Large Scale Automated Engineering (LSAE)
Overview, Uses, and Benefits
Hydrology
Hydraulics
Risk Map Products
Requirements for Model Upgrades
Validation and Risk Assessment
Overview, Uses, and Benefits
Riverine Study Types

- Large Scale Automated Engineering (LSAE)
- Approximate Studies (Zone A)
- Detailed Studies (Zone AE)

Regulatory
Study Types

Detailed (Zone AE)
- Typically be the most expensive to perform
- Provide the most information about flood hazards, establishes base flood elevations, special and moderate flood hazard areas, and floodways where appropriate
- Structure geometry will be sourced from as-builts, design plans, or measured in the field

Approximate (Zone A)
- Yields approximate floodplains to be used in regulatory maps
- May or may not include structures. Structure data from national or state sources, or estimated based on topography and aerial photos
Study Types

**LSAE**

- Uses highly automated processes to rapidly build, run, and map the results from engineering models – typically performed over large areas
- Also called First Order Approximation (FOA) or Base Level Engineering (BLE)
LSAE Uses and Benefits

- Modeling previously unmapped areas
- Determining effective Zone A floodplain credibility (CNMS validations)
LSAE Uses and Benefits

Availability to efficiently upgrade to a regulatory study
Island hit by two hurricanes - widespread flooding, potential dam failures, island-wide power outage.

BLE modeling used for rapid response to determine where to focus relief efforts and potential areas that are at risk for rebuilding efforts.

Now that we have base models, it will be easier for future flood analysis to be performed in Puerto Rico.
2 Hydrology
Hydrologic Data Development

**Initial Tasks**

- Research the effective regression equations, regression equation inputs (drainage area, precipitation, slope, etc), National Resources Conservation Service (NRCS) structures, other large dams not included in the NRCS database
- If large dams are present, obtain historic flow data
- Download and process HUC8-wide DEM
- Research populated areas in watershed
- Download and process NHD high-resolution flow lines
Developing Gridded Hydrologic Data

Flow Accumulation Grid
• Burn NHD stream lines into DEM
• Create dam features
• Fill in sinks
• Create flow direction grid
• Create flow accumulation grid
• Convert flow accumulation to appropriate units
Developing Gridded Hydrologic Data

**Basin Average Precipitation Grid**
- Obtain gridded mean annual precipitation data from PRISM
- Run basin average script in RFD

**Main Channel Slope Grid**
- Run main channel slope script in RFD on the NHD stream lines
Creating Flow Grids

- Once all regression equation parameter grids have been computed, use the “Raster Calculator” tool in ArcMap

- EX:

\[ Q_{0.2\%} = 126(\text{CONTDA}^{0.64})(\text{PRECIP}^{0.64})(\text{CSL10_85f}^{0.19}) \]
3 Hydraulics
Rapid Floodplain Delineation (RFD) is software that automates many aspects of floodplain modeling and delineation:

- Can automatically generate cross-sections, perform backwater calculations, and delineate floodplains in a single step.
- RFD is run from the command-line and all the required options are specified in a text file.
Hydraulic Data Development

- Generate scoped streams
- Redelineate all scoped streams to the DEM
- Develop Manning's n raster – created from NLCD data
- Combine all data into a “masterstream” shapefile
- Run batch processor in RFD to create initial floodplains and HEC-RAS models
Model with Updates Added
Finalized Model
LSAE Floodplains vs Effective Floodplains

*Slide contains restricted data*
Special Issues & Model Limitations

- Hydraulic structures
  - Culverts
  - Bridges
  - Dams
- Split flow, channel loss, 2D flow
- Ineffective areas
- Bank stations located at cross-section end points
  - Thalweg location and/or elevation not contained within the channel
  - Single Manning n value for each cross-section
4 Risk Map Products
Floodplains
Water Surface Elevation Grids
Depth Grids
5 Requirements for Model Upgrades
Upgrading to Zone A

Requirements
• Add bank stations
• Define channel and overbank Manning’s n values
• Calculate overbank flow lengths
• Add elevations to ineffective areas and modify ineffective stationing where appropriate
• Combine all recurrence intervals into one HEC-RAS model
• Address any special case scenarios called out in initial LSAE modeling
6 Validation and Risk Assessment
Coordinated Needs Management Strategy (CNMS)

Overview

- Assesses validity of current study using physical environment, climate patterns, and engineering (PCE) factors.
- “Living” Database
  - Continuous new input and assessment
  - “Valid” studies and reassessed every five years
- Frequently assess streams to maintain accurate FEMA stream inventory
Examples of Checks

- C1/C2 – checks for major changes in gage record on AE streams
- C5 – identifies instances of the AE stream channel going outside SFHA
- C6 – identifies addition or removal of structures on AE streams
- S6 – is new topographic data (LiDAR) available?
- S7 – changes in land use
- S8 – changes in imperviousness

There are many more checks, these are just examples!
Base Level Engineering

- Floodplains for BLE projects are required to be evaluated in CNMS through the same checks as a regular study, with exception of the A5 check.
- A5 Check
  - Determines if the BLE study is still ‘Valid’ based on comparison to the effective floodplains.
  - Performed by comparing the effective floodplain to the BLE 1pct plus and 1pct minus floodplains to confirm it is within tolerance.
CNMS

Base Level Engineering
• A5 Check Overview

Legend
- BLE 1pct Minus
- Effective 1pct
- BLE 1pct Plus
**Base Level Engineering**

- A5 Check Process
  - Obtain effective Zone A floodplains for streams within the watershed
  - Group polygons were drawn around each stream to be scored separately.
Base Level Engineering

- A5 Check Process
- Points are generated every 200 feet along the effective floodplains
Base Level Engineering

• A5 Check Process
  • Automated check is performed to determine if the effective floodplain is valid at each point based on the vertical and horizontal offsets from the 1%+ and the 1%- floodplains.
  • A percentage passing is computed by averaging the score of each point in the Group Zone.
Base Level Engineering

- A5 Check Process
  - Obtain dataset of risk class areas. Population density and anticipated growth are taken into account for an area.
  - Streams are determined to be passing based on the Risk Class area they fall in.

<table>
<thead>
<tr>
<th>Risk Class</th>
<th>Characteristics</th>
<th>Minimum Passing Percent for A-5 Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>High population and densities in the floodplain and/or large amount of anticipated growth</td>
<td>95%</td>
</tr>
<tr>
<td>B</td>
<td>Medium population and densities in the floodplain and/or modest anticipated growth</td>
<td>90%</td>
</tr>
<tr>
<td>C</td>
<td>Low population and densities in the floodplain and little or no anticipated growth</td>
<td>85%</td>
</tr>
</tbody>
</table>
Hazus

Overview

• Hazus is a series of models/GIS tools that are used to estimate potential physical, economic, and social impacts of natural disasters.

• Hazus analysis is run as part of the Risk Map Products to produce a loss analysis to serve as a baseline estimate.
Hazus

Overview
• Hazus is a free program that was created by FEMA to help approximate losses during natural disasters.
  • Census Data vs. User Inputted Data
    • Essential Facilities
Example

- Lower Cimarron Watershed - Exposure (in thousands of dollars)

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>Exposure ($1000)</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>7,953,308</td>
<td>82.5%</td>
</tr>
<tr>
<td>Commercial</td>
<td>918,788</td>
<td>9.5%</td>
</tr>
<tr>
<td>Industrial</td>
<td>234,158</td>
<td>2.4%</td>
</tr>
<tr>
<td>Agricultural</td>
<td>36,773</td>
<td>0.4%</td>
</tr>
<tr>
<td>Religion</td>
<td>148,420</td>
<td>1.5%</td>
</tr>
<tr>
<td>Government</td>
<td>57,890</td>
<td>0.6%</td>
</tr>
<tr>
<td>Education</td>
<td>294,250</td>
<td>3.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9,643,587</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>
### Example

- Lower Cimarron Watershed - Damage Estimates

#### Table 3: Expected Building Damage by Occupancy

<table>
<thead>
<tr>
<th>Occupancy</th>
<th>1-10</th>
<th>11-20</th>
<th>21-30</th>
<th>31-40</th>
<th>41-50</th>
<th>Substantially</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>(%)</td>
<td>Count</td>
<td>(%)</td>
<td>Count</td>
<td>(%)</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Commercial</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Education</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Government</td>
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<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Industrial</td>
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<td>0</td>
<td>0.00</td>
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<tr>
<td>Religion</td>
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<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Residential</td>
<td>86</td>
<td>17.30</td>
<td>158</td>
<td>31.79</td>
<td>60</td>
<td>12.07</td>
</tr>
</tbody>
</table>

| Total       | 86    | 158   | 60    | 47    | 41    | 105           | 21.13          |
Example

- Lower Cimarron Watershed – Essential Facilities

### Table 5: Expected Damage to Essential Facilities

<table>
<thead>
<tr>
<th>Classification</th>
<th>Total</th>
<th>At Least Moderate</th>
<th>At Least Substantial</th>
<th>Loss of Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Stations</td>
<td>26</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hospitals</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Police Stations</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Schools</td>
<td>69</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Hazus Example

- Debris Example

Debris Generation

Hazus estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

Debris Breakdown (tons)

The model estimates that a total of 10,229 tons of debris will be generated. Of the total amount, Finishes comprises 42% of the total, Structure comprises 27% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 409 truckloads (85 tons/truck) to remove the debris generated by the flood.
Questions?

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