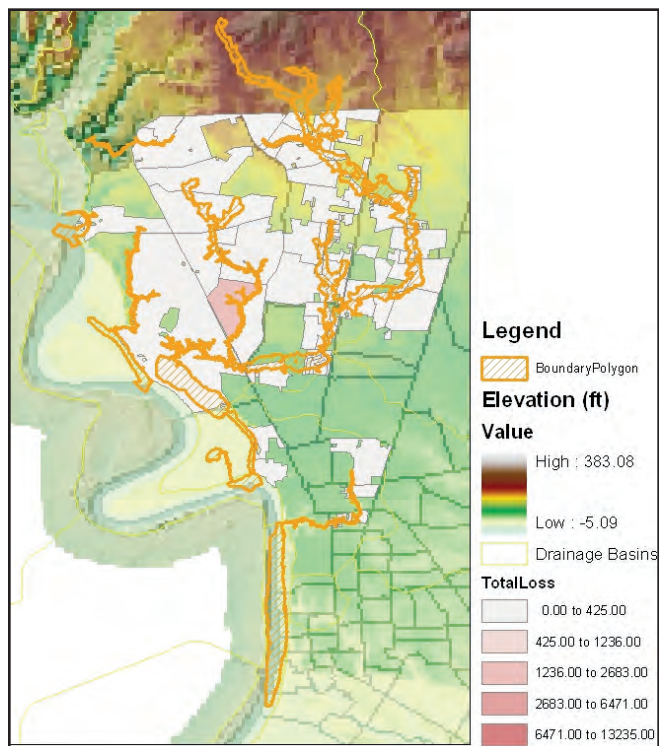


Figure 3. Northwest drainage boundary total economic loss for pre-FIRM and post-FIRM residential dwellings.

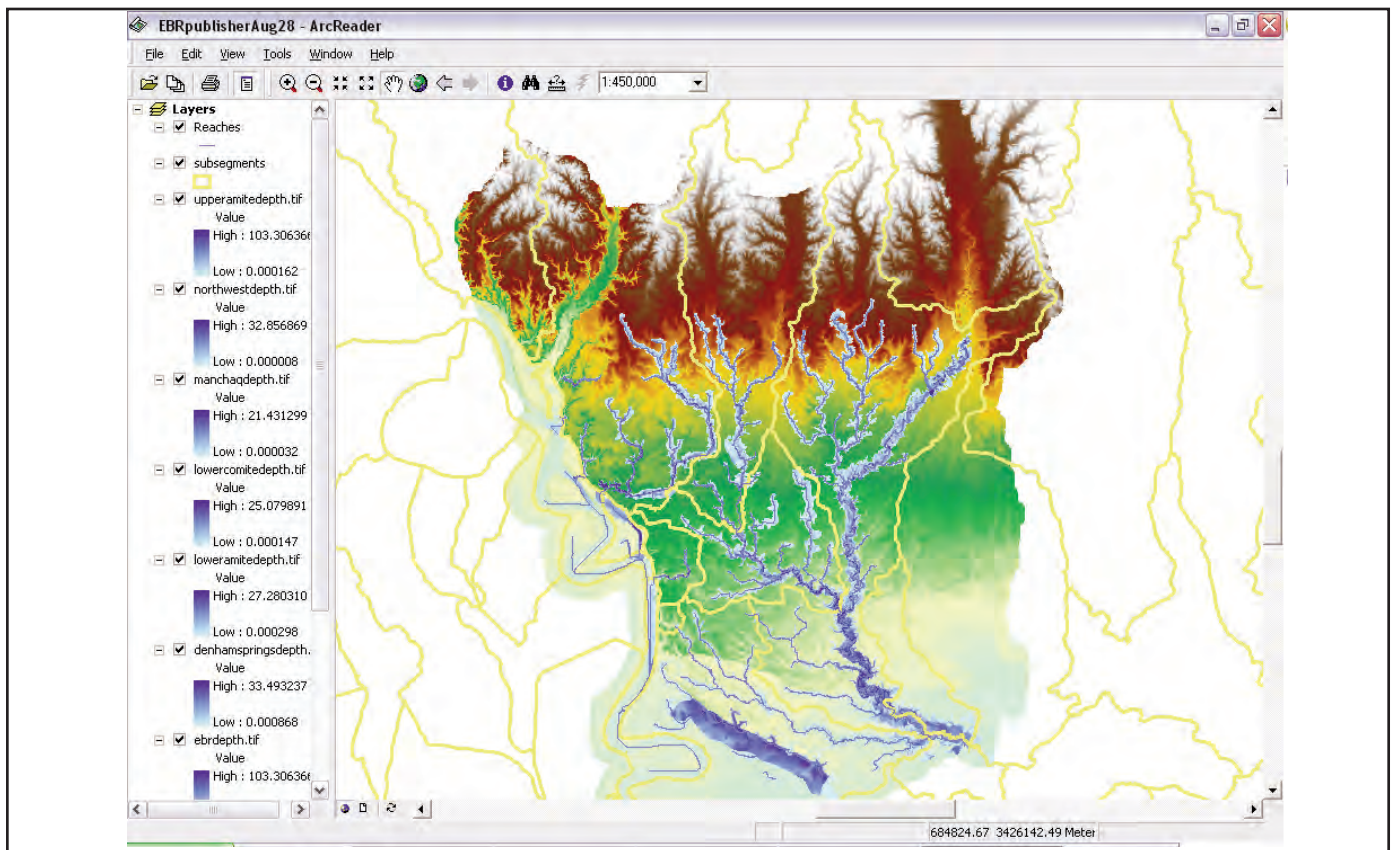


Figure 4. East Baton Rouge Parish flood layers in ArcReader format.

losses. It is possible to get lost in the details; however, the hazard mitigation team was very specific in defining the type of information needed in their plan. The researchers determined that the additional data in HAZUS-MH is useful when local officials need to make decisions as to which houses might be identified for a buyout or other costly public works projects.

TIMELINESS

The timeliness criterion is sensitive to concerns that many day-to-day decisions are time sensitive. Decisions on how to respond to situations must be made quickly. Timely information has several components: 1) Is the information provided when it is needed for decision making? 2) Is the information from the model updated as needed? 3) When conditions change (for example, does more concrete in the drainage basin displace more water?) is information provided as often as needed or at an appropriate frequency?

As noted earlier, the HAZUS-MH basic analysis

is general. Timeliness is not always evident in the flood hazard analysis and flood loss estimation. Hazards analysis uses data that reflect the USGS National Flood Frequency Program (NFF), which is based on over 10 years of flood data and is not sensitive to recent rain events. An advanced analysis is more localized and requires the user to adapt building inventory data to ensure that the flood loss estimate is based on current building characteristics, which reflect the value of the structures and their contents. This study used a basic analysis. Local data might not reflect changes since the 2000 Census.

COMPLETENESS

The results of the model must be complete to be of value to decision makers, which raises several questions. Is the scope of the information sufficient to allow the decision maker to make an accurate assessment of the situation and to arrive at a suitable decision? Does the decision maker have access not only to

current information but also to past history? Are the results of the model presented to the decision maker in a concise form but with sufficient detail to provide the decision maker with enough depth and breadth for the current situation? Is sufficient relevant information provided to the decision maker without information overload?

The hazard mitigation study prepared for the local jurisdiction reflects all hazards for the area. The basic analysis provided by HAZUS-MH gave sufficient information to allow decision makers to make an accurate assessment of the risks in their jurisdiction. An advanced analysis using hydraulic modeling results, such as HEC-RAS, provides more accurate data for decision makers. This takes considerable time and is not possible for most jurisdictions in the United States. However, the local jurisdiction can set a goal to obtain the detailed hydraulic analysis for their area and input the data into HAZUS-MH.

A balance between conciseness and detail appear to be provided in HAZUS-MH. As noted earlier, reports generated by the basic analysis can be structured to provide general losses to the jurisdiction. More detailed information can be obtained with limited effort.

CONCLUSION

HAZUS-MH provides local government jurisdictions with an exceptional tool in the hazard mitigation process. The ease of use and the quality of the data provided with the program enable the user to generate information on where to expect losses in the community and considerable information on the nature of these losses. Difficulties in using HAZUS-MH can be overcome as local officials become more skilled in utilizing the power of ArcGIS and the riverine hazard model. Training scenarios can be prepared to help users anticipate common problems in using the riverine program. Feedback to FEMA on difficulties in using the program will also result in system changes.

One of the biggest concerns by local users is the quality of the data in HAZUS-MH from the flood frequency values in a geographic area, particularly concerning building counts and their characteristics. Studies to demonstrate the validity of building counts and the economic values associated with the structures will help

assure local officials of the validity of the data. For jurisdictions where major population shifts have not occurred since 2000, local officials can be more confident in the economic loss analysis provided by HAZUS-MH.

FEMA has created a powerful tool for the assessment of flood losses. The tool allows the user to execute a local analysis in a reasonable period of time and estimate losses to the jurisdiction. It provides a basis for examining the economic impact of flooding and using loss estimates in establishing hazard mitigation priorities at the local level. By allowing users to establish a four-county study area, the program facilitates a broader examination of hazard mitigation. Counties can work together to examine flood risks and concentrate more detailed hydraulic advanced analysis in HAZUS-MH to specific areas. As the program gains broad use, local jurisdictions will find help and overcome many technical problems that users are encountering today. HAZUS-MH is a powerful hazard mitigation tool that makes a significant contribution in informing local decision makers concerning the impact of flood hazards in their community.

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