FLOOD MAP ACCURACY

Statement of

David R. Maidment, Ph.D.
Director, Center for Research in Water Resources
Hussein M. Alharthy Centennial Chair in Civil Engineering
The University of Texas at Austin

and

Chair, Committee on Floodplain Mapping Technologies
and Chair, Committee on FEMA Flood Maps
National Research Council
The National Academies

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Good afternoon Chairwoman Landrieu, Chairman Pryor, and members of the Subcommittees.

My name is David Maidment and I am the Director of the Center for Research in Water Resources and the Hussein M. Alharthy Centennial Chair in Civil Engineering at The University of Texas at Austin. I understand that the purpose of this hearing is to evaluate preparedness and mitigation efforts among flood-prone communities and responsible federal agencies, by evaluating the accuracy of the FEMA flood map modernization process, mechanisms for dispute resolution, and the impact of levee inspections and certifications on determinations of flood risk. My testimony addresses the first of these questions, the accuracy of the FEMA map modernization process. Thank you for the opportunity to testify today.

I initiated the National Research Council's involvement in reviewing FEMA flood map modernization through its Mapping Sciences Committee, and I served as Chairman of the National Research Council's Committees on Floodplain Mapping Technologies (NRC, 2007) and FEMA Flood Maps (NRC, 2009). The National Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine of the National Academies, chartered by Congress in 1863 to advise the government on matters of science and technology.

FEMA has undertaken an ambitious program to provide the nation with coverage of Digital Flood Insurance Rate Maps (DFIRMs). The first phase of this program, called Flood Map Modernization, operated from 2003 to 2008, and a subsequent phase, called Risk Mapping Assessment and Planning (Risk MAP) is now in operation (FEMA, 2009). The Committees that I chaired assessed flood mapping practices during the Flood Map Modernization period. The main focus of our reports was on riverine rather than coastal flood mapping, and today I will confine my comments to the physical aspects of riverine flood mapping.

Committee on Floodplain Mapping Technologies – Elevation for the Nation (NRC, 2007)

During the annual appropriations hearings for Flood Map Modernization, concerns were expressed to Congress that the underlying framework data used as input to the flood mapping process were not of adequate quality in much of the nation to properly support the new digital flood map creation. The National Academies established a Committee on Floodplain Mapping Technologies to examine this issue (NRC, 2007). The underlying framework data consist of two components: firstly, land surface reference information that describes streams, roads, buildings and administrative boundaries that show the background for mapping the flood hazard zone, and secondly, land surface elevation which defines the topography or shape of the land surface. The Committee concluded that the nation's base mapping for land surface reference information is derived from regularly updated earth imagery, and is adequate to support floodplain mapping.

The insurance industry uses floodplain maps to determine if purchasers of new buildings need to have federal flood insurance. This determination is made on the basis of a horizontal criterion: does the building lie within or outside the floodplain? The current DFIRMs adequately support this flood insurance process. If a property owner whose building is classified as being within the floodplain wishes to protest that determination, a laborious and expensive procedure is undertaken, for both the owner and the government, to process a Letter of Map Amendment (LOMA).

An important component of flood maps is the base flood elevation, which is the water surface elevation that would result from a flood having a 1% chance of being equaled or exceeded in any year at the mapped location. Local communities regulating land development typically require the first floor elevation of buildings to be at or above the BFE. This criterion, based on vertical rather than horizontal criteria, is better than that used in flood insurance determinations. Base flood elevations are only shown on floodplain maps that have been prepared with high quality land surface elevation information and detailed or limited detailed flood modeling studies.

As of June 2005, approximately 1 million stream miles had been mapped under Flood Map Modernization, and of this total, one-quarter (247,000 miles) show the base flood elevation as well as the spatial extent of the floodplain, while three-quarters (or 745,000 stream miles) show only the spatial extent of the floodplain but not the base flood elevation. The Committee concluded that in order to adequately support the National Flood Insurance Program, updated floodplain maps should show the base flood elevation as well as the spatial extent of the floodplain boundary.

FEMA Map Modernization requires elevation data for floodplain mapping to represent the current conditions in the area, or to be supplemented with updated information. The current National Elevation Dataset is derived from contour information in USGS 1:24,000 scale topographic maps, which were made over a long period and have an average date of 1970. In other words the land surface topography depicted in them is, on average, 40 years old. For flood mapping, FEMA requires elevation data of 2-foot equivalent contour accuracy in flat areas, and 4-feet equivalent contour accuracy in rolling or hill areas. These standards correspond to root mean square errors of 0.61 to 1.22 ft, respectively. The existing National Elevation Dataset has a root mean square error of 7.68 feet. Thus, FEMA floodplain mapping standards call for elevation data that is approximately 10 times more accurate than the National Elevation Dataset. This means that the existing National Elevation Dataset, and the topographic contour information upon which it is based, are too old and inaccurate to support Flood Map Modernization, except where new high-accuracy elevation data are added from state and local sources. The Committee did not believe that ad-hoc data collection by state and local sources will create consistent elevation data of the required accuracy to fully support floodplain mapping over the nation.

The Committee concluded that a new national digital elevation data collection program is required, and called this program *Elevation for the Nation*. The Committee recommended that *Elevation for the Nation* should employ lidar as the primary technology for digital elevation data acquisition. Lidar operates by projecting short laser pulses of light from an aircraft or land-based sensor and measuring the time taken for these pulses to return to the sensor. This results in a dense cloud of measured points, some of which define the land surface while others bounce off vegetation and trees. With appropriate processing, 1-foot to 2-foot equivalent contour accuracy can be achieved in final bare-earth elevation data. This level of accuracy meets or exceeds FEMA elevation criteria for floodplain mapping in all areas. The data arising from *Elevation for the Nation* will have many beneficial uses beyond floodplain mapping and management.

Committee on FEMA Flood Maps – Mapping the Zone (NRC, 2009)

Following completion of the *Elevation for the Nation* study, FEMA and NOAA requested that the National Academies conduct a further study on flood map accuracy, and the Committee on FEMA Flood Maps was formed to address this task. This Committee addressed several subjects but I will confine my remarks to the accuracy of riverine flood mapping. Key components of the uncertainty of flood mapping are the uncertainty in hydrology (how large is the flood flow?), hydraulics (how deep is the flood water?) and topography (what is the elevation and shape of the land surface?) In collaboration with the North Carolina Floodplain Mapping Program, the Committee carried out detailed case studies to compare the hydrologic, hydraulic and topographic uncertainties in three physiographically distinct areas: mountainous Western North Carolina (city of Asheville), rolling hills in the Piedmont Region (City of Charlotte and Mecklenburg County), and in the very flat coastal plain (Pasquotank and Hertford Counties).

The Committee concluded that the largest effect by far on the accuracy of the base flood elevation is the accuracy of the topographic data. A comparison of lidar data and the National Elevation Dataset around three North Carolina streams revealed random and sometimes systematic differences in ground elevation of about 12 feet, which significantly affects predictions of the extent of flooding. These large differences exceed FEMA's stated error tolerances for terrain data by an order of magnitude. In two of the study areas, random errors in topographic data produce inaccuracies in floodplain boundaries, but do not significantly alter the total area of the floodplain. In the other study area, in addition to random errors, there is a large systematic difference between the lidar and National Elevation Dataset data that results from a misalignment of the stream location between the base map planimetric information and the topographic data. As a result, the total areas of the floodplains defined from lidar and from the National Elevation Dataset differ by 20 percent. Because the nation's capacity to acquire earth imagery is improving faster than its capacity to acquire elevation data, the misalignment problem between imagery and elevation data is growing more acute.

FEMA is moving from simply portraying flood hazard and flood insurance rate zones on maps to communicating and assessing risk, an ambitious goal that leverages the digital flood-related information and maps produced during the Map Modernization Program. Maps that show only floodplain boundaries have the disadvantage of implying that every building in a designated flood zone may flood and that every building outside the zone is safe. Providing floodplain residents with the elevation of structures relative to the expected height of a number of floods offers a better way to define graduated risk (from low risk to high risk). Where the necessary data are available (e.g., structure elevation, base flood elevations, flood protection structure performance), a geographic information system could be used to personalize flood risk to individual addresses.

The case studies of floodplain mapping in North Carolina done by the Committee on FEMA Flood Maps showed that the best determinant of an accurate base flood elevation is an accurate land surface elevation beneath it. These case studies confirmed the general conclusion that had been drawn by the earlier Committee on Floodplain Mapping Technologies that the nation's land surface elevation data is inadequate to support floodplain mapping and improved elevation data collection is needed.

Concluding Comments

Some significant developments have occurred since the two National Research Council reports were published. I am presenting now my own opinions and assessments of these developments.

As the Risk MAP program develops, there has been a significant policy shift by FEMA to emphasize collection of better land surface elevation information as a precursor to further floodplain mapping activities. The resulting flood maps will be more accurate, and should support both the definition of the base flood elevation and the floodplain boundary.

I understand that the U.S. Geological Survey is working to facilitate an improved National Elevation Dataset over the next four years that will involve extensive cooperation among various stakeholders, including other Federal agencies, and that the Department of Homeland Security is working on a related plan for improved elevation information. I hope that these agencies will inform you more fully about these plans. I believe these efforts are commendable and, if implemented, will help improve flood map accuracy across the nation.

References

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David R. Maidment is Director of the Center for Research in Water Resources and the Hussein M. Alharthy Centennial Chair in Civil Engineering at The University of Texas at Austin, where he has been on the faculty since 1981. Dr Maidment is a specialist in surface water hydrology, and in particular in the application of geographic information systems to hydrology. He is co-author of the text *Applied Hydrology*, Editor-in-Chief of the *Handbook of Hydrology*, and leader of the CUAHSI (Consortium of Universities for the Advancement of Hydrologic Science, Inc) project on Hydrologic Information Systems. Dr Maidment has received many professional awards, and in 2010 the American Water Resources Association's award in this field was renamed the *David R. Maidment Award for Water Resources Data and Information Systems* in his honor.