ASFPM Foundation's 5th Gilbert F. White Flood Policy Forum

# *"Climate-Informed Science and Flood Risk Management: Opportunities and Challenges*

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**George Washington University**

**Following is a collection of background reading papers from the invited participants that focus on three categories: Policy and Budget, Practitioner Implementation and Research.**

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## Reducing Flood Risk by Use of Better Hydrologic and Hydraulic Data and Methods

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### Introduction

President Barack Obama on Jan. 30, 2015, signed an Executive Order establishing a Federal Flood Risk Management Standard. The EO was an update and expansion of EO 11988 Floodplain Management with specific focus on community resilience in full consideration of adapting to a changing climate. Specifically the order directed federal agencies that are performing or funding an action in the flood hazard management with specific focus on community resilience in full consideration of adapting to a changing climate. It is contemplated that the flood hazard area be identified using an approach consistent with the following: "…the elevation and flood hazard area that result from using a climate-informed science approach that uses the best-available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science…." As an alternative the EO also allows for using either the 500-year standard or the 100-year standard that includes 2 feet of freeboard for standard federal actions or 3 feet of freeboard for federal "critical actions." The above stated goals and objectives involve use of engineering and mathematical analyses that will leverage the analyses conducted in the original design approach. Retrofit will likely be a key approach to accommodating changes in floodplain risk and impacts to existing flood control elements, particularly storage facilities and levees. Consequently, there may be significant cost savings and flood risk reduction by increased accuracy in the computations used in the engineering analyses. With a large portion of the flood control protection system being built using prior standards and analyses procedures, the ability to enhance existing systems by better use of computational methods and techniques may prove to be a significant flood risk reduction approach in itself. Extending the engineering and mathematical curriculum to include more computational and mathematical engineering techniques may be a worthwhile investment towards addressing the changes caused by the selected climate-informed science approach that uses the best-available, actionable hydrologic and hydraulic data and methods.

### Discussion

In the last decade, new advances have been made in computational and mathematical methods in hydrology, hydraulics and related engineering works. For example, the U.S. Army Corps of Engineers has recently released a two-dimensional unsteady flow computer program extension of their well-known computer program HEC-RAS. This enhanced computer program enables the detailed analysis of steady and unsteady flow characteristics in small and large scale two-dimensional floodplain problems. Three-dimensional computer programs, commonly known as Computational Fluid Dynamics or "CFD" computer programs, are also becoming used more frequently as the computational costs decrease with advancements in inexpensive computer power. Generally, the CFD applications can be found in rapidly varied flow effect modeling such as spillways, dam breach analysis, turbulent flow situations and other highly computational problem simulations. These computational advances enable a significant increase in computational accuracy and the simulation of complex effects that were typically not considered in the original engineering design. Rather, more conservative designs were often adopted as a reasonable and safe engineering solution to flood risk problems. But with retrofit situations likely to become more of concern, the conservativeness built into the prior engineering designs may find additional use in providing increased flood risk reduction, assessed by more accurate mathematical computations and analyses made possible by use of the improved computational methods.

In order to better distribute such increased computational and mathematical methods to the practicing engineering and planning community, there is a need to enhance the inclusion of computational and mathematical engineering methods in the university curriculum. Although most civil engineering programs include at least one-dimensional hydrologic and hydraulic analysis tools in their curriculums, there may be a new need to augment such courses to include two- and three-dimensional computer computational methods such as CFD and two-dimensional HEC-RAS, among other computational tools. Also needed are courses detailing the more complex mathematics utilized in such enhanced computational tools.

A review of the university curriculums indicates programs of computational and mathematical engineering exist, but such programs of study are not yet commonplace throughout the nation. There are "themes" such as "computational geosciences" that typically involve several courses of more advanced mathematical areas of study that transcend the typical level of mathematical study for many engineering programs. Again, such inclusion of more advanced mathematical coursework is not commonplace.

**Recommendation**
It is our recommendation that engineering curriculums be reviewed in light of the available computational and mathematical tools and knowledge base, and that focus be made, if possible, in enhancing such curriculums to address world level problems such as the climate change impacts. For example, at the Department of Civil and Mechanical Engineering at the United States Military Academy at West Point, New York, an infrastructure engineering course is as much about "policy" as it is about "technical engineering." As such, university curriculums that may consider adding such a course may consider trying to include other departments such that an inter-disciplinary learning environment can better develop. At West Point, there has been good success with the infrastructure engineering course, including non-engineering majors, especially in the area of policy discussions. Other possible programs of study may include mathematical techniques for modeling and simulation as well as methods for organizing, exploring, visualizing and analyzing very large data sets. This new curriculum leverages the power of computation in addressing the most important challenges in engineering.

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