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

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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.

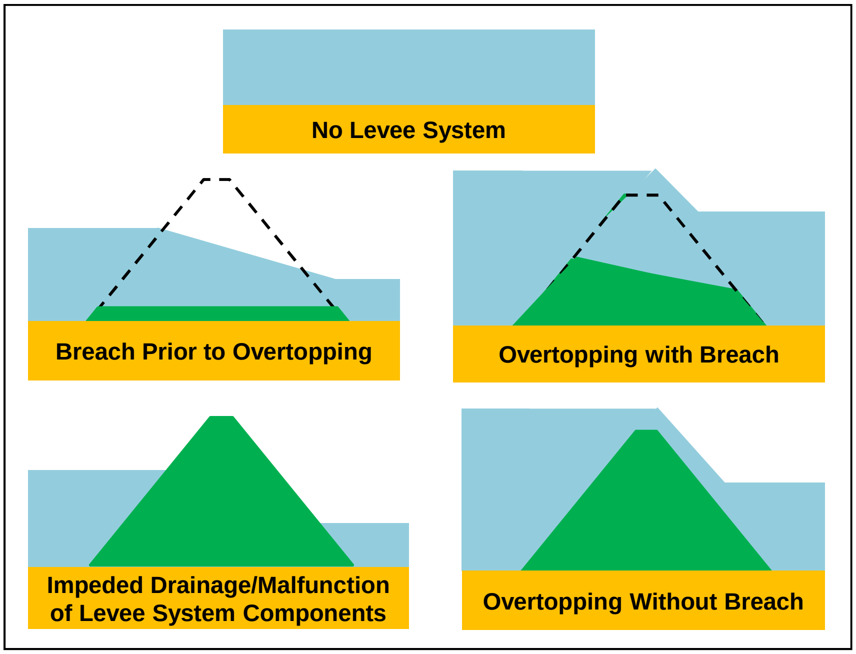

Figure 1 - Flooded Area Inundation Scenarios

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

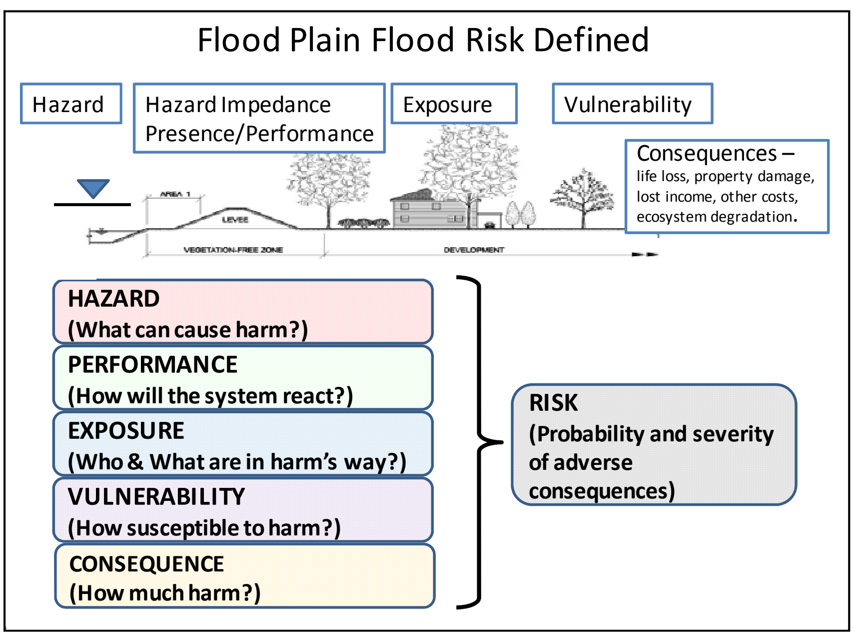

Figure 2 – Components of Inundated Area Flood Risk

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.

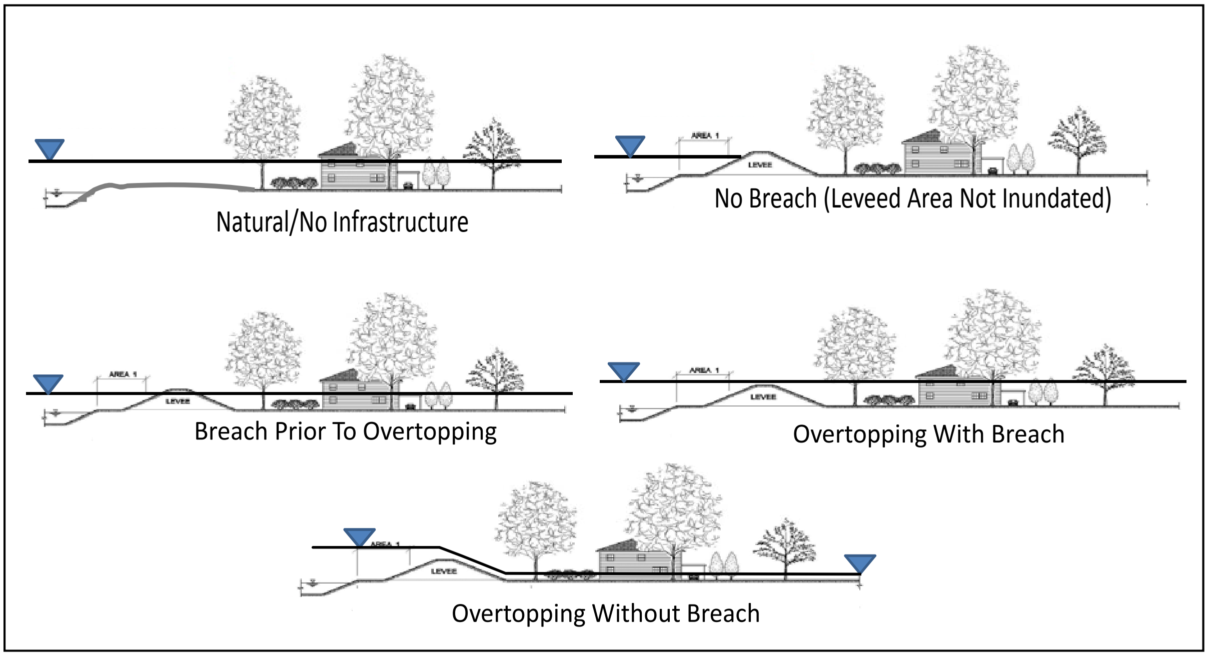

Figure 3 - Schematics Illustrating Relationships Between the Inundation Scenarios and the Flood Risk Components

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.

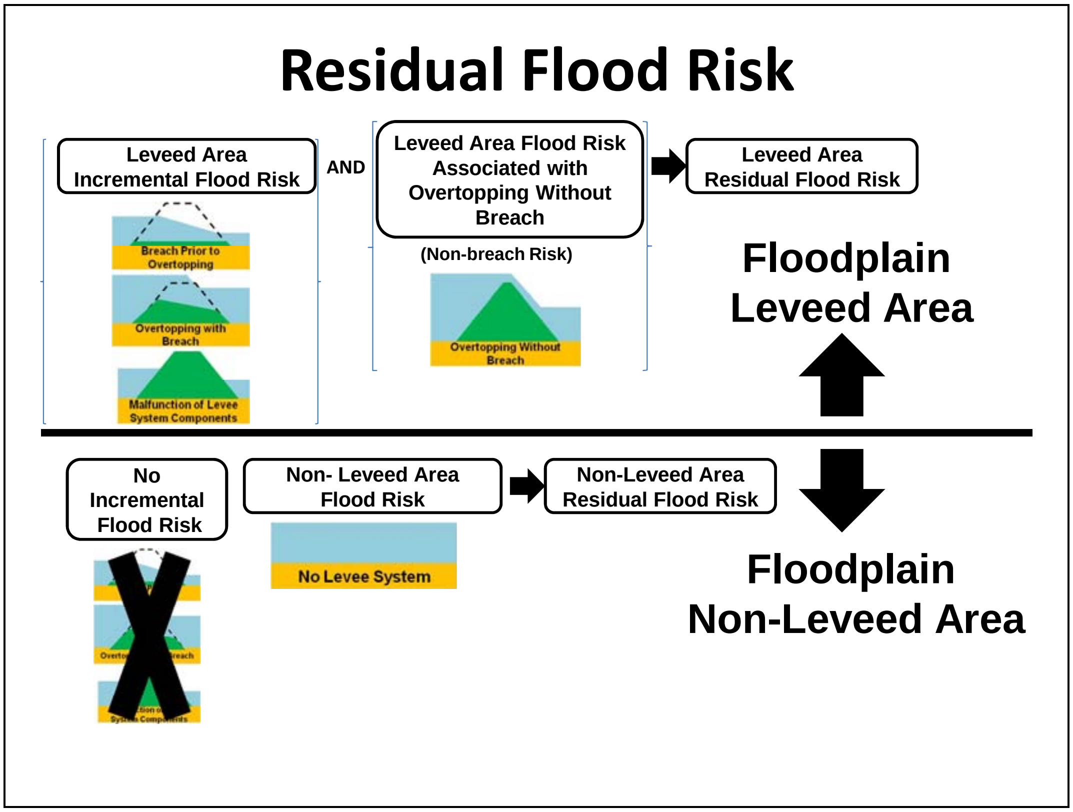

Figure 4 – Definition Sketch – Incremental and Residual Flood Risk

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.

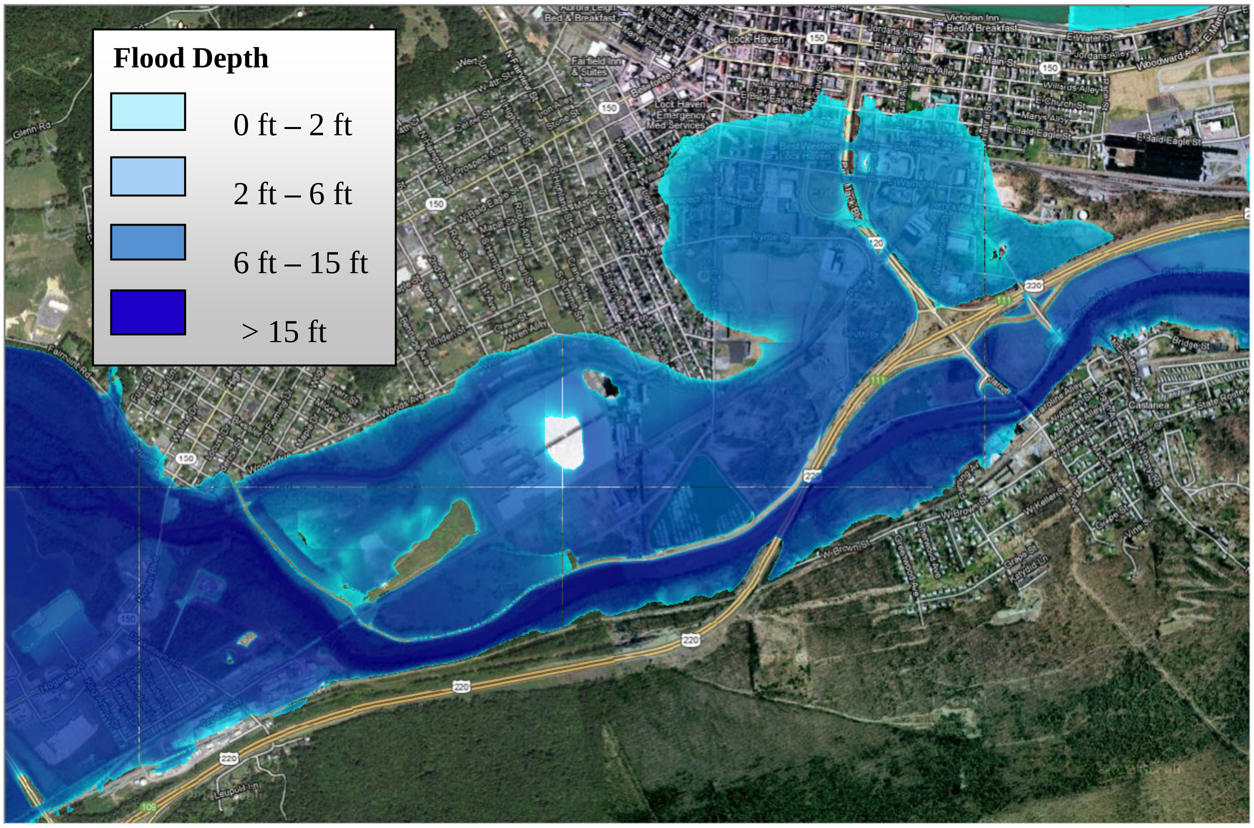

Figure 5 – Example Levee Overtopping Shaded Depth Map

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).

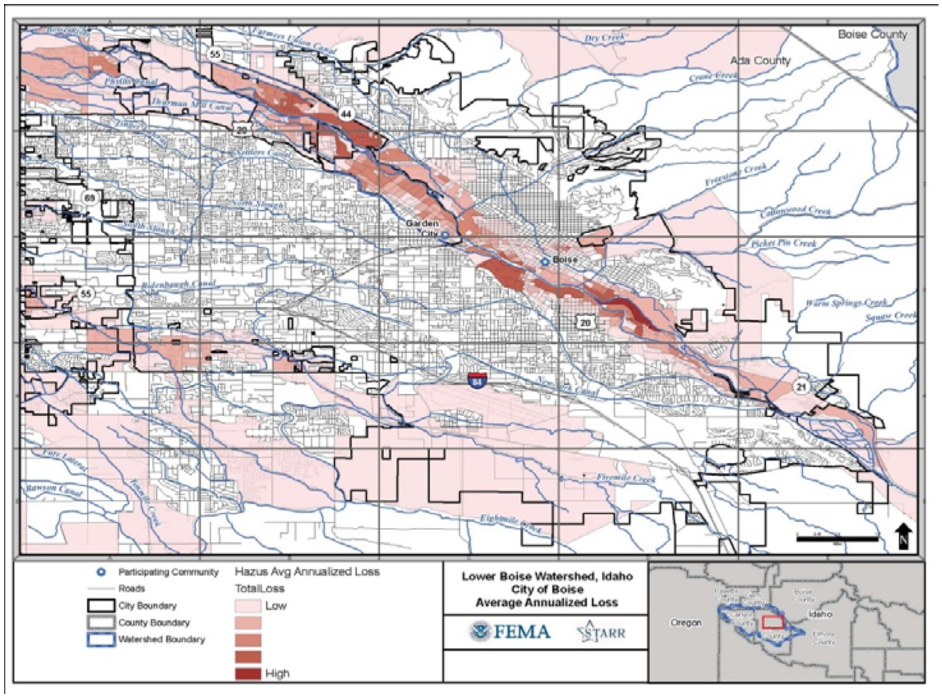

Figure 6 – Flood Risk Depiction Taken from FEMA RiskMAP Slide Set (dated 11/7/2012)

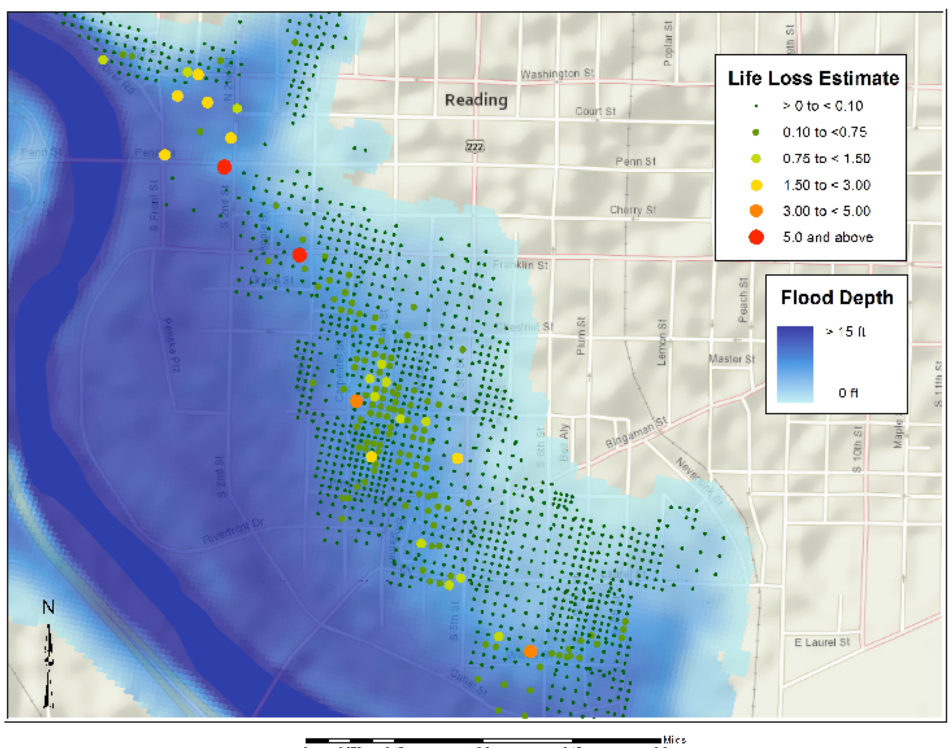

Figure 7 – Example - ‘Towards’ a Life Safety Risk Map

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.

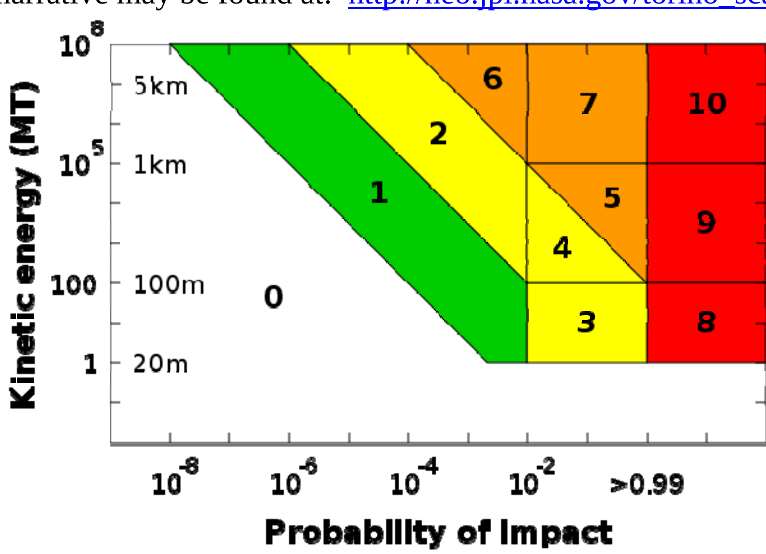

Figure 8 - Torino Impact Hazard Scale

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.

<table>
<tr><th colspan="3">Levee Safety Action Classification</th></tr>
<tr><th>Urgency of Action</th><th>Actions</th><th>Characteristics</th></tr>
<tr><td>Very High
(1)</td><td rowspan="5">Actions recommended for each class.</td><td rowspan="5">Likelihood of inundation with associated consequences characterizes each class.</td></tr>
<tr><td>High
(2)</td></tr>
<tr><td>Moderate
(3)</td></tr>
<tr><td>Low
(4)</td></tr>
<tr><td>Normal
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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

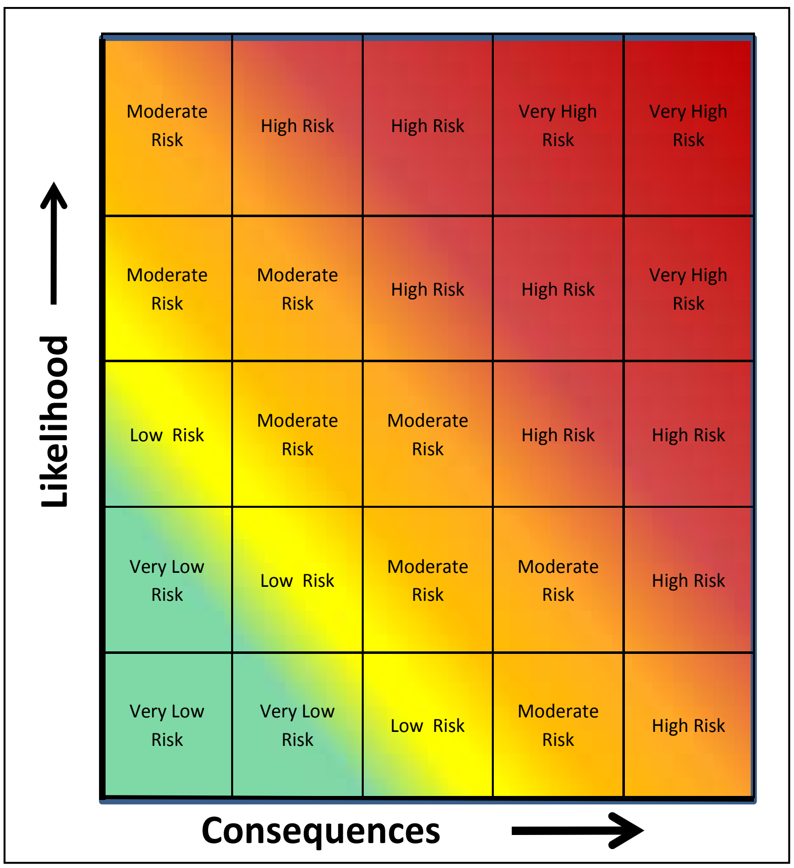

Figure 9 – Risk Matrix

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

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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.			

Protocol: Levee Safety Action Class (LSAC) Adjustment Guidelines		
URGENCY OF ACTION (LSAC)	**Reasons to adjust Levee Safety Action Class**	
VERY HIGH (1)	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.	
HIGH (2)	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.	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.
MODERATE (3)	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.	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.
LOW (4)	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.	
NORMAL (5)	N/A	