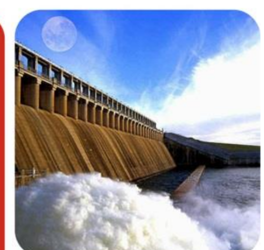
Submitted by
Abt Associates Inc.
4550 Montgomery Avenue
Suite 800 North
Bethesda, MD 20814

Contract W912HQ-10-D-0005

Inter-Agency Flood Risk Characterization Workshop: Summary Report



Submitted to
Jeff Jensen
U.S. Army Corps of Engineers
Institute for Water Resources

May 13, 2014

Inter-Agency Flood Risk Characterization Workshop: Summary Report

Table of Contents

1. Overview

On February 25-27, 2014, the Institute for Water Resources (IWR) hosted an inter-agency workshop focused on the feasibility and value of developing a comprehensive national flood risk characterization. The workshop included over 30 participants from the U.S. Army Corps of Engineers (USACE), the Federal Emergency Management Agency (FEMA), the Environmental Protection Agency (EPA), the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), the Department of the Interior, and the Department of Housing and Urban Development (see Appendix 3 for a list of attendees). This report provides a summary of the workshop and documents some of the key outcomes that may guide follow-up activities by USACE and possibly other agencies.

The purpose of the workshop was to gather federal agency participants to explore approaches being used to characterize existing and future flood risk, with emphasis on use at the national and regional levels as opposed to community and project levels. Presentations and discussions were meant to examine what existing approaches are able to tell us about national flood risk and what they are not able to tell us, and to explore how these approaches can be leveraged or extended for national flood risk characterization that can be used for multiple purposes. Finally, the workshop included discussions about each agency's perspectives, interests, and concerns so that they can be taken into account in any further development of flood risk characterization approaches. The workshop agenda is provided in Appendix 1 and a workshop planning document is provided Appendix 2. Other workshop materials, including the reading materials shared with participants in advance of the workshop and slide presentations, are presented in the appendices.

USACE will use the discussions from the workshop to inform its further work on flood risk characterization and potential development of a risk classification system, recognizing that flood risk reduction and residual risk management is a partnership effort.

USACE workshop organizers consulted an interagency steering committee in designing the workshop around the following goals and driving questions.

Workshop Goals:

- Assess the potential benefits and uses of national flood risk characterization approaches
- Evaluate existing approaches, noting their supporting tools and datasets, for potential in further developing national flood risk characterization
- Establish information-sharing and explore the potential for collaboration mechanisms to move toward a more consistent national flood risk characterization approach that can address USACE and other agency needs

Potential Questions for a National Flood Risk Characterization Approach:

- What is the national and regional baseline risk against which we can begin measuring progress?
- What is the historical change in flood risk and what factors drove those changes?
- What is the projected future change in flood risk and what are the driving factors of those changes?

- What are the most significant gaps and uncertainties in our ability to characterize current and future flood risk?
- To what level of precision do we need to characterize flood risk?
- Where should we focus our resources and activities to reduce risk? (i.e., what regions?)
- What policy and program changes can be implemented to reduce risk once we have identified the drivers of risk and the highest risk areas?
- How would rising sea level impact risk? What policies and programs could be implemented to address risks associated with sea level rise?
- What is USACE's contribution to reducing flood risk?
- What opportunities exist for collaboration across federal agencies to reduce flood risk? What opportunities exist for increased collaboration across all levels of government and with the non-profit or private sectors?
- What would be the impact to flood risk if federal investments were tied to a requirement for first floor elevations to be at least one foot above the Base Flood Elevation?
- How can a national flood risk characterization support decisions about appropriate Federal and non-Federal government activities to reduce risk?

2. Summary of Presentations

This section provides a brief summary of each technical presentation made during the workshop and some of the key discussion points that followed each presentation. The slides for each presentation are available on the National Flood Risk Management Program (NFRMP) website[1] and are attached to this report in Appendix 8.

2.1 Flood Risk Framework: Terminology - Dave Moser, USACE

Dr. Moser's presentation provided a conceptual foundation for the workshop and standard terminology that can be used as part of a flood risk characterization effort. The presentation acknowledged that no universal risk vocabulary exists; in fact, even the most general terms have variation, with risk assessment, risk framework, risk analysis and risk management often used interchangeably. Dr. Moser defined risk characterization as the "qualitative or quantitative description of the nature, magnitude and likelihood of the adverse effects associated with a hazard with the purpose of supporting decisions." Flood risk was defined as consisting of the following components:

- *Hazard – what can cause harm?*
- *Performance – how the system will react (e.g., infrastructure, management)?*
- *Exposure – who and what can be harmed?*
- *Vulnerability – how susceptible to harm are exposed people and assets?*
- *Consequences—how much harm?*

An important element for USACE's infrastructure safety programs was distinguishing incremental risk and residual risk. Incremental risk is the additional risk that arises when flood risk defense systems (e.g., levees) do not perform as planned. Residual risk is the level of flood risk for people and assets located in a floodplain that remains after implementation of flood risk reduction actions.

In addition to the slides presented at the workshop, Dr. Moser prepared a summary document of flood risk concepts and terminology. That paper is provided in Appendix 4.

2.2 National Flood Risk Characterization – Jeff Jensen and Peter Rabbon, USACE

Jeff Jensen and Pete Rabbon described the motivation for a flood risk characterization effort from the USACE perspective. Many of the motivating factors are covered by the questions presented in Section 1, such as the need to understand relative risk across the nation to support budget and program management decisions. USACE wants to better understand the nation's flood risk, regional differences in risk, whether and how USACE activities help reduce that risk, and how the risk might change in the future. Further, in coordination with other agencies, USACE wants to assess the potential benefits of flood risk characterization across agencies, evaluate existing tools and data, and establish a mechanism for information sharing and collaboration.

[1] http://www.iwr.usace.army.mil/Missions/FloodRiskManagement/FloodRiskManagementProgram/NewsandEvents/FloodRiskCharacterizationWorkshop.aspx

Section 2032 of the Water Resources Development Act of 2007 calls for a national flood vulnerability study which would require a national flood risk characterization; however, the study has yet to be funded by Congress. In addition, activities and priorities of the Federal Interagency Floodplain Management Task Force (FIFMTF) and the Mitigation Framework Leadership Group would also benefit from a national flood risk characterization.

2.3 USACE Dam and Levee Safety Programs – Eric Halpin, USACE

Eric Halpin described the principles that guided development of the USACE Dam and Levee Safety Action Classification systems and the lessons learned through those programs. Mr. Halpin pointed out that the safety programs were focused on incremental risk of infrastructure systems, but the principles and lessons learned are applicable to more general risk characterization (i.e., residual risk). Consistent risk characterization has been crucial to success in the safety programs because it has allowed for better communication and more defensible decisions. The approach was designed to allow for comparison across systems/regions and was generally conservative in dealing with uncertainty. As the safety programs developed and released risk classifications, they faced a number of challenges with sponsors of projects and other stakeholders. Lessons from this experience include depicting risk visually (e.g., with inundation maps on satellite imagery) rather than describing it verbally. In addition, those in the safety program learned how to better work with sponsors to communicate risks with the broader community. Finally, Mr. Halpin discussed the notion of tolerable risk, which was the focus of a previous USACE workshop[2]. During discussions about the safety programs, the fact that the classification process included a group decision-making protocol became an important point for designing any potential national flood risk characterization. This is covered in more detail in Section 3.7.

2.4 National Flood Risk Characterization Tool – Jeff Jensen, USACE

Jeff Jensen, Deputy Director, USACE National Flood Risk Management Program, presented ongoing work to develop a National Flood Risk Characterization Tool (NFRCT). The NFRCT was developed in order to meet two related objectives. The first was to test the feasibility of developing a tool that could identify areas of relatively high flood risk using national-level and publicly available data. The second objective was to provide USACE with an easy-to-use method to identify areas facing potentially high relative flood risk in order to support flood damage reduction budgeting decisions. The NFRCT uses FEMA's National Flood Hazard Layer (NFHL) and the National Elevation Dataset from the U.S. Geological Survey to estimate flood depths across all mapped flood zones in the country. These flood depths are used with Census, HAZUS, and other data to estimate damages to physical assets, population exposure, vulnerability of exposed communities and other flood risk metrics. The results provide flood risk metrics for the entire U.S. and enable regional comparisons, but the results are limited by the fact that only 1% and 0.2% annual chance flood events are mapped as part of the NFHL. Results are aggregated by HUC-8 watersheds and displayed on a map-based interface. The interface enables the user to drill down into individual watersheds and view detailed reports. Current work includes adding functionality to integrate the NFRCT with tools and processes for watershed based budgeting.

---

[2] Proceedings of the 2010 workshop "Exploration of Tolerable Risk Guidelines for the USACE Levee Safety Program" are available at http://www.iwr.usace.army.mil/Portals/70/docs/frmp/10-R-8.pdf .

2.5 HAZUS and Applications – Eric Berman, FEMA

Eric Berman of the Federal Emergency Management Agency presented an overview of FEMA's HAZUS-MH, a tool for estimating losses from natural hazards. HAZUS is a GIS-based tool that contains a substantial database that enables a high-level analysis of potential losses from floods. Location-specific data, such as results from more detailed modeling of flood events and inundation, can be added to HAZUS to perform a more precise damage and loss estimation. Further, HAZUS enables technical experts to modify some of the key parameters and functions in the tool in order to prepare a very detailed damage and loss estimate for planning activities. Mr. Berman's presentation summarized the data and methods that are used for each level of HAZUS analysis.

2.6 RiskMAP – Andrew Read, FEMA

Andrew Read of the Federal Emergency Management Agency provided an overview of FEMA's on-going Risk Mapping, Assessment and Planning program, known as RiskMAP. RiskMAP follows on FEMA's Map Modernization process yet also integrates flood hazard mapping, estimation of flood impacts and characterization of overall risk. RiskMAP products include identification of changes in the mapped flood zones since the last Flood Insurance Rate Map update as well as flood depth grids, something that was not provided in the past with flood maps. In addition, RiskMAP can incorporate data on flood impacts, such as potential damages from a range of flood frequencies and a characterization of relative flood risk. Each RiskMAP study produces a database, a flood risk report and a flood risk map. Communities can opt to enhance their RiskMAP products by including additional data on coastal impacts and dam and levee safety data.

2.7 North Atlantic Coast Comprehensive Study – Karla Roberts, USACE

Karla Roberts from the USACE Baltimore District North Atlantic Coast Comprehensive Study (NACCS) team presented on the study framework, technical components, and timeline. The goal of the study is to provide a risk reduction framework that supports resilient coastal communities and coastal landscapes in areas affected by Hurricane Sandy. The framework considers where flood risks exist, who and what is exposed to flood risk, what are the appropriate strategies and measures to reduce flood risk, how those strategies align with existing regional plans, what is the relative cost of measures, what data are available to make risk-informed decisions, and what are the data gaps. An exposure assessment based on population density and infrastructure, socio-economic groups, environmental/cultural, and composite indices was conducted to inform the vulnerability assessment. The study provides risk reduction measures that may be suitable for areas identified as vulnerable, with measures including structural, natural and nature-based, non-structural (e.g. flood-proofing, acquisition), and policy and programmatic activities. Additionally, the study considers future scenarios defined by alternative levels of sea level rise, socioeconomic, and environmental stressors. The study team recognizes particular advantages and disadvantages to its framework approach, with advantages including some automation and replication at multiple scales and disadvantages including coarse analysis, development of a weighting scheme, and inability to provide site specific solutions.

2.8 CWMS Inundation Modeling/Mapping – Chris Dunn, USACE

Chris Dunn, with the USACE Hydrologic Engineering Center, presented the Corps Water Management System (CWMS). CWMS is an integrated suite of hardware, software, and communication resources supporting the Corps' real-time water management mission and provides for an integrated Water Control

Data System. Mr. Dunn provided an example of the real-time flood inundation mapping and consequence estimation, which was noted to assist with risk communication. Additionally, a proposed CWMS National Implementation Plan was described, noting the benefits of a nationally consistent display of inundation maps and metric reporting, information sharing across agencies, and flood watch and warning systems. Mr. Dunn suggested that if CWMS were deployed throughout the USACE portfolio, it could provide inundation mapping for a range of flood frequencies throughout the country and support detailed modeling of flood consequences, such as life risk assessment and damage estimates. HEC estimates that nationwide deployment of CWMS would cost approximately $127 million; modeling and mapping a range of flood events would require additional work.

2.9 Estimates of Hydrologic Risk – Karen Weghorst, Bureau of Reclamation

Karen Weghorst with the U.S. Bureau of Reclamation presented information related to the Bureau's Dam Safety Program. The Reclamation Safety of Dams Act authorizes modification of Reclamation dams resulting from new hydrologic or seismic data as deemed necessary for safety purposes, not from aging or normal deterioration of infrastructure. The Dam Safety Public Protection Guidelines informs Reclamation on how to use risk and risk assessment to manage a portfolio of high and significant hazard dams. Risk based decisions provide for risk estimates focused on identified failure modes that are easier for decision makers, management and stakeholders to understand. The risk analysis process was reviewed, with an emphasis on determining failure modes (e.g. static loads, floods and seismic) and estimating the probability of events and failure.

2.10 NOAA's Digital Coast Resources – Maria Honeycutt, NOAA

Dr. Maria Honeycutt presented on NOAA's Digital Coast tools and resources, some of which could be used to support national flood risk characterization. Digital Coast tools and partnerships described include Coastal County Snapshots, NOAA Sea Level Rise (SLR) and Flooding Impacts Viewer, New York Post-Sandy Risk Assessment, New Jersey Flood Mapper, and the NOAA Roadmap to Adapting to Coastal Risk. These tools are designed to help coastal communities build capacity for local decision-making and are typically built in coordination and partnership with the end-users. Dr. Honeycutt also presented NOAA's latest tool, Coastal Flood Exposure Mapper, which is still in development. This tool will provide a collection of maps with different aspects of community exposure to flood hazards, including ecosystem and infrastructure exposure. Dr. Honeycutt also noted a Coastal Vulnerability Index available from the U.S. Geological Survey (USGS), and Coastal Change Hazards Portal currently in development by the USGS.

2.11 Climate Change Pilots and Flood Risk Studies – Kate White, USACE

Dr. Kate White provided an overview of climate change adaptation and flood risk activities being conducted by the USACE. Adaptation policy and guidance related to flood risk was largely initiated following post-Katrina analyses that supported the need to incorporate new and changing information. Dr. White provided a review of the tools to implement adaptation policy and guidance related to vertical datums, sea level change, post-Sandy flood risk recovery standard, hydrology, and vulnerability assessments. USACE is currently conducting initial coastal and riverine screening-level assessments to ensure that USACE can successfully carry out its missions, execute programs, and operate projects in the climate-changed future. USACE is evaluating the vulnerability of coastal projects to the impacts of sea level change, with more detailed assessments to follow for projects with the greatest vulnerabilities and consequences. For inland projects, the initial screening-level vulnerability analysis is at a coarser resolution as the understanding of hydrologic impacts are less well defined. USACE has developed a watershed screening analysis at the HUC-4 scale to evaluate the vulnerability of USACE business lines. Each of these tools and the information they provide allow USACE to explore vulnerability across its business lines or HUCs in order to develop a relative sense of vulnerabilities to climate change. This information also provides for an indication of the trend in climate vulnerability over time for specific indicators and as grouped in business lines.

2.12 Impact of Climate Change and Population Growth on the NFIP – Mark Crowell, FEMA

Mark Crowell provided an overview of FEMA's "Impacts of Climate Change and Population Growth on the National Flood Insurance Program (NFIP)" report which was released in 2013. This study was intended to report on whether climate change should be incorporated into management of the NFIP, and findings recommend that this is essential for FEMA. The objective of the study was to quantify impacts of climate change (changes in precipitation patterns, changes in frequency and intensity of coastal storms, and changes in sea level) on the location and extent of regulatory floodplains; the relationship between the elevation of insured properties and the 100-year base flood elevation; and the economic structure of the NFIP. The study explored a 90-year timeframe and adopted a probabilistic approach rather than a scenario-based approach. The riverine analysis focused on the development of regression equations that relate flood discharges to watershed characteristics and climate change indictors so that projections may estimate future changes in flood discharges. The coastal analysis included a regionalization of areas based on sea level rise and storm influence. Findings of the study suggest that the total area in regulatory floodplains may increase by 40% to 45% by the year 2100. The presentation also included a description of the Biggert-Waters Act of 2012 and components of climate change in the act.

2.13 Estimating Loss of Life from Flooding – Jason Needham, USACE

Jason Needham described the USACE life loss estimation methods, wherein a variety of methods are available depending on the scale of the assessment (e.g. screening versus HEC-FIA and LifeSim). The presentation provided an overview of the essential elements for life loss estimation – initial distribution of people, redistribution of people or evacuation effectiveness, flood characteristics, shelter, and fatality rates. Factors increasing and decreasing the effectiveness of flood warnings, such as dense urban environment (pro) and phone systems overloaded (con), as well as relationships defining the responses to warning were described.

2.14 Flood Risk and Potential for a National Flood Risk Classification System – Darryl Davis, USACE

Darryl Davis presented ideas on how the risk classification methods of the USACE dam and Levee Safety Programs could be extended to create a national flood risk classification system. Mr. Davis provided an overview of flood risk, hazard, and inundation scenarios that addressed many of the topics presented earlier and possible ways to move forward. Revisiting residual and incremental risk, it was clarified that incremental risk does not exist in non-leveed floodplains, and residual flood risk in leveed areas includes the incremental risk and non-breach risk. A risk classification scheme provides a means to collapse and summarize information for comparison purposes. Mr. Davis presented ways that the existing infrastructure risk classification approaches could be extended to a national approach applicable both where risk is influenced by the presence of a flood risk management structure as well as where it is not. The presentation served as the foundation for continued discussion about how USACE and partners might create a new national flood risk characterization and/or classification approach. Mr. Davis' presentation was based on a white paper that he and several USACE collaborators prepared for the workshop. That paper can be found in Appendix 5.

3. Key Themes from Workshop Discussions

The workshop took place over the course of two and half days and constructive discussions occurred throughout that time. The summary below seeks to synthesize the discussion along nine key themes. Toward the end of the second day, workshop organizers and facilitators listed some of the emerging themes on a white board and invited participants to consider the proposed themes and offer feedback on whether they were the right ones. Workshop organizers revisited these themes as part of formal report-back presentation and discussion near the end of the workshop. The themes presented below are drawn from those discussions. The summaries are drawn from notes taken throughout the workshop.

There were a number of points raised that did not become the focus of any substantial discussion but might still be interesting and useful for future work on national flood risk characterization. These points are briefly presented in subsection 3.10.

3.1 Purpose of National Flood Risk Characterization and Decision Relevance

This theme came up repeatedly. It is crucial for USACE to clearly define its purposes and intended uses of a national flood risk characterization so that the resulting approach can meet expectations. USACE personnel described several general purposes that they envision. One is to support the flood risk management program budgeting process – i.e., deciding where and how much to invest in new projects, maintenance of existing projects and so on. USACE is currently developing and piloting a new watershed-based budgeting process, which was discussed extensively during the workshop. The larger goal with watershed budgeting – to use a systems approach to prioritize investments across regions and USACE business lines – was generally understood by participants to be a worthwhile goal.

In addition, as a lead Federal contributor to flood risk management, USACE envisions using national flood risk characterization to assess areas of relative high flood risk, track progress in reducing risk, evaluate how USACE infrastructure contributes to managing flood risk, and inform policy decisions internally within USACE and in conjunction with its flood risk management partners. By the end of the workshop, the USACE needs for national flood risk characterization were synthesized into the following themes:

- Provide a rational basis for allocating USACE resources (e.g., project investments);
- Measure progress and improvement in national and regional flood risk; and
- Understand and communicate risk between agencies and with the public.

It was generally agreed that USACE should flesh out these purposes in greater detail, and possibly consider narrowing its focus, before continuing work on developing a national flood risk characterization.

Other agencies discussed how they might use a national flood risk characterization. In general, several agencies can envision using such information as one input, among others, to support program management and policy development. Specific possibilities mentioned during the workshop are shown below. The ideas below were drawn from brainstorming type discussions and should not be considered commitments or requests by any particular agency.

- EPA participants noted the potential to use national flood risk characterization data to help guide decisions about wetlands and ecosystem protection, which can help mitigate flood risk. In addition, they mentioned the possibility of using this information to support policy development.

- HUD representatives noted that national flood risk characterization could be very useful for comparing regions across the country to help with program management, such as where they make new investments in local communities.
- FEMA participants suggested that they could use national flood risk characterization data to support decisions about long-term risk reduction/avoidance activities and to help make those decisions more quickly.
- USGS participant noted the potential to use national flood risk characterization to guide program management and investment decisions, such as funding stream gages.
- NOAA participants highlighted that any tool or source of information that could promote coordinated policy would be valuable, but also asserted that if this tool/product will be driven by USACE, then USACE should clarify and prioritize its own needs first.

3.2 Aggregation

Nearly all of the approaches and tools reviewed during the workshop incorporate various metrics and indicators of risk, including population exposure, life risk, damage to physical assets, social vulnerability, and exposure of critical infrastructure. For a national flood risk characterization, such metrics will need to be aggregated in some way to enable regional comparisons. There has been some discussion at USACE Headquarters about developing a national flood risk index – a single number that can encapsulate all elements of regional flood risk in a consistent way. This notion came up during the workshop. An index can help with high level screening or prioritization of a project portfolio, but it can become a meaningless number that is relied on too heavily. Participants emphasized that any risk index should be approached cautiously and be accompanied by more detailed information to substantiate the index values.

The USACE safety programs dealt with these issues in developing the classification systems. The classifications are based on life risk assessments, damage assessments and other factors. Instead of combining these into a risk index, the safety programs developed the idea of a risk-informed action classification, which places each project (a levee system or dam) into a priority category for investment based on the risk (see Exhibit 5-1). If a classification system is used for overall national flood risk, it can borrow from the methods used by the safety programs to aggregate various risk metrics into a single classification system.

3.3 Defining Risk

Beyond the typical definition of risk being a measure of the probability and severity of undesirable consequences, there are various types of risk and these types would play different roles in a national flood risk characterization. The USACE safety programs focused on incremental risk, which is the additional risk imposed by structures if they fail to perform as planned. Residual risk is typically defined as the risk that remains after certain risk reduction activities have been implemented; sometimes the term total risk is used interchangeably with residual risk. Incremental risk is part of residual risk. A national flood risk characterization would address residual risk, as it is defined here, throughout the country. It should be noted, however, that distinctions between incremental and residual risk could be confusing for the public and there will be a need to clearly define these terms and to be consistent.

Exhibit 5-1: USACE Dam Safety Action Classification System

TABLE 3.1 – USACE DAM SAFETY ACTION CLASSIFICATION TABLE* 12 February 2013		
URGENCY OF ACTION	ACTIONS FOR DAMS IN THIS CLASS	CHARACTERISTICS OF THIS CLASS
VERY HIGH (1)	Take immediate action to avoid failure. Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Implement interim risk reduction measures, including operational restrictions. Ensure the emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite investigations to support remediation using all resources and funding necessary. Initiate intensive management and situation reports.	CRITICALLY NEAR FAILURE: Progression toward failure is confirmed to be taking place under normal operations. Dam is almost certain to fail under normal operations within a few years without intervention. OR VERY HIGH INCREMENTAL RISK**: Combination of life or economic consequences with likelihood of failure is very high. USACE considers this level of life-risk to be unacceptable except in extraordinary circumstances.
HIGH (2)	Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Implement interim risk reduction measures, including operational restrictions as justified. Ensure the emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite confirmation of classification. Give very high priority for investigations to support justification for remediation.	FAILURE INITIATION FORESEEN: For confirmed and unconfirmed dam safety issues, failure could begin during normal operations or be initiated as the consequence of an event. The likelihood of failure from one of these occurrences, prior to remediation, is too high to assure public-safety. OR HIGH INCREMENTAL RISK**: The combination of life or economic consequences with likelihood of failure is high. USACE considers this level of life-risk to be unacceptable except in extraordinary circumstances.
MODERATE (3)	Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Implement interim risk reduction measures, including operational restrictions as justified. Ensure the emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Prioritize investigations to support justification for remediation informed by consequences and other factors.	MODERATE INCREMENTAL RISK**: For confirmed and unconfirmed dam safety issues, the combination of life, economic, or environmental consequences with likelihood of failure is moderate. USACE considers this level of life-risk to be unacceptable except in unusual circumstances.
LOW (4)	Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Conduct elevated monitoring and evaluation. Give normal priority to investigations to validate classification, but do not plan for risk reduction measures at this time.	LOW INCREMENTAL RISK**: For confirmed and unconfirmed dam safety issues, the combination of life, economic, or environmental consequences with likelihood of failure is low and the dam may not meet all essential USACE guidelines. USACE considers this level of life-risk to be in the range of tolerability but the dam does not meet all essential USACE guidelines.
NORMAL (5)	Continue routine dam safety activities and normal operations, maintenance, monitoring, and evaluation.	VERY LOW INCREMENTAL RISK**: The combination of life, economic, or environmental consequences with likelihood of failure is very low and the dam meets all essential USACE guidelines. USACE considers this level of life-safety risk to be tolerable.

*At any time for specific events a dam, from any action class, can become an emergency requiring activation of the emergency plan.
** INCREMENTAL RISK is the risk that exists due to the presence of the dam and this is the risk used to inform the decision on the DSAC assignment. The information presented in this table does not reflect the NON-BREACH RISK associated with the presence of the dam or from operation of the dam.

In addition, there will be a need to agree on what is meant by the notion of *relative risk*. USACE has been using that term to mean the comparative risk across different regions of the country. FEMA typically uses the term to mean the assessed risk for a particular region compared to the size of its economy or capital stock, which provides useful community-specific information (cross-community comparisons would require a means of normalizing that information.) For example, from the FEMA perspective, a metric of relative risk would be the percentage of infrastructure in a given community that would be damaged by a particularly flood event. If USACE and its partners move forward with a national flood risk characterization approach, they will want to agree on a clear definition of relative risk and have separate terms for these two notions.

3.4 Climate Change

Climate change clearly imposes substantial uncertainty for future flood risk characterization as there is little doubt that it will result in changes in storm patterns, hydrology, and sea level. NOAA, USACE, FEMA, USGS and others are working to understand the impacts of climate change on flood risk (as well as other risks). Presentations and discussions at the workshop pointed to two key themes. First, the scientific community has a pretty good understanding of future sea level rise trends and the impacts that sea level rise will have on U.S. coasts. For example, NOAA has inundation data for six sea level rise scenarios that are regionally adjusted for tidal patterns. However, the scientific community is less confident about probabilities of sea level rise in any given location, limiting the ability to use this information for a true risk characterization. Similarly, there is less confidence in the impact that climate change will have on storm patterns and resulting frequency of storm surges along the coasts.

For riverine systems, the impact of climate change is even more uncertain. There is wide agreement that there will be changes in extreme events and regional differences in these changes, but research to date has failed to detect any signal in hydrologic data. Downscaling of output from global circulation models is complicated and results in a wide spread of possible futures. For example, using results from multiple General Circulation Models and carbon emissions scenarios, a consortium of Federal agencies and other organizations has come up with 100 possible future scenarios of regional hydrology[3]. These scenarios suggest a wide range of possible future hydrologic conditions with no way to estimate which of these is more or less likely. Further, the data for these future scenarios are at a monthly timestep, making it difficult to use them for flood risk analysis. USACE has completed work to summarize these possible futures and make them usable for vulnerability analysis. However, it was unclear to workshop participants how the information could be used for anything but very general vulnerability assessments.

In addition, FEMA has completed a study of the impact of climate change on the National Flood Insurance Program, as noted in Section 2.12. The work was based on national scale statistical analysis and found that climate change could increase the total area in regulatory floodplains by 40% to 45% by the year 2100. Because of the national scale of their analysis it is not appropriate for local or regional use. So the results support the conclusion that climate change will impact (likely increase) overall flood risk, but they cannot be used for regional flood risk characterization.

The extent of the uncertainty about climate change impacts on flooding suggests that climate change might be best used as a discriminator for risk characterization (see section 3.8 below) until our technical understanding improves.

3.5 Spatial Resolution and Level of Detail

It is possible to drive risk characterization with very detailed, highly sophisticated modeling and analysis. Under RiskMAP, FEMA and partner communities carry out detailed hydrologic, hydraulic, and flood impact modeling to map flood zones, generate depth data, and estimate flood consequences. In addition, for the dam and levee safety programs, USACE carried out detailed studies of dam and levee failure scenarios, resulting inundation, life loss estimation and other elements. Finally, USACE is currently deploying CWMS in several districts and there have been discussions about deploying it nationwide. CWMS would provide detailed inundation data for any range of flood scenarios (including infrastructure failure). Under ideal circumstances, national flood risk characterization would be based on this sort of very detailed modeling and data. As noted during the workshop, such methods could describe inundation depth and timing structure by structure throughout the U.S. (assuming such data were available) and estimate damages structure by structure. Results could then be aggregated to any desired large spatial unit, such as counties or HUC-8 watersheds. The question posed repeatedly by workshop participants was how much detail is needed for the intended purposes of national flood risk characterization? This has to be considered carefully. A project in a high risk region or watershed might not be the most beneficial project to invest in, so the risk context must be combined with specific information about projects and other investment options.

---

[3] World Climate Research Program, Coupled Model Intercomparison Project. Available at: http://cmip-pcmdi.llnl.gov/

There was also discussion about using less detailed data to inform policy discussions. A less detailed approach would be less costly to implement but would require some caution to avoid potentially misleading results with overly-generalized information. Another possibility is to consider small case studies that could be extrapolated to other locations or situations for which little information may exist. There was general agreement that the specific purpose at hand will inform the necessary level of detail, and that time and resources available will shape the approach.

3.6 Integration of Coastal and Riverine Areas

Following numerous discussions about USACE plans for watershed budgeting, and several presentations based on the riverine flood context, it was pointed out that the conceptual basis for national flood risk characterization must be equally applicable to coasts and riverine areas. For example, watersheds are simply not relevant to coastal regions, where work tends to occur at the community and county level. Similarly, concepts associated with infrastructure performance may need to be reviewed to ensure that they are applicable to coastal storm protection infrastructure, such as beach nourishment and sea walls. Several participants asserted that this may be more an issue of terminology and that it can be addressed by defining and adopting more general terms for certain concepts (e.g., region instead of watershed).

In addition, there was some discussion about integrating the physical modeling of coastal, riverine, and urban (i.e., stormwater) flooding. In certain situations, inundation from storm surge and from runoff and river discharge will meet and potentially increase inundation.

3.7 The Role of Computation and Expert Judgment

The USACE safety programs incorporate a governance phase in which modeling and other data are considered by an expert oversight committee to determine the final risk classification. The National Flood Risk Characterization Tool currently in development by the USACE NFRMP uses a computational approach to produce risk characterizations. It was pointed out that both approaches include expert judgment and assumptions, but there are some fundamental differences between the two. In a computational approach, expert judgments and assumptions are built into the design of a tool because they arise in decisions about what data to use, developing calculation methods, and framing results. In the approach used for the USACE safety programs, expert judgment likely influences modeling in a similar way, but it is also included in the final stage of the risk characterization process.

USACE personnel who led development of the safety programs pointed out that the governance protocol allowed for a more flexible process and more defensible decisions. The process was more flexible because the final expert committee decision process could use multiple types of information from different models and other sources. In can be difficult to design a useful, sensible tool that can combine data and information from different sources. The safety programs' process avoided this problem. In addition, having a well-developed, transparent committee decision process can make the final risk ratings more defensible than calculated outputs from a model, which can be perceived as a black box. People with experience in the safety programs pointed out that it is nearly impossible to design a bullet proof model. On the flip side, a process that relies on committee decisions for each risk rating is likely to be much more time consuming and expensive than designing a tool that produces risk characterizations. In addition, while a governance protocol is meant to mitigate the influence of subjectivity in the risk characterization/classification decisions, the results of a committee-driven process may not be fully reproducible because some subjectivity is unavoidable.

Ultimately, USACE and its partners will have to consider the pros and cons of each approach in light of the intended purposes and uses for national flood risk characterization. NFRMP leadership suggested that there will be a need for a tool that is adaptable to changing conditions and information over time. That might suggest the need for a governance process. A governance process would not eliminate the need for computational tools (indeed, the USACE safety programs conducted extensive analytical studies) so both elements will need to be considered in designing a national flood risk characterization approach.

3.8 Risk Discriminators

As part of the committee decision-making process, the USACE safety programs were able to use what they labeled *discriminators* in determining final risk classifications. Discriminators are pieces of information that may be separate from the standard risk assessment process but can be used to provide context or broader indicators of risk trends or potential impacts. These discriminators could influence the final decision. For example, USACE identified valuable cultural resources that could be affected by inundation resulting from levee breach. They did not evaluate potential impacts to these cultural resources as part of the quantitative flood risk assessment, but they were considered in the final decision process as an additional factor that might warrant a higher risk classification. Some uncertainties, such as those associated with climate change, could be treated similarly.

If a national flood risk characterization included a governance or committee review phase, it would need to include some list of discriminators and how they would be treated in the process. There were a number of data or impact categories that were discussed as potential discriminators, including:

- Ecosystem indicators, especially for wetlands;
- Cultural resources;
- Climate uncertainties; and
- Social impacts of flooding and social vulnerability.

With adequate data some of these could be included in the quantitative risk modeling rather than as discriminators. For example, the U.S. Fish and Wildlife Service maintains a GIS database of the national wetlands inventory. Risk characterization could quantify the amount of wetlands present and the role they play in mitigating flood hazards, and spatial trends in wetlands loss. Personnel from the U.S. EPA highlighted recent work by the state of Maryland and other agencies to develop a watershed resources registry for the state (http://watershedresourcesregistry.com/home.html). This site includes data on wetlands, riparian habitat, areas suitable for restoration and more. Such data could also be used as input or discriminators for a flood risk characterization process.

3.9 Leveraging and Aligning Agency Efforts

Interagency communication and the potential to align different agency activities was a primary motivation for holding this workshop and it was a continuous theme of discussions during the workshop. Because of its role administering the National Flood Insurance Program and flood risk mitigation activities, FEMA is widely recognized as the lead agency in assessing and communicating flood risk. FEMA has not endeavored to develop a national flood risk characterization that would enable regional comparison across the country because it is not viewed as particularly helpful or useful for its mission. FEMA has developed HAZUS, which is designed for location-specific risk assessments for flood and other natural hazards. HAZUS can be used to characterize national flood risk but such an analysis has not been completed. In addition, FEMA's RiskMAP program involves detailed flood risk mapping, with a focus on updating flood hazard maps and a goal of updating 80% of hazard maps by the end of FY2014. RiskMap is a substantial effort, with roughly $220,000,000 in funding in FY2010. FEMA personnel pointed out that there is potential for confusion among state and local governments and the broader public with both RiskMAP and a new flood risk characterization product from USACE. Similarly, NOAA has developed a number of tools that summarize flood risks in coastal communities, with new tools anticipated in the near future. USACE has developed a risk classification system for its safety programs and both the methods and findings from those programs could be valuable for a broader flood risk characterization. As noted above, there will be a need to ensure that any new national flood risk characterization is designed to be equally applicable to coastal and inland regions.

The process of organizing the workshop and the workshop discussions have helped to identify existing and upcoming flood risk relevant activities within USACE, FEMA, NOAA, USGS and other agencies. Most of these efforts can contribute data and methods for national flood risk characterization. While it may prioritize its own needs, USACE will need to consider how each agency's work can contribute and how new risk characterization products align with existing tools and products.

3.10 Other Issues and Considerations

As noted earlier, the workshop included continuous discussion through the two and half days. The themes above are meant to capture and synthesize the most important issues identified and discussed. A host of other topics came up but did not generate any detailed discussion. Some of these are presented below so that they can be referenced in the future as work on national flood risk characterization progresses.

- Urban or stormwater flooding – FEMA's flood mapping rarely addresses urban stormwater flooding because such events fall below the NFIP threshold of 1% annual chance exceedance. National flood risk characterization will need to consider urban stormwater flooding and how its impacts compare with larger but less frequent riverine and coastal floods.

- Ecosystem services – In addition to the impacts of floods on ecosystems, there will be a need to consider how ecosystems mitigate flood hazard. This was noted above under the section on discriminators, but was mentioned a number of times throughout the workshop.

- Dealing with uncertainty –There was a recurring theme during workshop discussions about the need to recognize the uncertainty inherent in flood risk assessment and any resulting risk characterization. At the same time the presence of uncertainty does not necessarily imply that science and information about flood risk is poor quality. Some uncertainty can be reduced through new data collection and research, while other sources of uncertainty are unavoidable.

- Ownership and sustainability – Participants noted that any substantial effort will require resources and leadership to initiate and sustain it over time. While there is a desire to incorporate interagency collaboration, USACE NFRMP was identified as the most appropriate party to take the lead in developing the risk characterization and sustaining it into the future.

4. Conclusions and Next Steps

4.1 Conclusions

Overall conclusions from the workshop are presented below. These key outcomes were discussed and affirmed by participants toward the end of the workshop.

- National flood risk characterization is conceptually and technically feasible, and sufficient information exists to support it, including datasets and tools from other agencies.
- National flood risk characterization would be valuable to USACE, FEMA, and other agencies.
- USACE should take the lead in developing and maintaining national flood risk characterization for its purposes, but other federal agencies might find it useful as one input to their decision-making.
- USACE should clarify its intended purposes and uses for national flood risk characterization before proceeding with new methods or analyses.
- The focus of national flood risk characterization should be residual flood risk.
- The approach should encompass all possible types of flooding (riverine, coastal, and stormwater).

4.2 Next Steps for National Flood Risk Characterization

Following from the conclusions above, there are several action items that USACE and possibly its partner agencies can pursue over the next year. Some of these were specifically discussed and agreed upon during the workshop; others were formulated by workshop organizers based on the input received during the workshop.

4.2.1 Clarify the Purpose of National Flood Risk Characterization

There was general agreement that an informative national flood risk characterization is feasible and would be valuable to USACE, FEMA and other agencies, provided it was developed to address some of the concerns described above. It was also generally agreed that the USACE National Flood Risk Management Program would spearhead and fund this effort. There was clear consensus that the first step in pursuing a new national flood risk characterization is to clarify the purpose and intended uses. USACE participants agreed to these general principles for the purpose of national flood risk characterization:

- Provide a rational basis for allocating USACE resources (e.g., project investments);
- Measure progress and improvement in national and regional flood risk; and
- Understand and communicate risk between agencies and with the public.

In addition, participants from other agencies suggested that national flood risk characterization would be useful as one input to program management, policy and other decision-making (examples presented in section 3.1).

Working from the general principles above, USACE NFRMP leadership should clarify the specific purpose for national flood risk characterization, with sufficiently narrow focus to facilitate successful testing and implementation, and define specific ways in which USACE would use that

characterization. NFRMP leadership will necessarily need to consult with leaders of other programs within the Corps of Engineers, and will take into account the observations and perspectives provided by various federal agency personnel and experts during the workshop. Documenting a clarified focus will provide the basis for developing the approach, including through initial pilot testing.

4.2.2 Establish a USACE Working Group

National flood risk characterization will need to incorporate multiple areas of expertise so that it can effectively draw on a wide range of tools and methods as well as address the needs of various programs within and possibly outside USACE. **Therefore, the USACE National Flood Risk Management Program should organize an internal working group, which will be charged with developing and testing the approach and its outputs to meet the clarified purpose.**

In order to ensure that a future risk characterization approach is informed by an appropriate range of USACE expertise, the working group should consist of members from various programs and disciplines, such as the USACE safety programs, the USACE Planning Community of Practice, coastal flood risk experts and others. The NFRMP and working group members will need to establish processes for convening meetings, making decisions, assigning tasks, staff support and other aspects of the group's work.

4.2.3 Develop and Pilot Test an Approach

With a clearly defined purpose for national flood risk characterization, the working group can begin to develop and test a new approach. Many workshop participants suggested that it will be nearly impossible to "get it right" on the first attempt. Managers of the safety programs found that they had to retool their approach regularly as they got new information and communicated preliminary findings to partners and the broader public. An iterative approach will likely be essential.

To get started, the **USACE working group should develop an approach meeting the clarified purpose, identify suitable pilot test areas, and initiate a pilot test of that approach**. The pilot test should consist of a realistic application of the approach to a limited sample of regions, to include both watersheds and coastal areas. The sample of regions for the test should be representative of the potential range of community types and flood risk situations across the country, ideally including urban and agricultural areas, arid and humid environments, mountainous and flat regions, coastal and estuarine regions, areas with a range of existing flood control, etc., as feasible within available resources. The pilot test should seek to iteratively develop and apply flood risk characterization, in whatever format is selected by the working group, for each test region. **Most importantly, the pilot test should include a realistic exercise of using the characterization results to make hypothetical decisions of the sort envisioned in the purpose for the national flood risk characterization**, possibly conducted initially within the working group and subsequently with anticipated decision-makers. The test would likely need to include separate exercises for budget and policy decisions. For example, if NFRMP leadership and the USACE working group propose to use national flood risk characterization to support flood risk management program budget decisions, then the pilot test should include mock decision-making about specific USACE flood risk management budget proposals using draft flood risk characterization results. Similar mock decisions can be carried out to test how national flood risk characterization would be used for USACE policy decisions. Lessons learned from the pilot test can inform further work as the working group refines the approach and moves toward a full, nation-wide application. At a suitable point of development, results should be reviewed by an interagency team to determine whether the results are realistic and consistent with other results (e.g., RiskMAP).

4.2.4 Profile Existing Tools and Data

There was a clear recommendation to align any new effort with existing agency efforts and to leverage the products of those existing efforts. This workshop took a first step at identifying all of the relevant efforts and describing how they might contribute to national flood risk characterization. One task that could further contribute to interagency coordination and leveraging is to describe each of the existing products, tools and datasets in detail. Perhaps as an initial undertaking, **the working group should consider documenting in detail each of the existing tools and datasets and describing how each of them can contribute (if at all) to national flood risk characterization.**

The presentations from the workshop, as well as the read ahead materials, provide a starting point for this task. The working group could come up with a framework for describing how each tool and dataset can contribute to the goals of the national flood risk characterization. The framework would be based on the refined purpose for national flood risk characterization, as well as factors such as spatial resolution, national coverage, and the frequency of updating data for each tool. The descriptions would map out how each tool might fit into a new approach for national flood risk characterization and also help identify key gaps in the existing information base.

Appendix 1 - Workshop Agenda

DAY 1: Tuesday, February 25	
Time	**Item**
9:00 AM	Welcome and Introduction • Participants introduce themselves • Facilitator reviews the agenda and design of the workshop • Jeff Jensen covers purpose, objectives, and anticipated outcomes • Opening discussion about expectations
9:45 AM	Opening remarks, Ms. Karen Durham-Aguilera (via phone), Director of Contingency Operations and Office of Homeland Security, USACE
10:00 AM	Flood Risk Framework, *Dave Moser, USACE* • What is risk? And how would estimates of risk drive decisions? • What are the components of flood risk and the terminology? This will include discussion of how to assess flood hazard, performance, exposure, vulnerability, and consequences.
10:30 AM	USACE Needs for National Flood Risk Characterization, *Jeff Jensen & Pete Rabbon, USACE* • What is it? What is the need? How would it be used? • Q&A
11:15 AM	Facilitated Discussion • Perspectives on USACE's views and needs for National Flood Risk Characterization • How might FEMA, EPA, USGS, HUD, other federal agencies, and potentially states and others use National Flood Risk Characterization? How would their work be reflected in National Flood Risk Characterization? • Should this be used for public information and communication? If so, when and how?
NOON	LUNCH (pizza)
1:00 PM	Current Approaches Applicable to National Flood Risk Characterization 1. *Eric Halpin, USACE, Levee Safety and Dam Safety Approach* 2. *Jeff Jensen, USACE, National Flood Risk Characterization Tool* 3. *Eric Berman, FEMA, HAZUS and Applications (e.g., AAL Study)* 4. *Andrew Read, FEMA, RiskMAP* 5. *Karla Roberts, USACE, North Atlantic Coast Comprehensive Study* 6. *Chris Dunn, USACE, CWMS Inundation modeling/mapping*
3:15 PM	BREAK
3:30 PM	Current Approaches Applicable to National Flood Risk Characterization (continued)
5:00 PM	Open Discussion: Closing Thoughts for Day 1
5:30 PM	**End Day 1**

DAY 2: Wednesday, February 26	
Time	**Item**
9:00 AM	Welcome and Preview the Day
9:15 AM	Current Approaches Applicable to National Flood Risk Characterization (cont.) 7. *Karen Weghorst, Bureau of Reclamation, Estimates of Hydrologic Risk* 8. *Maria Honeycutt, NOAA, NOAA's Digital Coast (to include highlights regarding ecosystem and socioeconomic considerations)*
10:15 AM	Presentations on climate change, life safety, and flood risk • *Kate White, USACE*, Climate change pilots and flood risk study • *Mark Crowell, FEMA*, Study on climate change impacts on the National Flood Insurance Program • *Jason Needham, USACE,* Estimating Loss of Life from Flooding
11:15 AM	Potential for Extending USACE Safety Programs Classification System to a National Flood Risk Classification, *Darryl Davis, USACE* • Brief revisit of components and definition of flood risk • Overview of USACE classification systems for dam and levee safety programs • Potential for extending levee safety classification system to national classification as a feature of flood risk characterization
NOON	LUNCH (sandwiches)
1:00 PM	Breakout groups round 1: Review and Evaluate Existing Characterization approaches/tools 1. Are there approaches/tools that were not included? If so, what do they contribute? 2. Are the approaches/tools consistent? At odds? Redundant? How so? Provide specific examples to discuss. 3. How well do they address major components of flood risk: hazard (flood probability, extent and depth), consequences (life safety, damages), vulnerability and resilience? 4. Is the spatial resolution sufficient for intended purposes? 5. Do any of the approaches/tools adequately cover potential future changes? Can we do better on this? If so, how?
2:00 PM	Breakout round 1 report back
3:00 PM	BREAK
3:15 PM	Breakout groups round 2: Discuss potential for developing comprehensive national flood risk characterization that can address various agencies' interests/concerns 1. What are pros and cons of extending USACE's classification system to create a national classification approach? How is classification different from characterization and what are the implications of those differences? 2. Can a classification system meet the various agency needs discussed on day 1? Could it be modified to meet different agencies' needs? 3. What alternative to the classification system would you propose? Would it be a completely new idea or a modification/variation of one of the approaches we heard about earlier? 4. Do we collect sufficient data to create a comprehensive characterization? What's missing? 5. How would the approaches/tools we heard about contribute to a comprehensive

	approach? What's missing?
4:15 PM	Breakout round 2 report back
5:15 PM	Open Discussion: Closing Thoughts for Day 2 and Expectations for Day 3
5:30 PM	**End Day 2**

Day 3: Thursday, February 27	
Time	**Item**
9:00 AM	Welcome and Opening Thoughts
9:15 AM	Facilitated Discussion: Review Evolving Concepts for Flood Risk Characterization *This would be a review of what workshop organizers have heard so far (will present a summary) and a discussion, all organized according to these themes:* 1. What is the purpose of national flood risk characterization and/or classification? 2. How would or could it be used? 3. Is consistency across agencies important? 4. How can the presented tools and approaches contribute? 5. Do we have the necessary data? If not, how can gaps be filled?
10:45 AM	BREAK
11:00 AM	Facilitated Discussion: Charting a Path Forward 1. What can we do in one year? Five years? Ten years? 2. How USACE might use some of the information and insights from the workshop to improve its tools and how it would be used? 3. How might other agencies use the outcomes of the workshop in flood risk characterization? 4. What are remaining needs and ways of addressing those needs (i.e., potential changes to data collections, possible new studies or new ways of using existing data, new data sharing platforms)? 5. Are agencies interested in migrating from coordination to collaboration?
11:45	Recap and Agree on Future Directions
12:15	Open Discussion: Closing Thoughts for the Workshop
12:30	**Workshop ends**

Appendix 2 – Workshop Planning Document

Updated: January 28, 2014

Flood Risk Characterization Workshop Planning Read-Ahead
Feb 25-27, 2014
U.S. Army Corps of Engineers' Institute for Water Resources (Alexandria, VA)
Approximately 20-30 federal participants

Workshop Goal

Explore with key internal (USACE) and federal external partners specific approaches for characterizing national and regional flood risk using existing data for the purpose of facilitating information sharing among federal partners, beginning to reflect infrastructure integrity, and improving USACE national flood risk characterization tools useful for its policy development and program effectiveness in advancing national flood risk management decision making, internally and in conjunction with federal partners.

Workshop Objectives

1. Overview various approaches for identifying current and future flood risk (as determined by flood hazard, system performance, exposure to hazard, vulnerability, and consequences) on national and regional basis (as opposed to a community or project basis); identify and document key differences, advantages, and limitations

2. Overview various measures of flood hazard, exposure, and vulnerability; review categorized list of existing geospatial data layers that include metrics for such measures with national coverage available for sharing among federal agencies*;* identify missing existing measures, adding if available and discussing possible means for using proxies if not available

3. Review high-cut components of flood risk currently in use by USACE and FEMA in national-level portrayals integrating various aspects of flood hazard, performance, exposure, and vulnerability; identify initial high-cut list of possible key components

4. Explore analytical approaches for documenting performance of flood hazard reduction projects (e.g., effects of dams, levees, floodwalls, channels, etc., on flood hazards), taking into account recent advances in dam and levee portfolio management and risk characterization; consider ability to move beyond USACE portfolio, consider ability to reflect environmental projects' effects on flood risk

5. Discuss how the determinants of flood risk (hazard, performance, exposure, vulnerability, consequence) could be characterized on a national scale with a common framework, with options for downscaling to the regional and watershed level

Updated: January 28, 2014

Additional Background Information

Workshop "Success Exercise": outcomes that will have happened if we're happy with what the workshop accomplished; not in any priority order.

- Key federal players involved in identifying flood hazards and their effects (national scale) are aware of each others' efforts and any major distinctions in approaches (NOT that they agree on one approach); initial list of high-cut key components for agencies to consider in a national portrayal of "what is our flood risk" has been identified (NOT inter-agency agreement that these are the "right" or "only" elements, but that the elements are important)

- Key federal players are aware of relevant data layers, agree to share them (or explain what cannot be shared and why), and have contact information

- Participants can readily access any data "missing" to them (contact point, web link, etc., for data layers)

- Consideration has been given to a possible framework that can characterize flood risk on a national/regional scale in a manner consistent with project-oriented risk characterization but applicable to areas where risk is not influenced by structures, and the expected advantages, limitations, and potential use have been explored.

- Utility of proceeding with further USACE national flood risk characterization work has been clarified; intended purposes of proceeding and intended desired usage(s) have been clarified

Appendix 3 - List of Participants

1. Eric Berman, Federal Emergency Management Agency
2. Bill Blanton, Federal Emergency Management Agency
3. Geoff Bonnin, National Weather Service
4. Lisa Bourget, U.S. Army Corps of Engineers
5. Stephanie Bray, U.S. Army Corps of Engineers
6. Tim Cohn, U.S. Geological Survey
7. Mark Crowell, Federal Emergency Management Agency
8. Cynthia Curtis, Environmental Protection Agency
9. Darryl Davis, U.S. Army Corps of Engineers
10. Chris Dunn, U.S. Army Corps of Engineers
11. Siamak Esfandiary, Federal Emergency Management Agency
12. Ignacio Escuder, Spain MAGRAMA representative to USACE partnership
13. Lisa Hair, Environmental Protection Agency
14. Eric Halpin, U.S. Army Corps of Engineers
15. Brian Harper, U.S. Army Corps of Engineers
16. Claudia Hoeft, Natural Resources Conservation Service
17. Victor Hom, National Weather Service
18. Maria Honeycutt, National Oceanic and Atmospheric Administration
19. Jeff Jensen, U.S. Army Corps of Engineers
20. Kevin Long, Federal Emergency Management Agency
21. Dave Moser, U.S. Army Corps of Engineers
22. Jason Needham, U.S. Army Corps of Engineers
23. Pete Rabbon, U.S. Army Corps of Engineers
24. Andrew Read, Federal Emergency Management Agency
25. Karla Roberts, U.S. Army Corps of Engineers
26. Mark Roupas, U.S. Army Corps of Engineers
27. Jerimiah Sanders, Housing and Urban Development
28. Paul Scodari, U.S. Army Corps of Engineers
29. Karen Weghorst, Bureau of Reclamation
30. Kate White, U.S. Army Corps of Engineers

USACE contractor support:

1. Charlie Koch, Abt Associates
2. Mark Lorie, Abt Associates
3. Len Shabman, Resources for the Future

Appendix 4 – Flood Risk Framework by Dr. Dave Moser

Flood Risk Terminology for National Flood Risk Characterization Workshop

Final Draft 2-10-2014

by David A. Moser, Ph.D.

USACE Chief Economist and Dam and Levee Safety Policy and Procedures Teams

Terminology in risk is messy. We need to specify the terms and their usage for our purpose. These are not universal but at least this provides points of reference and common understanding during this endeavor. The vocabulary of flood risk management (FRM) terms below should be kept in mind during presentations and discussions of this workshop. Part I contains terms adapted to the flood risk context while Part II has terms encountered in risk more general discussions.

The development of the vocabulary began with the glossary of terms in ER 1110-2-1156 and the draft levee safety Engineering Circular. Additionally, the Department of Homeland Security "Lexicon of Risk 2010" was consulted as was the "Attachment A: Vocabulary of Flood Risk Management Terms" from the draft report "Improving the U.S. Army Corps of Engineers' Contribution to Flood Risk Management" and the draft IWR report "Principles of Risk Analysis for Water Resources."

Part I.

1. **Flood Risk**. The likelihood and consequences that may arise from inundation by flood water. Flood risk is determined by the following components: flood load (magnitude and likelihood of the hazard); the performance or response of any flood defense system (e.g., levee system – if such is present) to the flood load; the exposure to flood water of the item(s) at risk that might be harmed by flood water (population, property, infrastructure, etc); the vulnerability of the items at risk to harm from flood water; and the resulting measure of the harm, i.e., consequences that result from the flooding event (number of fatalities, dollar economic damages, environmental impacts, etc.).
2. **Flood Risk Assessment**. A systematic, evidence-based approach to qualitatively and/or quantitatively describe one or more determinants or elements of flood risk for assets and people, and the expected effects of flood risk reduction actions on flood risk. Risk assessment includes explicit acknowledgment of the uncertainties in the risk.
3. **Flood Risk Communication**. The process by which flood risk assessment results are disseminated to floodplain occupants and agencies of government for their consideration in decision-making relating to floodplain location and use as well as the choice of actions to reduce flood risk and manage residual risk. More generally risk communication is the open, two-way exchange of information and opinion about hazards and risks leading to a better understanding of the risks and better risk management decisions.
4. **Flood Risk Management**. The mix of federal and non-federal government policies and programs that influence the decisions made by communities and individuals relating to floodplain location and their choice of actions to reduce flood risk and manage residual risk. The term also includes the decisions made by all levels of government and by individuals to implement actions to reduce flood hazard, exposure, and vulnerability as well as to increase resiliency. More generally risk management is the process of problem finding and initiating action to identify, evaluate, select, implement, monitor and modify actions taken to alter

levels of risk, as compared to taking no action. The purpose of risk management is to choose and prioritize work required to reduce risk.

5. **Residual Flood Risk**. The level of flood risk for people and assets located in a floodplain that remains after implementation of flood risk reduction actions. Residual risk includes "transformed risk." Residual risk is often defined as the risk beyond the "level-of-protection" provided by hazard reduction infrastructure. However, level of protection refers only to the return frequency of a specific flood elevation, and so does not include all of the determinants of residual risk.
6. **Transformed Flood Risk**. The change in the nature of flood risk for some area associated with the presence of hazard reduction infrastructure. For example, the presence of a levee system can result in a more sudden inundation of a floodplain location if the levee breaches (with or without overtopping), thus increasing the vulnerability of exposed populations in that location.
7. **Transferred Flood Risk**. A change in flood risk (or financial costs) in one location due to a floodplain location and use choice and/or implementation of a risk reduction action in another location. Transferred risk occurs when floodplain location and use and/or risk reduction actions result in: 1) financial costs for risk reduction actions paid by another entity, such as from general tax revenues of a higher level of government instead of by the floodplain occupants; 2) induced flood hazard in another location, and; 3) diminution of natural functions of floodplains that adversely affect the well-being of others (e.g.,. reduction in recreational fishing success).
8. **Flood Risk Management Strategies**. Actions that are intended to reduce the likelihood or the potential adverse consequences of a future flood. They include actions to reduce the hazard, reduce exposure, and reduce vulnerability, as outlined below.
    a. Reduce the Hazard. Reduce the likelihood of flood water inundating a location, for a given duration, through:
        i. New investments to increase upstream flood water storage (dams, wetlands and floodplain restoration, runoff controls for pervious surfaces) and to secure flowage easements,
        ii. New investments in channels, levee systems, walls, and culvert sizing to keep floodwater away from an area of the floodplain
        iii. Proper O&M, inspection for structural integrity, and rehabilitation of past investments
        iv. Temporary flood-fighting.
    b. Reduce Exposure to the Hazard. Reduce the potential for people and assets to come into direct contact with flood waters that inundate the floodplain through:
        i. Information programs intended to affect floodplain location and use decisions.
        ii. Regulation intended to direct and limit new floodplain land occupancy and use decisions.
        iii. Payments made to relocate assets and associated populations that are currently in the floodplain in order to change floodplain land settlement patterns and use.
        iv. Payments made by landowners (occupancy fees or mandatory insurance premiums) that can influence their floodplain occupancy and use choices
    c. Reduce Vulnerability to the Hazard. Reduce the likelihood that people and assets will realize adverse consequences from their exposure to the flood hazard through:

        i. Cost reimbursements, building codes, insurance premium adjustments to encourage or require flood proofing, building elevation, ring levees, etc.
        ii. Local emergency warning systems, evacuation plans and transportation equipment, and shelters combined with:
            1. Information programs to encourage individual preparedness planning, and
            2. Strategies for enforcing and executing mandatory evacuation, including evacuation assistance.

9. **Residual Flood Risk Management Actions**. Actions that increase the ability of people and assets to recover from floods and minimize the long term consequences of floods. These actions include:
    a. Planning and program design to assure rapid and effective execution of post disaster assistance programs, including:
        i. Post flood counseling
        ii. Rebuilding of public infrastructure
        iii. Emergency aid and recovery assistance.
    b. Increased availability and subsequent purchase of insurance (NFIP/ commercial, crop insurance) to assure larger and more immediate post flood payouts.
10. **Flood Resilience**. The ability to avoid, minimize, withstand, and recover from the adverse effects of a flood.
11. **Flood Risk Robustness**. The ability of a system (physical, social, cultural or economic) to continue to operate correctly across a wide range of flood conditions, with minimal harm, alteration or loss of functionality, and to fail gracefully outside of that range. The wider the range of conditions included, the more robust the system.
12. **Level-of-flood Protection**. A levee design concept that is founded on the principle of providing a high degree of assurance that the levee system will neither breach nor overtop when loaded with a specific recurrence interval flood. The recurrence interval of the flood for this design principle is then used as an expression of the performance of the levee system at the time of design. For the purposes of its use in levee safety documents, this terminology is restricted to applications when discussing design targets or design concepts; it is not to be used as a general expression of levee system performance.
13. **Incremental Risk for Levee Systems**. Incremental risk for levee systems arises when levee system flood defenses do not perform as planned. The flood risk for a leveed area attributed to the levee system in its existing condition is determined by subtracting the without breach flood risk from the flood risk with the levee performing in its existing condition (all failure modes and consequences assessed). As a manner of policy this difference is called the incremental flood risk due to the presence of the levee system. Note that for a floodplain that is non-leveed, there is no infrastructure present to impede the flood hazard from inundating the floodplain, so there is no incremental risk.
14. **Incremental Risk for Dams**. The flood risk to the pool area and downstream floodplain occupants that can be attributed to the presence of the dam should the dam breach prior or subsequent to overtopping, or undergo component malfunction or misoperation. The consequences typically are due to downstream inundation, but loss of the pool can result in significant consequences in the pool area upstream of the dam and loss of other project outputs.

15. **Incremental Consequences**. The consequences for a leveed area attributed to the levee system in its existing condition is determined by subtracting the without breach flood risk from the flood risk with the levee performing in its existing condition (all failure modes and consequences assessed). As a manner of policy this difference is called the incremental consequences due to the presence of the levee system. Note that for a floodplain that is non-leveed, there is no infrastructure present to impede the flood hazard from inundating the floodplain, so there are no incremental consequences. In incremental consequences for a dam are defined in a similar manner.

Part II

1. **Risk Characterization**. Risk characterization is the qualitative or quantitative description of the nature, magnitude and likelihood of the adverse effects associated with a hazard with and without a risk management action. A risk characterization often includes: one or more estimates of risk; risk descriptions; evaluations of risk management options; economic and other evaluations; estimates of changes in risk attributable to the management options.
2. **Uncertainty**. Used to describe any situations without sureness, whether or not described by a probability distribution. In the context of flood risk, uncertainty can be attributed to (i) inherent variability in natural properties and events such as inherent variability in annual peak flood flows, and (ii) incomplete knowledge of parameters, variables, quantities and the relationships between them and the values of interest.
3. **Acceptable Risk**. The level of risk at which, given costs and benefits associated with risk reduction measures, no action is deemed to be warranted at a given point in time (DHS)
4. **Broadly Acceptable Risk**. Risks generally regarded as insignificant and adequately controlled. The levels of risk characterizing this region are comparable to those that people regard as insignificant or trivial in their daily lives. They are typical of the risk from activities that are inherently not very hazardous or from hazardous activities that can be, and are, readily controlled to produce very low risks.
5. **Tolerable Risk**. Tolerable risks are: risks that society is willing to live with so as to secure certain benefits, risks that society does not regard as negligible (broadly acceptable) or something it might ignore, risks that society is confident are being properly managed by those responsible for creating or managing the risk, and risks that those responsible for creating or managing the risk keep under review and reduce and manage still further if and as practicable
6. **Unacceptable Risk**. A level of risk bearing or imposition that cannot be justified except under extraordinary circumstances.
7. **Exposure Assessment**. Exposure occurs when a susceptible asset comes in contact with a hazard. An exposure assessment, then, is the determination or estimation (which may be qualitative or quantitative) of the magnitude, frequency, or duration, and route of exposure.
8. **Individual Risk**. The increment of risk imposed on a particular individual by the existence of a hazardous facility. This increment of risk is an addition to the background risk to life, which the person would live with on a daily basis if the facility did not exist.
9. **Societal Risk**. The risk of widespread or large scale detriment from the realization of a defined risk, the implication being that the consequence would be on such a scale as to provoke a socio/political response, and/or that the risk (that is, the likelihood combined with the consequence) provokes public discussion and is effectively regulated by society as a

whole through its political processes and regulatory mechanisms. Such large risks are typically unevenly distributed, as are their attendant benefits.

10. **Safety**. Safety is thought of as the condition of being free from danger, risk, or injury. However, safety is not something that can be absolutely achieved or guaranteed. Instead safety is the condition to which risks are managed to acceptable levels. Therefore, safety is a subjective concept based on individual perceptions of risks and their tolerability
11. **Variability**. The distribution or spread of values within a natural "population" or data set. This array of possible values in a population is caused by the inherent randomness of natural or social systems. The values in the statistical population have some probability distribution, and only limited knowledge of the entire statistical population and the probability distribution may exist. Sometimes variability is classed as a type of uncertainty although generally it should not be confused or interchanged with uncertainty as defined above. Variability is the notion that there is a range of possible values that will occur and not the lack of knowledge about that range or the distribution of those values.
12. **Risk Identification**. The process of finding, recognizing, and describing potential risks.

Appendix 5 - Flood Risk and Concepts for a National Flood Risk Classification System – Darryl W. Davis and Dale F. Munger

A White Paper - Flood Risk and Concepts for a National Flood Risk Classification System

By Darryl W. Davis, P.E. and Dale F. Munger, P.E.
USACE Dam and Levee Safety Policy and Procedures Teams

1. Preface: This paper is one of several read-ahead documents for the National Flood Hazard and Risk workshop sponsored by the US Army Corps of Engineers (USACE) to be held 25-27 February 2014 in Alexandria, VA. The focus of the paper is flood risk and includes basic definitional and descriptive narrative on what is meant by 'flood hazard' and 'flood risk'. Included are descriptions of the components comprising flood risk, a discussion of a national flood risk classification system, a brief assessment of the sources and availability of information that could support making risk classification assignments, and concluding thoughts on what might come next.

2. What is Flood Risk?: Risk *'is a measure of the likelihood and severity of undesirable consequences'*. Thus, flood risk is used in this paper as the risk associated with flooding of riverine and coastal floodplains, and urban/rural flooding that is the result of impeded drainage. Note here that 'risk' is not 'likelihood, probability, or chance of occurrence' only as is frequently, but improperly, used in some technical documents and the print media. *For example, the statement 'the risk of flooding is 1 in 100' is incorrect.* The correct phase would be 'the likelihood (chance, probability) of flooding is 1 in 100.'

Risk is depicted, for example, as a probability/cumulative density function of exceedance probability and damage/life loss/other undesirable consequence. The risk of interest could be presented as a plot/tabulation of probability of exceedance and consequence; as a complementary cumulative distribution function (F-N diagram used for dam safety; F, annual probability of life loss > N vs. N, life loss); or as an 'average/expected value' of damage/life loss/other undesirable consequence per year, such as average annual life loss.

a. Flood Hazard: Hazard is *'something causing unavoidable danger, peril, risk, or difficulty'*. Thus, flood hazard is used in this paper as describing/depicting the flood that causes the undesirable consequences. For example, flood hazard could be flood extent and likelihood (flood maps); flood depth and likelihood (depth-frequency); flood volume/duration and likelihood (flow-frequency), etc.

b. Inundation scenarios: The inundation of a floodplain area or urban flooding may arise from five inundation scenarios as depicted in Figure 1. Four of the scenarios shown are associated with a floodplain that is leveed and include: 1) levee breaches prior to overtopping; 2) levee overtopping with breach; 3) inundation resulting from drainage impedance and/or malfunction of levee system components, such as gates, pumps or culverts; and 4) levee overtopping without breach. The remaining inundation scenario represents natural/no structural impedance of the flood hazard affecting the floodplain. Risk associated with the breach and component malfunction inundation scenarios arises from the potential poor performance of a levee system. The overtopping without breach scenario is in recognition that there is residual risk with a perfectly functioning levee system. For simplicity, the inundation of urban areas from local excess rain or impaired drainage is conceptually included in the 'Impeded Drainage/Malfunction of Levee System Components' even if a levee is not involved.

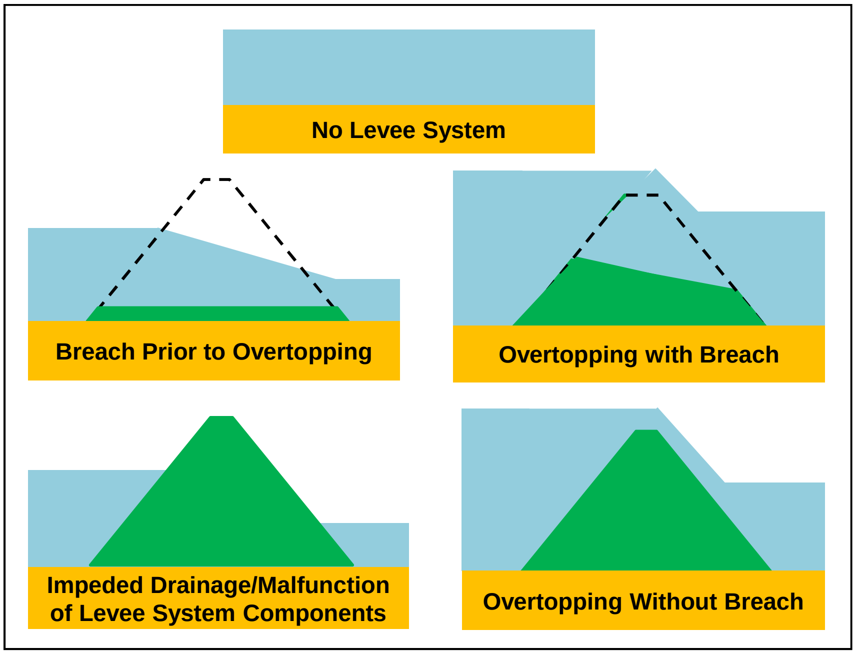


Figure 1 - Flooded Area Inundation Scenarios

c. Components Comprising Flood Risk: Inundated area flood risk is determined by the components depicted in Figure 2.

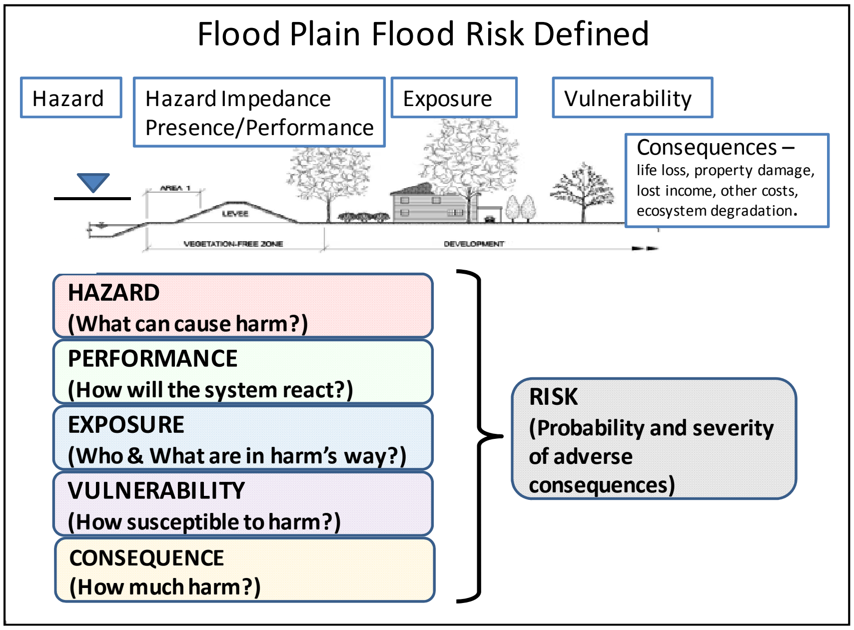


Figure 2 – Components of Inundated Area Flood Risk

These components are: Flood hazard threatening the potentially flooded area (magnitude and likelihood of the hazard); the presence, should such exist, and the performance or response of infrastructure impeding the hazard from flooding the area (e.g. levees/floodwalls); the exposure of the entities at risk (population, property, infrastructure in harm's way); the vulnerability or how susceptible to harm the items are to the hazard; and the consequences (number of fatalities, dollar economic damages, environmental impacts, etc).

Figure 3 below illustrates the relationship between the inundation scenarios and the components comprising flood risk.

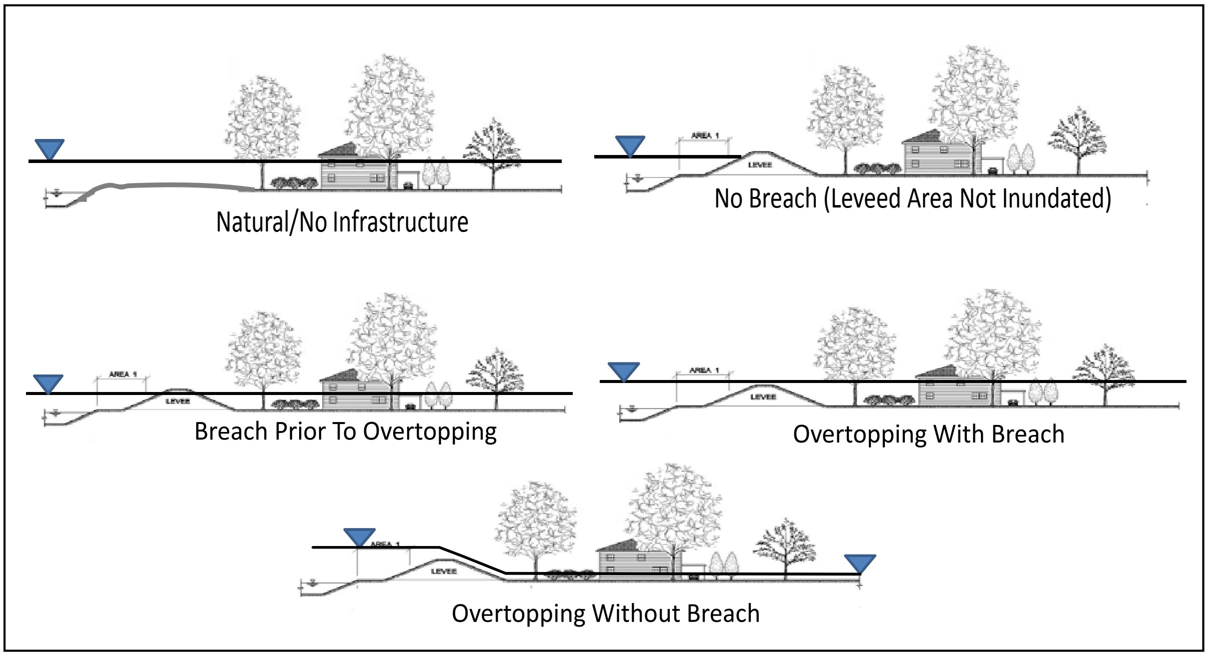


Figure 3 - Schematics Illustrating Relationships Between the Inundation Scenarios and the Flood Risk Components

d. Flood Risk Estimates - Time and Conditions Dependent: It is important to recognize that a risk estimate is performed, and thus represents, conditions at a point in time. The hazard characterization reflects all watershed and stream/shoreline conditions that exist at the time of the estimate, i.e. regulation by upstream reservoirs, status of upstream land use, and conveyance capacity of the associated stream/shoreline. Changes in any of these items over time would result in a change in the hazard, for example, new reservoirs, re-operation of existing reservoirs, de-forestation/urban development and potential climate change. Likewise, the presence/performance of infrastructure such as levee systems and floodwalls reflects impedance of flooding of the potentially flooded area. In the future, such infrastructure may be implemented if it does not presently exist, can be remediated if performing poorly, or removed if no longer deemed useful; the effect of these changes would be reflected in a new risk estimate. Additionally, over time, exposure (people/properties in the potentially flooded area) may change little or increase (new development occurs) or decrease (properties are removed to increase open space) and the effect of these changes would be reflected in a new risk estimate. Vulnerability (susceptibility to harm) could change with time as improved building codes are implemented and plans for temporary evacuation and removal of damageable property are implemented. All these changes would be reasons for revising the risk estimate. Thus, it is important the risk estimate, and associated risk characterization, be identified with the status of each of the risk components that exist at the time of the risk estimate.

e. Residual Flood Risk: The flood risk in the potentially inundated area at any point in time is herein referred to as 'residual flood risk', i.e. the risk that remains. **This is the risk that is to be characterized *and the focus of this workshop***. Figure 4 is a conceptual representation of incremental risk and residual risk for both leveed areas and non-leveed floodplains.

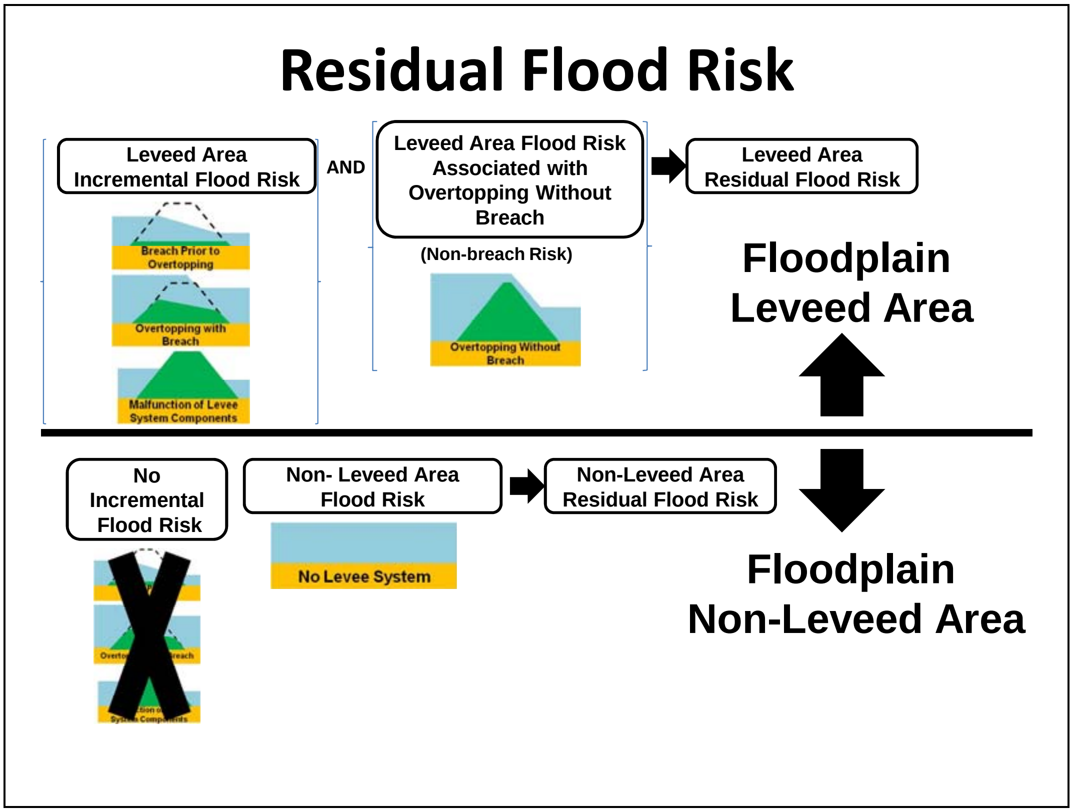


Figure 4 – Definition Sketch – Incremental and Residual Flood Risk

e.1. Incremental Risk: The flood risk for a leveed area attributed to the levee system in its existing condition is determined by subtracting the without breach flood risk from the flood risk with the levee performing in its existing condition (all failure modes and consequences assessed). As a manner of policy this difference is called the incremental flood risk due to the presence of the levee system. Note that for a floodplain that is non-leveed, there is no infrastructure present to impede the flood hazard from inundating the floodplain, so there is no incremental risk.

e.2. Estimating Residual Risk: Residual flood risk is estimated by subjecting the potentially inundated area to flood events ranging from threshold of area flooding to floods substantially inundating the area, including capacity exceedance/overtopping if infrastructure is present. The likelihood of each event is tabulated with the corresponding consequences. This data represents the likelihood–consequence function (residual risk) for the area. This function can be integrated to yield an expected annual consequence as average annual property losses, average annual life loss, and average annual environmental and social losses.

e.3 Accounting for Other Flood Risk Management Infrastructure: Residual flood risk also includes accounting for the effect of potential failure of other infrastructure that may affect the floodplain of interest (i.e. upstream dams, upstream or adjacent levees, improved channels, etc). The potential for these other structures to not function as intended contributes to the residual flood risk. This potential of increased risk due to other infrastructure failure or poor performance is most often not considered for reasons of practicality and complexity. If such external (to the floodplain under consideration) failures or otherwise poor performance were to be included, the strategy would be to reflect such circumstances in the 'hazard' component of risk (magnitude and likelihood of the hazard).

f. Complexity of Flood Risk: The spatial variability of flooding and associated consequences are quite complex. Flood depths from inundation of an area often vary from quite deep near where the flood enters the potentially flooded area (near the stream or shoreline) to feathering to zero at the inundated area boundary, and is often quite variable throughout the area as a result of the topography. For example low areas away from the flood boundary may be flooded the deepest. Depth of inundation is the primary parameter that describes the magnitude of flooding and most often is used as a predictor of consequences. Other factors such as velocity, duration, and debris content on the hazard side play a role in estimating losses but are rarely directly included in assessments. The response to inundation of buildings (referred to as fragility), people, and other consequence items of interest are also highly variable and may be functions of locality (local customs), demographics, and season. Losses and recovery are also affected by other factors such as where the population is in the floodplain, warning times, road capacity and access for egress, and if a levee present, where it overtops or breaches, and how many properties are insured. Figure 5 is a shaded depth map that illustrates the variability of the hazard in an inundated area.

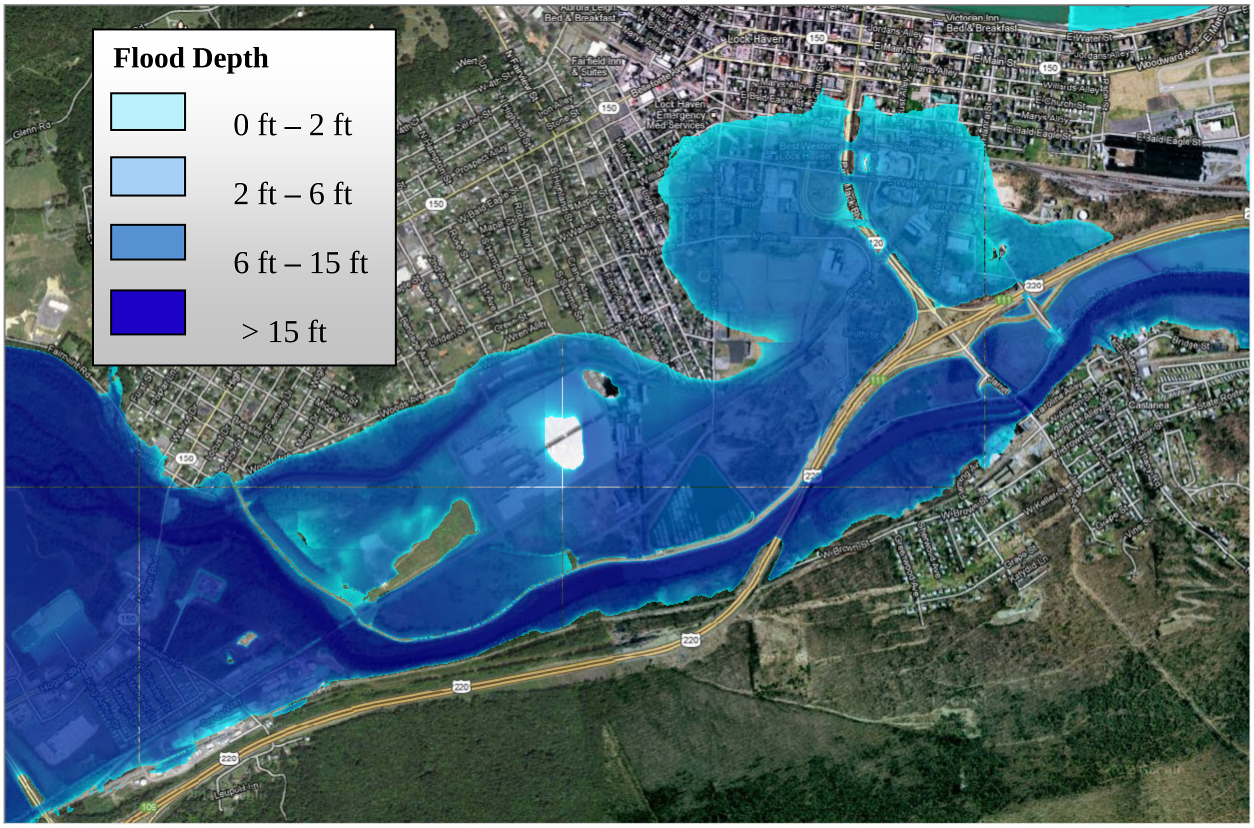


Figure 5 – Example Levee Overtopping Shaded Depth Map

3. Hazard and Risk Depiction: Flood hazard has been mapped for decades. The maps typically show the flood boundary for a specific flood (e.g. 1% annual chance exceedance (ACE) event) overlaid on an aerial photograph or topographic map. At times, several events are depicted on the same map, such a 2%, 1%, .5% and .2% ACE with depth zone color coded, usually different intensities of blue similar to Figure 5. These maps do not display risk but they contain information that is foundational to estimating and displaying risk and are available from various Federal and local agency sources throughout most of the US. Maps displaying flood risk are much less common, just recently being proposed by FEMA as a product of their 'RiskMap' program (FEMA 2012). The maps are planned to display an estimate of likelihood and flood damage losses – see Figure 6. The USACE dam and levee safety programs assess life-safety risk and this life-safety risk could be mapped and likely will at a future time. None-the-less, Figure 7 depicts a step towards a life-safety risk map (life loss in dot form); the map shows estimated life loss for an extremely rare event (dam failure at full pool).

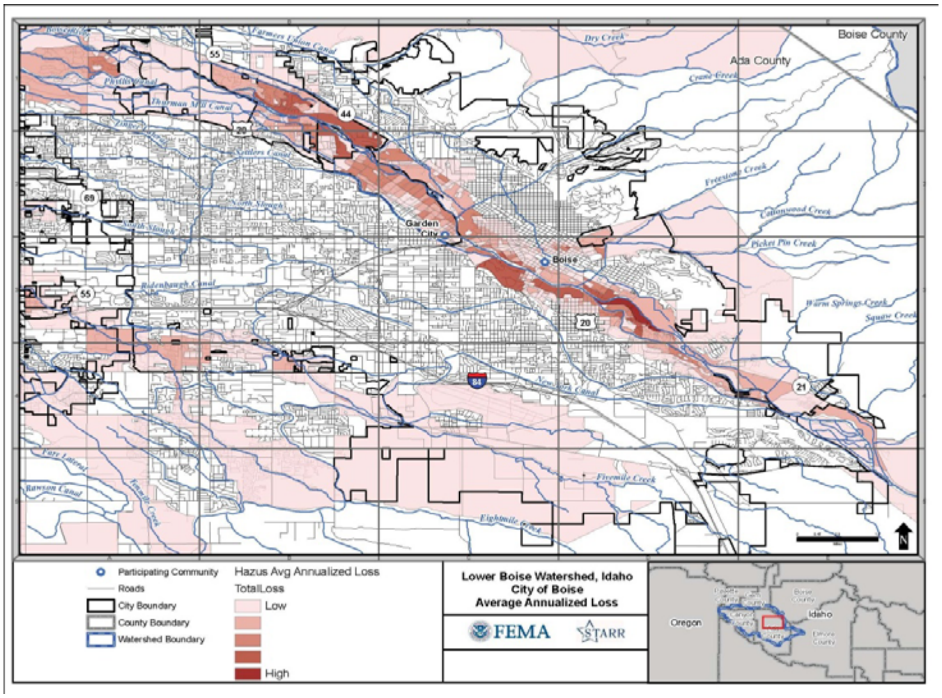


Figure 6 – Flood Risk Depiction Taken from FEMA RiskMAP Slide Set (dated 11/7/2012)

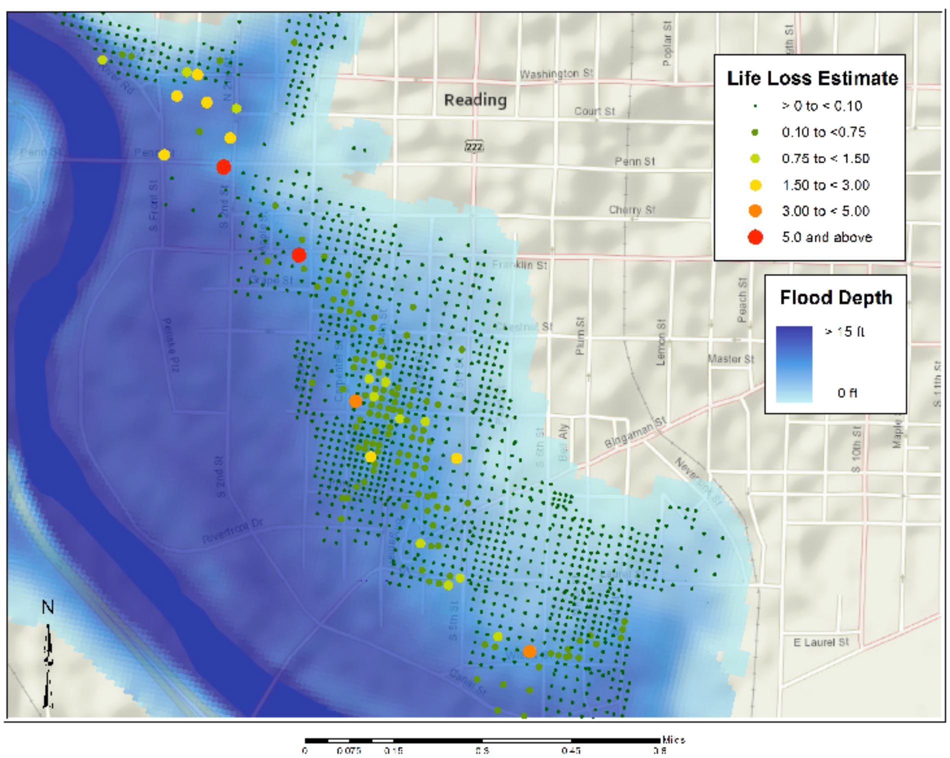


Figure 7 – Example - 'Towards' a Life Safety Risk Map

The scale at which the risk assessments are performed and displayed is important to the utility of the results for decision making. For national flood hazard and risk characterization – the focus of this workshop – the hope is to deliver the risk assessment results not at the project scale, but at regional/watershed scales yet to be defined. This scale concept was chosen to support broad budgeting and policy decisions rather than justifying or supporting specific project investments, although in the end, the budgeting/investments would often be for project-level activities. A key question for this workshop is, "Is it possible (or desirable) to aggregate or roll up results from local, more detailed assessments to display at the regional level or should we seek to develop surrogates for the detailed floodplain/project scale risk assessments and perform the assessments at the more aggregate or regional scale?"

4. Characterizing National Flood Risk by Application of Risk Classification: Risk information in its basic form (likelihood and consequences) is useful in its own right, but may also be translated to risk classification systems as a means of providing a standardized, comparable scale reflecting a 'value interpretation' of the risk data.

a. Examples of Classification Systems: Selected examples of hazard and risk classifications systems include:

a.1. Saffir-Simpson' Hurricane Scale: Five categories comprise the scale - 1 (75 mph) through 5 (155 mph) reflecting mostly wind velocities but implying damage potential as well. This is a widely recognized and media used scale. Its use has recently been questioned as to whether is reasonably depicts potential damage to property and threat to life.

a.2. NASA's Torino Impact Hazard Scale: The Torino Scale (Figure 8) (NASA 2005) reflects likelihood of categories of Earth asteroid impacts and appropriate consequences/actions (graphic representation of scale reproduced below). Each category has a paragraph narrative describing the likelihood, certainty/uncertainty of collision, energy released, scale of impact and appropriate response. Two narrative paragraphs are tabulated below the figure (scale Nos. 5 and 9). The complete narrative may be found at: http://neo.jpl.nasa.gov/torino_scale1.html.

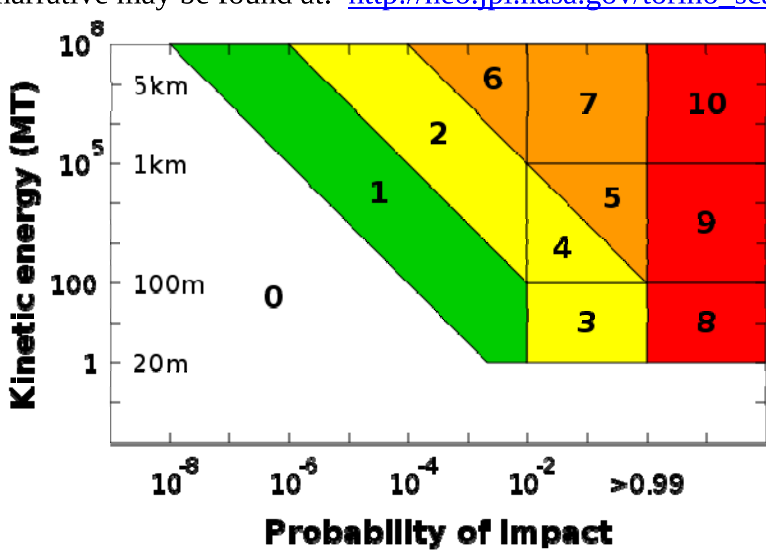


Figure 8 - Torino Impact Hazard Scale

5 – Threatening: *A close encounter posing a serious, but still uncertain threat of regional devastation. Critical attention by astronomers is needed to determine conclusively whether or not a collision will occur. If the encounter is less than a decade away, governmental contingency planning may be warranted.*

9- Certain Collisions: *A collision is certain, capable of causing unprecedented regional devastation for a land impact or the threat of a major tsunami for an ocean impact. Such events occur on average between once per 10,000 years and once per 100,000 years.*

a.3. USACE Dam and Levee Safety Action Classification Systems: These classification scales range from 1 (highest urgency) to 5 (lowest or normal urgency) with corresponding recommended actions that are appropriate to the class. The classifications are informed by risk characteristics that are associated with each class. The acronyms are Dam Safety Action Classification (DSAC) and Levee Safety Action Classification (LSAC). The scales, actions, and risk characteristics are similar but reflect the distinct differences between risks associated with dams and levee systems. A simplified representation of the LSAC is depicted in Table 1. The full LSAC table is appended to this paper. Risk (likelihood and consequences) forms the basis for the classification systems. A process for risk information development, interpretation, and synthesis is in place and tested. Key to the practicality and credibility of the resulting classifications is the structured vetting process within USACE (USACE 2014a). The participants and roles in the process are:

1) A multidiscipline field office team compiles data, performs risk assessments, and enters data into a record system;

2) A national cadre of experts reviews the findings, considers input from the USACE Risk Management Center (USACE 2014), and recommends a classification for each levee system segment/project;

3) A Senior Oversight Group (SOG) that includes selected HQUSACE leadership and leadership of Communities of Practice reviews the recommendations in an open dialogue with field office project representatives and then the SOG forwards its recommendations to -

4) The USACE Dam and Levee Safety Officer, who has final approval authority for the classifications.

The SOG considers an established protocol (also attached, which is a companion to the LSAC table) that guides adjusting the recommended classifications based on their deliberations. It is important to note that criterion have been adopted (Tolerable Risk Guidelines (TRG)) for life loss – see (USACE 2010) – as a background guide for the classification assignments. While the TRG was derived and intended for application to the 'incremental risk' – the risk due to the presence of a structure – considering its application for a national flood risk classification seems reasonable.

Levee Safety Action Classification		
Urgency of Action	Actions	Characteristics
Very High (1)	Actions recommended for each class.	Likelihood of inundation with associated consequences characterizes each class.
High (2)		
Moderate (3)		
Low (4)		
Normal (5)		

Table 1 – Simplified Version of the USACE Levee Safety Action Classification Table

b. Potential for Extending the USACE Levee Safety Program Classification Scheme to a National Flood Risk Classification: The needed adjustments from the USACE action classification system to a national flood risk classification are: include non-breach and no infrastructure risk inundation scenarios (therefore the risk assessment is to focus on the residual risk); accepting the background life loss criterion reflected by the TRG; and devising a similar tolerability of risk criterion for property losses – this does not yet exist although economic loss is considered in making DSAC/LSAC classification assignments. The classification system would incorporate assessment of the risk arising from all five inundation scenarios as noted in paragraph 2.b; would use a similar scale of five risk and action levels as adopted for use in the DSAC/LSAC system, and would make use of background life loss criterion as the basis for a tolerable risk level. The TRG to be referred to is documented in (USACE 2011a). It would be desirable that a companion background property loss criterion, as mentioned above, also be developed and adopted. There would be tabular and graphical representations of the classification scheme. Table 2 is a simplified version of a Flood Risk Classification table analogous to the LSAC table. Much of the narrative contained in the appended LSAC table would be applicable for the Flood Risk Classification table.

A risk matrix similar to that in Figure 9 reflecting the tolerable risk criterion would help guide the classification assignments and provide a visual means of displaying and communicating the flood risk. A protocol would be developed for interpreting the risk assessment information and adopting a risk classification – akin to the protocol that is employed for the LSAC assignment. The classifications would be accomplished at the floodplain scale where data is available.

Flood Risk Classification		
Risk Classification	Actions	Characteristics
Very High (1)	Actions recommended for each class.	Likelihood of inundation with associated consequences characterizes each class.
High (2)		
Moderate (3)		
Low (4)		
Very Low (5)		

Table 2 - Simplified Version of an Example Flood Risk Classification Table

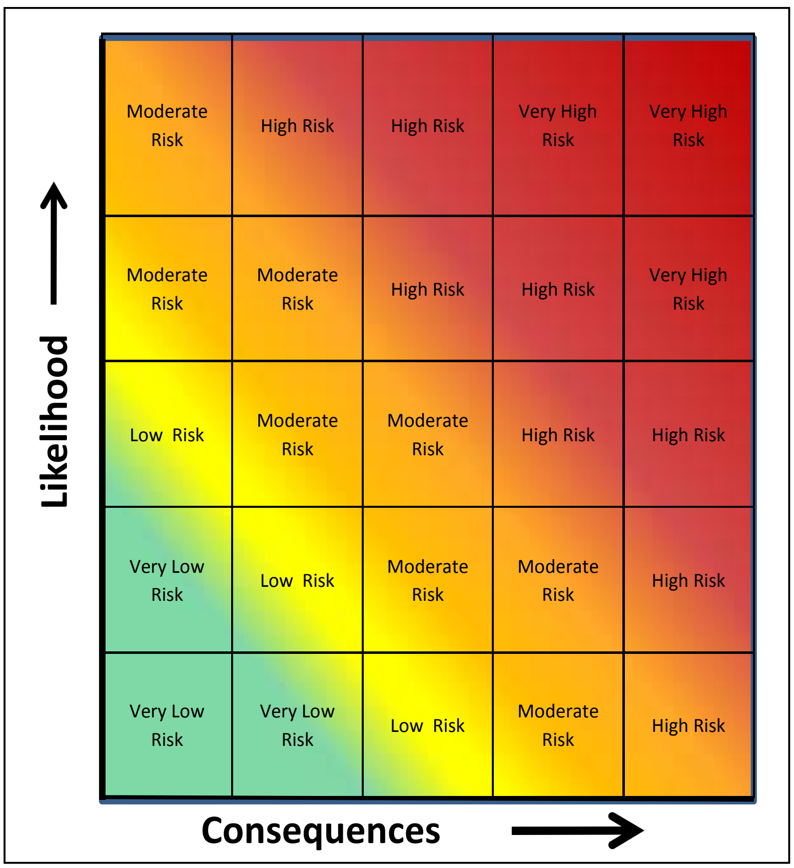


Figure 9 – Risk Matrix

5. Considerations in Implementing a National Flood Risk Classification system: Discussion of key aspects of implementing a national flood risk classification system follows.

a. Project/Floodplain Specific Approach: The concept of developing and applying a risk classification system at the project/floodplain scale has been successfully demonstrated for both the USACE dam and levee safety programs. The extension to incorporate non-breach risk and no infrastructure (e.g. no levee system present) risk in the classification system is straight forward – apply the existing classification process but instead of the metric being 'incremental risk', the metric would be 'residual risk'. For the safety programs, the risk assessment is performed at a scale in which the floodplain is segmented as needed for adequate representation. Interpretation of the data is then project/floodplain specific – the intent of the classifications. While the data is geo-referenced, it does not constitute a continuous GIS layer as is usually the circumstance for displaying spatial information at a more regional scale like HUC codes, counties, basins, etc.

A fundamental issue then is, "Can the project/floodplain specific risk characterization be rolled up to regional basin scales?" A significant attribute of the USACE project/floodplain specific classification approach is that it enables capturing flood risk reduction infrastructure performance (the increment of increased risk due to likelihood of breach and overtopping) along with the non-breach risk – thus the residual risk at what might be called the sub-basin level. What is needed is an approach to aggregating these classifications on a basin wide (HUC 8) or regional scale that links the project interdependencies as a "system" within a region or basin. This poses a significant challenge and does not yet exist. The challenge would be sorting out a scheme to address the complexities noted in paragraph 2.f. above – the spatial variability of flooding and associated consequences. The un-aggregated flood risk information at the project scale will be available for much of the flood threatened and leveed areas in the US over the next five years, and could serve as a valuable initial test of the utility of the classifications for regional/basin interpretations. When the USACE dam and levee safety programs screening-level risk assessments are completed (perhaps by end of 2019, funding dependent), there will be significant gaps in the coverage for the US as a whole because the safety programs are limited to the USACE portfolio of dams and levees. The approximate floodplain coverage within the US by the USACE dam and levee safety risk assessment performed in support of USACE dam and levee safety program risk classifications and Corps Water Management Systems (CWMS) (USACE 2011b) has not as yet been compiled in map form. Suffice it to say that the gaps are likely significant given that USACE levee system portfolio covers about 15,000 miles and there is estimated to be more than 100,000 miles of levees in the US.

b. GIS layer approach: An alternative approach is to perform the flood risk assessment and consequent risk classification from a GIS-like approach. For example:

- GIS layers of flood depths for a range of frequency floods assuming the flood risk reduction infrastructure (if present) functions perfectly (this does not presently exist on a wide-spread basis, but it is believed this is within the capability of HAZUS Flood (FEMA 2011);
- Population location and density (exists in generalized form in Census file/HAZUS);
- Property location and density (ditto for Census files/HAZUS);

- Flood risk reduction infrastructure of dams and levees; and
- Social and environmental surrogate layers.

GIS-based analysis as performed with FEMA's 'HAZUS Flood', USACE National Flood Risk Characterization Tool (NFRCT) (USACE 2011), or USACE software supporting the dam and levee safety programs and CWMS implementation (USACE 2014b) would then be performed to derive risk (economic, life loss, other parameters) spatially within floodplain and urban areas. Note that while these software systems are capable of estimating economic flood losses, the capability to estimate life-safety risk does not presently exist for HAZUS and NFRCT, but does exist in the USACE CWMS software suite. The risk classification system would then be applied to the risk assessment results at the scale the risk is computed, or at a more aggregate scale yet to be determined for life-safety risk and economic risk. As noted before, ideally, economic loss criterion would need to be developed for economic damage. Thus, at least these two 'flood risk classification' GIS layers would be developed. Some important caveats: the risk calculations need to be credible and defensible (a tall order given the coarseness of the nationally available topographic data and calculation schemes now used in the cited GIS-based tools); a way is needed to include flood risk reduction infrastructure in the GIS risk calculation schema if the capability does not exist; and a way is needed to include potentially poor performance of the infrastructure if the capability does not exist. To be complete, GIS layers that reflect social and environmental losses, or surrogates, would also be desirable.

The GIS layer application setting also adds another dimension worth consideration. The setting for a typical 'basin' or 'region' would likely have a number of sub-basins, some with reservoir storage (USACE and others), and some sub-basin floodplains with levee systems (USACE and others) and others not leveed. An aggregating or weighting approach would need to be devised to be able to assign a 'classification' for the aggregate basin – such does not yet exist. In other words, with a mix of infrastructure spatially distributed across the basin, and consequently the flood risk for floodplains likewise varying spatially, some scheme would be needed to devise a 'representative' risk for the basin.

It is recognized that while the focus of this GIS approach discussion has been on flood risk classification, other GIS layers of flood hazard, built environment, social vulnerability, critical infrastructure, and maybe some others, are necessary to contribute to a complete understanding of the nation's flood hazard and flood risk. The 'classification' layers would be intended to provide a degree of interpretation of the data in a more aggregate sense. On the topic of aggregation, the scale at which aggregation becomes un-informative is also an important consideration – states and counties likely being questionable because the aggregation scale is generally too large and/or river/watershed boundaries often do not follow political boundaries. Clearly some investigation and experimentation is in order. We acknowledge the desire for displaying the risk and classifications at the local, county, state, tribal, and national levels to facilitate the communication of the flood risk to all stakeholders, but how that might be meaningfully accomplished is open for discussion.

c. Data sources and availability: The main sources of data for flood risk assessment and classification on a national scale include, but are not limited to:

- FEMA HAZUS data sets;
- FEMA flood insurance and other mapping products (DFIRMS, RiskMap);
- US Census tract files;
- Others such as NOAA coastal data, satellite imagery, etc.;
- USACE dam and levee safety program's data layers, risk assessment results, and floodplains with associated LSAC assignments;
- Other USACE - National Levee Data Base (NLD) (USACE 2014c), Corps Water Management System CWMS), and Flood Risk Management studies.

Note that some of the data sets are mostly complete for the nation (HAZUS, Census tracts, DFIRMS for most populated areas), while others will cover only parts of the nation when complete (USACE dam/levee safety programs, NLD), and other are just beginning (CWMS, RiskMap).

6. What Might Come Next

a. Near term:

a.1. Commission exploratory pilot studies for: 1) the GIS Layer Risk Characterization approach; 2) the Project/Floodplain Specific Risk Characterization approach; and 3) other approaches as might emerge from workshop deliberations. Closely link the pilot studies so that there would be a joint effort to develop an aggregation approach that would enable potential adaptation of the approaches into a combined process for generating regional flood risk classifications.

a.2. Identify several watersheds/basins where each of the pilot efforts would be applied, and the aggregation approach jointly conceived could be tested. Pilot test the proposed classification systems for life-safety risk in these selected geographic areas – where sufficient supporting data exists, likely where potentially flooded area risk assessments have been performed. This test would include flood risk classification at the same scale as the screening level risk assessments performed for the levee safety program; and an attempt at flood risk classification at a more aggregated or basin/regional scale using the same basic risk assessment data.

a.3. Convene a 'lessons learned – way forward' workshop in 18 months to two years comprised of roughly the same workshop participants as this one to review the pilot tests outcomes and assess future actions.

b. Long term:

b.1. Monitor progress of the on-going flood risk assessment activities in the dam and levee safety programs, FEMA RiskMap project and/or implementation of the National Research Council recommendation to move the NFIP to a risk-informed program; and CWMS implementation.

b.2. Implement national flood risk characterization efforts beyond the pilots when monitoring of progress of ongoing project/floodplain risk characterization as progressed sufficiently to proceed.

7. References

FEMA (2011). Federal Emergency Management Agency. “Multi-hazard Loss Estimation Methodology, Flood – HAZUS MH Users Manual”. September 2011.

FEMA (2012). Federal Emergency Management Agency’s “Risk Mapping, Assessment, and Planning (Risk MAP) Fiscal Year 2012 Report to Congress”. February 23, 2012.

NASA (2005). National Aeronautics and Space Administration. “The Torino Impact Hazard Scale". NASA/JPL Near-Earth Object Program Office. 13 Apr 2005.

USACE (2010). US Army Corps of Engineers. “Exploration of Tolerable Risk Guidelines for the USACE Levee Safety Program”. USACE Institute for Water Resources. March 2010, (10-R-8).

USACE (2011). US Army Corps of Engineers, Institute for Water Resources. “National Flood Risk Characterization Tool, Model Documentation”. 21 November 2011.

USACE (2011a). US Army Corps of Engineers. Engineering Regulation, ER 1110-2-1156, Safety of Dams – Policy and Procedures. October 2011.

USACE 2011b). US Army Corps of Engineers “Accelerated Corps Water Management System (CWMS) Deployment Campaign, under the American Recovery and Reinvestment Act”. Institute for Water Resources, Hydrologic Engineering Center. August 2011.

USACE (2014). US Army Corps of Engineers, Institute for Water Resources, Risk Management Center. Website: http://www.iwr.usace.army.mil/About/TechnicalCenters/RMCRiskManagementCenter.aspx.

USACE (2014a). US Army Corps of Engineers. Levee Safety Program. Website: http://www.usace.army.mil/Missions/CivilWorks/LeveeSafetyProgram.aspx.

USACE (2014b). US Army Corps of Engineers, Institute for Water Resources, Hydrologic Engineering Center. Website: http://www.hec.usace.army.mil/software/.

USACE (2014c). US Army Corps of Engineers. Website: http://nld.usace.army.mil/egis/f?p=471:1:.

USACE Levee Safety Action Classification Table* 17 Jan 2014 * At any time, a levee system from any action class can become an emergency requiring activation of the emergency action plan.		
Urgency of Action (LSAC)	Actions for Levee Systems in this Class *(Adapt actions to specific levee system conditions.)* *Additional actions in 1) apply to USACE Operated and Maintained Levee Systems; and actions in 2) apply to Levee Systems Operated and Maintained by Others in USACE Program*	Characteristics of this Class
Very High (1)	Immediately inspect levee system; assure O&M is up to date; communicate risk findings to sponsor, state, Federal, Tribe, local officials, and public; stress improved floodplain management to include: verification that warning, evacuation and emergency action plans are viable; flood inundation maps are current; there is an active community hazard awareness program; recommend purchase of flood insurance; and vigilant levee monitoring program is in place. Support portfolio priorities for risk reduction actions. 1) Take urgent action to reduce the likelihood of a breach and mitigate consequences through implementation of interim risk reduction measures. 2) Responsible entity to implement interim risk reduction measures.	Likelihood of inundation due to breach and/or system component failure in combination with loss of life, economic, or environmental consequences results in very high risk. USACE considers this level of life-safety risk to be unacceptable except in extraordinary circumstances.
High (2)	Inspect levee system; assure O&M is up to date; communicate risk findings to sponsor, state, Federal, Tribe, local officials, and public; stress improved floodplain management to include: verification that warning, evacuation and emergency action plan are viable; flood inundation maps are current; there is an active community hazard awareness program; recommend purchase of flood insurance; and vigilant levee monitoring program is in place. Support portfolio priorities for risk reduction actions. 1) Take immediate action to implement interim risk reduction measures. 2) Responsible entity to implement interim risk reduction measures.	Likelihood of inundation due to breach and/or system component failure in combination with loss of life, economic, or environmental consequences results in high risk. USACE considers this level of life-safety risk to be unacceptable except in extraordinary circumstances.
Moderate (3)	Verify inspection is current; assure O&M is up to date; communicate risk findings to sponsor, state, Federal, Tribe, local officials, and public; stress improved floodplain management to include: verify that warning, evacuation, and emergency action plan are viable; flood inundation maps are current; there is an active community hazard awareness program; and routine levee monitoring program is in place; recommend purchase of flood insurance; and develop and execute levee monitoring program. Support portfolio priorities for risk reduction actions. 1) Implement interim risk reduction measures; schedule development of risk reduction studies. 2) Responsible entity to develop interim risk reduction and risk remediation plans.	Likelihood of inundation due to breach and/or system component failure in combination with loss of life, economic, or environmental consequences results in moderate risk. USACE considers this level of life-safety risk to be unacceptable except in unusual circumstances.
Low (4)	Verify inspection is current; assure O&M is up to date; communicate risk findings to sponsor, state, Federal, Tribe, local officials, and public; stress improved floodplain management to include: verify that warning, evacuation, and emergency action plan are viable; flood inundation maps are current; there is an active community hazard awareness program; and routine levee monitoring program is in place; recommend purchase of flood insurance; develop and execute levee monitoring program. Support portfolio priorities for risk reduction actions. 2) Responsible entity to develop risk remediation plans.	Likelihood of inundation due to breach and/or system component failure in combination with loss of life, economic, or environmental consequences results in very low to low risk. USACE considers this level of life-safety risk to be in the range of tolerability but does not meet all essential USACE guidelines.
Normal (5)	Continue routine levee safety activities, operation and maintenance, normal inspections, stress improved floodplain management to include: annually ensure that warning, evacuation and emergency action plan are functionally tested; recommend purchase of flood insurance; maintain levee monitoring program.	Likelihood of inundation due to breach and/or system component failure in combination with loss of life, economic, or environmental consequences results in very low to low risk and the levee system meets essential USACE guidelines. USACE considers this level of life-safety risk to be tolerable.
Incremental risk is the risk that exists due to the presence of the levee system and this is the risk used to inform the decision on the LSAC assignment. The information presented in this table does not reflect the overtopping without breach risk associated with the presence or operation of the levee system.		

<table>
<tr><th colspan="4">Protocol: Levee Safety Action Class (LSAC) Adjustment Guidelines</th></tr>
<tr><th colspan="2">URGENCY OF ACTION (LSAC)</th><th colspan="2">Reasons to adjust Levee Safety Action Class</th></tr>
<tr><td>VERY HIGH
(1)</td><td></td><td colspan="2">To Class 'High Urgency - 2'
• Studies/Investigations do not support suspected defect or failure mode.
• Consequence estimate considered too high (order of magnitude) and not reasonably defensible.
• Primary risk driver is overtopping and breach due to overtopping.
• Extreme risk is not supported.</td></tr>
<tr><td>HIGH
(2)</td><td></td><td>To Class 'Very High Urgency - 1'
• Flood fighting was required during a past event that successfully prevented a breach in progress from continuing to full breach status, thus averting a catastrophe.
• Consequences of inundation, including vulnerable critical infrastructure in leveed area, could result in significant local, regional, and national consequences beyond those reflected by the current estimate.</td><td>To Class 'Moderate Urgency - 3'
• Primary risk driver is breach due to overtopping for extremely infrequent events.
• History indicates good performance for loadings at or near top of levee.
• Egress well planned; population less vulnerable than suggested by current estimate.
• Minimal critical infrastructure.</td></tr>
<tr><td>MODERATE
(3)</td><td></td><td>To Class High Urgency (2)'
• Flood fighting required past events for failure modes that could lead to breach prior to overtopping.
• Field observations indicate signs of distress.
• Project has high potential failure mode risks that are credible.
• Inundation includes vulnerable critical infrastructure in leveed area that could result in significant local, regional, and national impacts beyond those reflected by the current estimate. Life risk moderate to high.
• Effectiveness of prior repairs is questionable.</td><td>To Class 'Low Urgency – 4'
• Primary deficiency is breach during overtopping for very infrequent events.
• Primary risk driver is overtopping and breach during overtopping is unlikely.
• Low potential failure mode risk that is defensible.
• Consequences and life-risk low to very low.
• Economic impact manageable at local and state levels.</td></tr>
<tr><td>LOW
(4)</td><td></td><td>To Class 'Moderate Urgency - 3'
• Data supporting risk estimate (likelihood and consequences) highly uncertain.
• Life-loss threat not well represented in risk assessments and highly uncertain.
• Floodplain undergoing rapid urban expansion.
• Levee system aged yet relatively untested by flood event.
• Consequences of inundation, including vulnerable critical infrastructure in leveed area, could result in significant local, regional, and national consequences beyond those reflected by the current estimate. Life risk moderate.</td><td></td></tr>
<tr><td>NORMAL
(5)</td><td></td><td colspan="2">N/A</td></tr>
</table>

Appendix 6 – Summary of Federal Flood Risk Programs

Federal Flood Risk Programs – for discussion purposes only.

For a program to be included the agency program description had to assert that the principal program mission is flood risk reduction and management, that program execution relied on flood risk mapping and/ or flood risk assessment, or that the program mission was to provide such risk information.

Program	**Mission**	**Risk mapping and/ or Risk Assessment as part of program execution**
FEMA		
National Flood Insurance Program	Provides an opportunity for property owners in communities that choose to participate in the NFIP to purchase insurance to offset damages realized from flooding. Some purchase is mandatory and some purchase is voluntary.	FEMA approves maps that designate flood levels in different areas of the floodplain, with emphasis on the 1% change flood event. Insurance premiums are based on individual property risk ratings that take into consideration individual building base flood elevations, in relation to those levels, within areas of the flood plain.
Pre-Flood Hazard Mitigation Planning and Grants (various programs)	Programs provide assistance to local communities and individual property owners within those communities to help them plan for and then take actions that reduce flood exposure and vulnerability to flood damages and accelerate post flood recovery. The mitigation grants component provides financial assistance (channeled through governments) intended to reduce flood damages, with a focus on reducing claims on the NFIP.	In support of these programs, as well as the NFIP – see above- FEMA has in place tools (HAZUS) and programs Risk MAP that allow communities to do original analysis of their flood risk. Risk MAP proposes to provide consistent, quantitative risk assessments for riverine and coastal areas, in support of, but not limited to, the need to continually update maps for use in the NFIP. FEMA also requires an original benefit - cost assessment by applicants who apply for a mitigation grant.
Post Flood Disaster Assistance	FEMA may provide post flood recovery assistance, as allowed by specific processes and regulatory guidelines, to individuals and to public facilities in communities. At times funding for that aid is made through emergency supplemental appropriations.	Criteria for disbursement of aid and the uses of that aid rely on existing understandings of flood risk in specific places.
HUD	HUD offers immediate post flood recovery	HUD relies on mapping and risk assessments of other

Federal Flood Risk Programs – for discussion purposes only.

For a program to be included the agency program description had to assert that the principal program mission is flood risk reduction and management, that program execution relied on flood risk mapping and/ or flood risk assessment, or that the program mission was to provide such risk information.

(Various post flood assistance programs)	assistance to communities and individuals in the form of grants and loans. After Katrina/Rita and Sandy Congress authorized significant sums for the Community Development Block Grant Program for recovery and for building community resilience against future storms. These funds are dispersed in response to grant requests, with accompanying spending plans, prepared and submitted by nonfederal governments.	agencies in making post flood recovery grants.
NOAA	NOAA has a number of products that provide data for use by others or analyses of data (modeling) that can be used for characterizing flood risk and for the conduct of risk assessments. These products include: data, warnings and forecasts of the National Weather Service and coastal inundation modeling and forecasting.	There are a number of NOAA programs that provide, or can be used by others to create, original analyses flood risk and risk reduction and management measures at the project scale and at the larger watershed/ community scale.
TVA	TVA is an independent agency is responsible for dam and levee operations and maintenance and dam safety. It also has a long standing technical assistance program in floodplain management.	TVA relies on its river forecast center and continues to do original analyses of place specific flood risk, and risk reduction and management measures, with a geographic scope limited to the Tennessee River drainage. TVA is not joining the USACE and BOR in doing original analyses of dam failure risk and consequences, and risk reduction and management measures at the project scale.
USACE		
Flood and Coastal Storm Damage Reduction	Participate, with non-USACE partners, in planning and then funding investments to reduce flood and coastal storm risk.	Original analyses of place specific flood risk and risk reduction and management measures at the project scale.
Dam Safety Program	Evaluate risk of failure in USACE constructed	Original analyses of dam failure risk and consequences,

Federal Flood Risk Programs – for discussion purposes only.

For a program to be included the agency program description had to assert that the principal program mission is flood risk reduction and management, that program execution relied on flood risk mapping and/ or flood risk assessment, or that the program mission was to provide such risk information.

	dams and then prioritize funding within the USACE budget for investments to reduce that risk.	and risk reduction and management measures at the project scale.
Levee Safety Program	Still evolving program to assess and then report the life safety risk associated with the USACE portfolio of levees.	Original analyses of life safety risk from failure of, or overtopping of, levees, at the project scale, relying in part on the levee inspections conducted under the Rehabilitation Program.
Technical and Planning Assistance (various programs)	Provide advice on place specific flood risk, on risk reduction and management alternatives and on federal flood risk reduction and management programs.	Relies on providing access to and interpretation of existing flood risk information.
Rehabilitation Program	Flood hazard reduction projects are enrolled by their owners in the Rehabilitation Program under PL 84-99. Once it is determined that the project meets all necessary eligibility criteria, it becomes eligible to receive repair funds if damaged in a flood event. At times funding for that aid is made through emergency supplemental appropriations.	USACE inspections of projects enrolled in the Rehabilitation Program can be interpreted as a form of risk assessment, focused on the structure itself. Results from the inspections may be used by FEMA for SFHA levee accreditation purposes.
USBOR	USBOR has responsibility for dam operations and dam safety for projects it has built and now operates in the 17 western states. Flood risk reduction may be a purpose in a BOR multipurpose project. The BOR has a limited number of activities related to flood risk reduction and management outside of dam operations.	BOR does original analyses of dam failure risk and consequences, and risk reduction and management measures at the project scale.
USDA	Authorized program called watershed and flood prevention operations (a legacy of the PL 566	Historically had relied on original analyses of place specific flood risk, and risk reduction and management

For a program to be included the agency program description had to assert that the principal program mission is flood risk reduction and management, that program execution relied on flood risk mapping and/ or flood risk assessment, or that the program mission was to provide such risk information.

	small watershed program) may provide technical assistance for assuring the reliability of aging flood hazard reduction projects. However, program has received limited appropriations in recent years.	measures. Any new funding, if received, likely will need to rely on existing watershed studies and risk assessments.
USDOT	Post flood aid program that is used to rebuild eligible transportation infrastructure, with some attention to reducing risk from future floods and storms.	Criteria for disbursement of aid and the uses of that aid rely on existing understandings of flood risk in specific places.
USFWS	The USFWS has the responsibility of implementation of the Coastal Barrier Resources Act that has the purpose of discouraging spending of Federal funds on lands in a designated Coastal Barrier Resources Area.	Decisions are based on location of land parcels and not on risk assessment.
USGS	Various data collection and dissemination programs.	The USGS has critical responsibilities for river flow and mapping data and dissemination that are the foundation for flood risk assessment at the project and watershed scales. In selected locations the USGS will prepare studies that characterize flood and storm risk (ex-post and ex-ante).

Appendix 7 - Overview of Available Data for Flood Risk Characterization

Inter-Agency Flood Risk Characterization Workshop
February 25-27, 2014
USACE Institute for Water Resources, Alexandria, VA, IWR Classroom

Summary of Available Datasets that are Relevant to Flood Risk Characterization

Dataset Name	Source	Flood Risk Category	Date Updated	Spatial Extent & Resolution	Format available	Access
National Flood Hazard Layer	FEMA	Hazard	Continuously	National; 1:12,000 scale	GIS data (raster)	Download. https://hazards.fema.gov/femaportal/NFHL/
The National Flood Hazard Layer (NFHL) dataset is a compilation of effective Flood Insurance Rate Map (FIRM) databases (a collection of the digital data that are used in GIS systems for creating new Flood Insurance Rate Maps) and Letters of Map Change (Letters of Map Amendment and Letters of Map Revision only) that create a seamless GIS data layer for United States and its territories.						
Hazus	FEMA	Consequences	February 2012	National	Windows software package	Order from FEMA MSC. http://www.fema.gov/hazus
Hazus is a nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods, and hurricanes.						
FEMA Disaster Declarations Library	FEMA	Consequences	January 2014	National	Excel Table	Download. http://tinyurl.com/nzlfzkp
FEMA Disaster Declarations Summary is a summarized dataset describing all federally declared disasters. This information begins with the first disaster declaration in 1953 and features all three disaster declaration types: major disaster, emergency and fire management assistance.						
National Elevation Dataset	USGS	Hazard	Bi-monthly	National; 1/3 arc-second and 1/9 arc-second	ArcGRID, GeoTIFF, BIL, GridFloat	Order from USGS. http://ned.usgs.gov/
The National Elevation Dataset (NED) is the primary elevation data product of the USGS. The NED is a seamless dataset with the best available raster elevation data of the conterminous United States, Alaska, Hawaii, and territorial islands. It can be used in models to estimate flood inundation extent, flood depths and other elements of flood hazard.						
2006 National Land Cover Database	USGS, Multi-Resolution Land Characteristics Consortium	Consequences	Every Five Years	National; 30-meter	GIS data (raster)	Download. http://www.mrlc.gov/
The National Land Cover Database (NLCD) serves as the definitive Landsat-based, 30-meter resolution, land cover database for the Nation. NLCD provides spatial reference and descriptive data for characteristics of the land surface such as thematic class (for example, urban, agriculture, and forest), percent impervious surface, and percent tree canopy cover. It can be used to estimate where people and structures are located for purposes of estimating flood exposure and damages. The 2011 NLCD is slated for release in late March of 2014.						

<table>
<tr><th>Dataset Name</th><th>Source</th><th>Flood Risk Category</th><th>Date Updated</th><th>Spatial Extent & Resolution</th><th>Format available</th><th>Access</th></tr>
<tr><td>Watershed Boundary Dataset</td><td>Natural Resources Conservation Service</td><td>Hazard</td><td>2004</td><td>National; 1:24,000 scale</td><td>GIS data (digital vector datasets)</td><td>Download. http://nhd.usgs.gov/wbd.html</td></tr>
<tr><td colspan="7">The Watershed Boundary Dataset (WBD) defines the areal extent of surface water drainage to a point, accounting for all land and surface areas. Watershed Boundaries are determined solely upon science-based hydrologic principles, not favoring any administrative boundaries or special projects, nor particular program or agency.</td></tr>
<tr><td>Flood Inundation Mapping Program</td><td>USGS</td><td>Hazard</td><td>Continuously</td><td>By community</td><td>Online tool</td><td>View online/download. http://water.usgs.gov/osw/flood_inundation/</td></tr>
<tr><td colspan="7">The USGS Flood Inundation Mapping Program focuses its efforts at state and local levels to help communities understand flood risks and make cost-effective mitigation decisions. The flood inundation map library contains a series of sequential maps that help communicate where flooding may occur over a range of river levels. The library can be connected to real-time and forecasted river levels at USGS streamgages to help communities identify immediate risks during a flood.</td></tr>
<tr><td>US Census: Demographics, Households, Income</td><td>US Census</td><td>Consequences Vulnerability</td><td>2010</td><td>National; Census block</td><td>CSV/ spreadsheet</td><td>Download. http://www.census.gov/main/www/access.html</td></tr>
<tr><td colspan="7">The US Census provides essential data on population, demographics, households, and income for mapping and estimating the consequences of flooding.</td></tr>
<tr><td>Social Vulnerability Index (SoVI) 2006-2010</td><td>University of South Carolina</td><td>Vulnerability</td><td>2010</td><td>National; County-level</td><td>CSV/ spreadsheet</td><td>Download. http://webra.cas.sc.edu/hvri/products/sovi.aspx</td></tr>
<tr><td colspan="7">The Social Vulnerability Index (SoVI®) 2006-10 measures the social vulnerability of U.S. counties to environmental hazards. The index is a comparative metric that facilitates the examination of the differences in social vulnerability among counties. Data from the American Community Survey is used in a principal components analysis to create the SoVI. In SoVI® 2006-10, seven significant components explain 72% of the variance in the data.</td></tr>
<tr><td>Homeland Security Infrastructure Program (HSIP) Gold</td><td>DHS</td><td>Consequences</td><td>2013</td><td>National</td><td>GIS data</td><td>Order DVDs. https://www.hifldwg.org/hsip-guest</td></tr>
<tr><td colspan="7">HSIP Gold is a unified homeland infrastructure geospatial data inventory assembled by National Geospatial Intelligence Agency in partnership with the Department of Homeland Security for common use by the Federal Homeland Security and Homeland Defense (HLS/HD) Community. It is a compilation of over 450 geospatial datasets, characterizing domestic infrastructure and base map features, which have been assembled from a variety of Federal agencies and commercial sources. Access is limited to federal government members, National Guard Forces, and to States with approved Presidential Disaster or Emergency Declarations to support the HD, HLS and NP – PPMR&R missions.</td></tr>
</table>

Dataset Name	Source	Flood Risk Category	Date Updated	Spatial Extent & Resolution	Format available	Access
HSIP Freedom	DHS	Consequences	2013	National	GIS data	Order DVDs. https://www.hifldwg.org/hsip-guest
HSIP Freedom is a subset of the HSIP Gold dataset that has been identified as license-free and distributable to participants within the state, local, and tribal homeland security; homeland defense; and emergency preparedness, response, and recovery mission areas.						
National Inventory of Dams	USACE	Flood Risk Reduction	5/1/2013	National		Download. http://geo.usace.army.mil/pgis/f?p=397:1:0
The NID contains data on the location, hazard potential, and other characteristics for over 80,000 dams across the U.S.						
National Levee Database	USACE	Flood Risk Reduction	2013	National	Web-based tool	Download. http://nld.usace.army.mil/egis/f?p=471:1:
The Levee Safety Program contains data on the location, hazard potential, and other characteristics of USACE owned/operated levees.						
Digital Coast Sea Level Rise Inundation data	NOAA	Hazard	TBD	National	Shapefile	Download. http://csc.noaa.gov/arcgis/rest/services/dc_slr
The NOAA Sea Level Rise Inundation maps use the best publically available and accessible elevation data to map literature-supported levels of sea level rise on top of mean high water.						
Integrated Climate and Land Use Scenarios (ICLUS)	EPA Global Change Research Program	Consequences	40665	National; County-level	GIS data (shapefiles and raster)	Download. http://www.epa.gov/ncea/global/iclus/
The EPA ICLUS project is developing scenarios broadly consistent with global-scale, peer-reviewed storylines of population growth and economic development, which are used by climate change modelers to develop projections of future climate. ICLUS provides projections of US county population and housing density, which can be used in estimating potential future trends in flood consequences.						

Dataset Name	Source	Flood Risk Category	Date Updated	Spatial Extent & Resolution	Format available	Access
US Regional Economic Forecasts & Analysis	IHS Global Insight	Consequences	Yearly	National; County-level	CSV/ spreadsheet	http://tinyurl.com/mkdhnwd
Both IHS Global Insight and Woods and Poole Economics produce forecasts of economic trends for U.S. counties. Both companies' forecasts go out 30 years and are updated regularly. IHS's forecasts cover over 30 variables including income, wages, and employment for 11 major industry categories. These forecasts can be used to estimate potential future flood consequences.						

County Economic Forecasts to 2040	Woods and Poole	Consequences	Yearly	National; County-level	CSV/ spreadsheet	CD-ROM. http://www.woodsandpoole.com/index.php
Both IHS Global Insight and Woods and Poole Economics produce forecasts of economic trends for U.S. counties. Both companies' forecasts go out 30 years and are updated regularly. The forecasts from Woods and Poole are similar to IHS's forecasts, which cover over 30 variables including income, wages, and employment for 11 major industry categories. These forecasts can be used to estimate potential future flood consequences.						

County-level economic activity data	IMPLAN	Consequences	2012	National; County-level		http://implan.com/
IMPLAN data can be used to calculate various measures of economic activity at the county level, including GDP, total output, and employee compensation.						