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Discussion Paper

Urban Flood Hazards: Challenges and Opportunities

ASFPM Stormwater Management Committee

INTRODUCTION:

This is a [DRAFT] discussion paper related to the topic of urban flood hazards, associated challenges, potential solutions, and recommendations to assist communities with identifying, managing, and mitigating urban flood hazards. This paper was prepared to provide background and discussion and it does not represent a position or policy of the Association of State Floodplain Managers (ASFPM), a non-profit organization dedicated to reducing flood losses and protecting floodplain functions and resources in the United States, without causing adverse impacts to others.

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SECTION 1: THE ISSUE

Congress established the National Flood Insurance Program (NFIP) in 1968 with passage of the National Flood Insurance Act, now codified in 44 CFR to partner with local governments and enable owners of real property in participating communities to purchase, federally-administered flood insurance.

In 1979, the Flood Insurance Administration (FIA) and the NFIP were moved under the Federal Emergency Management Agency (FEMA). Since the creation of the NFIP, the program has been actively mapping flood hazards throughout the United States to establish flood risk and insurance rates. These mapping efforts have primarily been focused on threats from both rivers and coastal storm surge. FEMA digitized legacy flood hazard mapping and completed new flood insurance studies (FIS) from 2003-2008 through Flood Map Modernization (Map Mod) and continued updating flood risk identification with Risk Mapping, Assessment, and Planning (Risk MAP) from 2009 to the present. To date, FEMA has mapped and established Special Flood Hazard Areas (SFHAs) for over 90% of the major population areas within the United States, identifying flood risk for both coastal and riverine environments.

Although FEMA has “modernized” floodplain mapping throughout the country there is still significant flood risk that has yet to be identified or mapped under the NFIP. Local floodplain and stormwater managers in highly urbanized areas understand that there is additional unmapped flood risk beyond the boundaries of the currently established SFHAs caused by urban stormwater runoff.

As cities grew over the last two centuries, many natural floodplains were channelized and filled in to accommodate population growth and community development. To those planning and developing these metropolitan areas the local drainageways may have appeared to be very small, posing relatively minor flood risks; the existing floodplains and their natural and beneficial stormwater management functions were often not a major consideration in the development and growth of these conurbations. To mitigate the flood risk stormwater pipe systems were designed and constructed to replace the lost conveyance that occurred due to filling and encroachment of the historic drainageways within the floodplain. Additionally, until recently the increased runoff from new impervious areas upstream of these stormwater systems has not been mitigated or controlled. Unfortunately, local stormwater systems in many developed watersheds are undersized, providing runoff conveyance for events with frequencies ranging from 1- to 10-years (100% - 10% chance events). When larger, less frequent events occur, the storm conveyance systems are overwhelmed, and the residual runoff remains on the ground resulting in flooding that inundates streets and sometimes existing structures. This is especially common in historic areas where infrastructure was not designed to meet current local drainage criteria. In addition to these existing systems being undersized, there has been an increase in the frequency and intensity of rainfall events, an indicator of climate change, resulting in more frequent and persistent flooding of the built environment. Many of these urban flood hazards are known by local managers and flood administrators due to their frequent flooding but remain unmapped and unregulated.

Over the past decade local government agencies and floodplain management professionals have taken a strong interest in identifying, mapping, managing, and mitigating urban flood hazards. Where these flood prone urban areas have been identified, strategies to address localized flooding typically come with very high capital improvement costs or feasibility challenges that are increasingly difficult to overcome. This discussion paper:

- Provides an overview of the challenges associated with urban flood hazards and opportunities for local floodplain and stormwater managers to utilize urban flooding best practices,
- Offers a framework to identify and manage urban flood hazard areas to reduce future flood damage, and
- Suggests recommendations on a national scale to assist communities with mapping and mitigating urban flood hazards.

SECTION 2: BACKGROUND

PRIMARY CAUSES OF URBAN FLOODING

Many communities have developed local drainage and stormwater criteria to address increased runoff due to development and for runoff conveyance systems to reduce flooding existing structures. Flood damages, however continue to be witnessed in cities throughout the country and in fact, flood damages to structures outside of the SFHA have been steadily increasing. The primary causes of flooding in these urban areas include: **Historic Loss of Natural Drainageways:** Before development, a significant portion of rainfall was infiltrated, and the remaining stormwater runoff was conveyed in swales, gulches, gullies, low lying drainageways, washes, creeks, rivers, and streams. Smaller natural drainageways were often filled or replaced by storm drainage systems that were only designed and constructed to convey small, frequent, rainfall events.



Figure 1: Construction of a brick storm drain system used to replace surface conveyance in a natural swale in the City and County of Denver circa 1920 (Denver Public Library).

Historic Development, Land Use, and Stormwater Management Criteria: Historic development occurred with minimal or no criteria for stormwater mitigation resulting in undersized stormwater drainage systems.

Inadequate Stormwater Management Criteria: Local criteria and design standards for stormwater infrastructure do not always address flooding from large rainfall events. Storm drain systems are typically designed only for the 2-year to 10-year rainfall events, thus rainfall in excess of the storm drain capacity must travel overland (on the surface) of drainage basins. Local criteria frequently account for this by specifying maximum flooding depths in streets, but this is a more recent regulatory development in stormwater criteria and doesn't address pre-existing and historic development. In other cases, sizing of stormwater systems to meet street conveyance capacity may be deemed too expensive or technically infeasible, leaving behind residual flooding hazards during and in the aftermath of larger storm events.

Increased Impervious Surfaces (Development) Upstream of Existing Stormwater Conveyance Systems:

As development occurs upstream within watersheds, runoff increases due to increases in imperviousness and decreases in infiltration. These runoff increases are not always accounted for by stormwater regulations and criteria and typically were not accounted for in historic infrastructure construction.

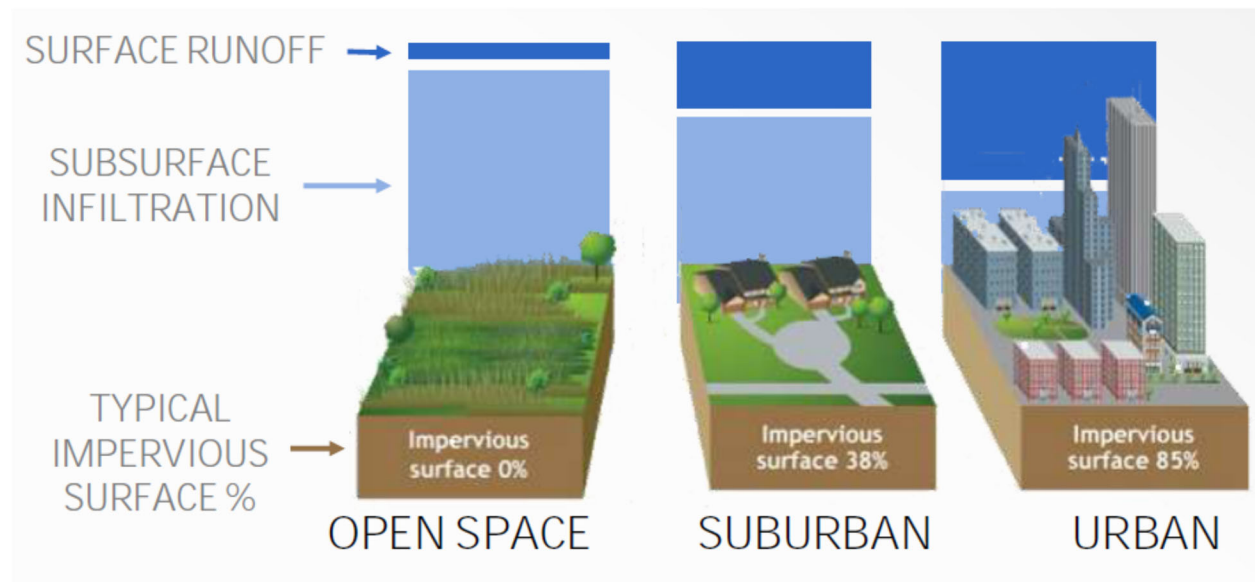


Figure 2: In more urban areas, less stormwater is infiltrated to the subsurface resulting in greater amounts of surface runoff (Image from Landscapeforlife.org).

Levee Systems and Residual Local Flooding: Where levee systems have been designed to keep river flooding out of urban areas, local stormwater can be backed up on the urbanized side of constructed levees creating residual flood zones if it wasn't planned for in the design of the system.

Combined Sewer Systems and Sewer Backups: In many communities east of the Mississippi, combined (sanitary and storm) sewer systems are common. These systems are not typically designed to accommodate all flood events, and when these systems are overwhelmed it can cause upstream flooding to structures, especially basement flooding. In addition, overflows of this type can be a violation of a community's NPDES permit for their treatment facility.

Insufficient maintenance: Constructed stormwater systems must be maintained to function as designed. Sediment or debris accumulation reduces the capacity of stormwater management systems and can eventually plug pipes or limit the efficiency of detention/retention facilities. If ditches are not mowed, the heavy vegetation reduces the capacity. If systems are not inspected and repaired, such as backflow prevention valves at discharge points into a river, stormwater will not be able to drain as intended. Having a consistent maintenance and inspection program and mapping the information can control the risk of urban flooding.

Climate Change: Climate change has resulted in alterations to the intensity and frequency of rainfall events around the globe. As a result, more frequent flooding is occurring in many locations and previously constructed stormwater systems no longer accommodate the increased frequency of the rainfall events for which they were designed. Climate change not only affects rainfall, it is also causing a

rise in sea levels affecting local drainage systems in coastal areas. As sea levels increase, existing stormwater drainage systems may experience backwater affects that reduce conveyance capacity, ultimately flooding upstream streets and structures.

RISKS ASSOCIATED WITH UNMAPPED URBAN FLOOD HAZARDS

Unmapped urban flood hazards pose significant risk to the public and to property owners. These areas can flood during a variety of rainfall events, resulting in recurring flood damage and repetitive structural losses. Since urban flood hazards tend to be unmapped, property owners often do not purchase flood insurance and are therefore at risk of significant financial loss. Unmapped and uninsured risk with the potential for repetitive flood loss makes identifying these flood hazards and educating communities and their government representatives about the associated risks critically important to the floodplain administrators and stormwater managers. These flood risks have remained unmapped for a variety of reasons including:

- **No Obvious Risk of Flooding:** Urban flood risk is not always obvious. These flood prone areas are often developed with streets, homes, and businesses, with no apparent natural drainageways or conspicuous stormwater conveyance structures.
- **Status Quo NFIP Mapping Standards:** FEMA does not generally map areas considered local drainage tributaries. FEMA typically starts mapping flood hazards where the upstream watershed area exceeds 1 square mile. Although many of these urban flood hazard areas have watersheds in excess of 1 square mile, there are no natural drainageways or riverine conveyances that exist and thus these areas have not been identified by floodplain managers as locations that require floodplain mapping.
- **Identification and Mapping Complexities:** The hydrologic and hydraulic analyses associated with mapping urban flood risk are complex, requiring the combination of 1-dimensional (1-D) pipe system modeling with 2-dimensional (2-D) surface modeling. Studies typically required to accurately map these areas can be cost prohibitive.

SECTION 3: OPTIONS TO ADDRESS THE ISSUE

Flood hazards in our communities are often best understood by the long-time residents and community leaders. Floodplain stewards and stormwater managers face significant challenges communicating urban flood risk due to the technical and cost challenges associated with mapping these complex hazard areas. Even when the risk has been mapped, they can also face internal and external communication challenges to get the public, senior government leadership, and politicians to acknowledge the risk. These communication challenges range from clearly establishing that hazards and risks exist—even when it is mapped—to a lack of willingness to make flood map information available to the public because of concerns regarding negative perceptions of flood insurance requirements; adverse impact to property values; and public calls to fix the problem immediately in the absence of adequate government resources. Infrastructure solutions to address these urban flood hazards come at significant cost; simply upsizing a stormwater system is often not a viable answer when natural flood conveyance has been lost and upstream development has increased the coverage of impervious surfaces, and thus the amount and rate of water draining through the system. As weather patterns continue along a dynamic path and storm events increase in frequency and intensity, our communities need to be better equipped with the tools to communicate future urban flood risk and provide communities with the knowledge and understanding to drive change from the top down and from the bottom up.

IDENTIFICATION AND MAPPING OF URBAN FLOOD HAZARD AREAS

Identifying flood hazard areas in urban environments poses significant challenges. Among those challenges is understanding that a flood risk exists in a specific location. In the absence of previous studies and mapping, anecdotal evidence such as complaint records, photographs and videos, or data showing repetitive flood loss are often relied upon by local managers to identify areas with significant flood risk in urban communities. Historically, stormwater master plans or outfall plans have focused on the capacity of piped systems and their ability to meet local conveyance criteria. These plans often reveal that piped systems do not provide adequate capacity for large flood events and the residual surface flows were not well understood or even ignored. Some studies utilize 1-dimensional (1-D) hydraulic models to predict flooding depths and extents. In urban areas, however, stormwater flows are not best modeled in a 1-D environment as flows split at intersections; approximating the volume of stormwater that goes one way as opposed to another becomes arduous and inexact. From a regulatory perspective, FEMA's reliance on 1-D modeling methodologies hinders accurate mapping of urban flood risk. In general, 1-D hydraulic modeling programs are not sophisticated enough to accurately analyze overflow flooding in road networks that occur in urban areas. Figure 1 illustrates an urban area that is more suited to 2-dimensional (2-D) analysis. Knowing the limitations of 1-D modeling communities may be reticent to

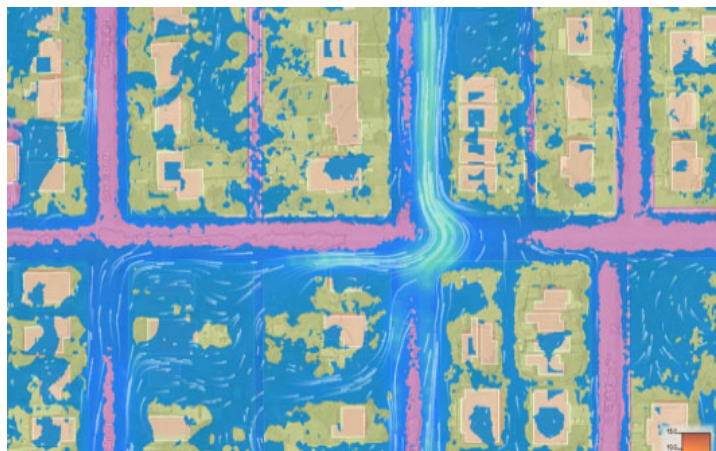


Figure 3- Image of a 2-dimensional rain on grid model with GIS layers of houses, roads, and grass separating each feature in the model.

request studies to model and map their urban flood risk, contributing to a resistance to regulate or require insurance in these areas,

Although 2-D modeling has been available since the mid 1990's, the complexity and cost associated with modeling urban areas and the finite resources of local agencies made such analysis cost prohibitive, infrequent, and unattainable. Over the last ten years, however, 2-D modeling has become much more prevalent and accessible to the engineering community, reducing the associated costs. Modern technologies for hydrologic and hydraulic modeling may offer more cost-effective methods to develop large scale urban inundation maps. Some of these modern technologies are now available at reduced or no cost, are user friendly, and can produce more accurate results than their 1-D predecessors. As a result of more readily available and accessible evaluation and modeling tools, urban inundation maps can be produced with relative ease by a knowledgeable, practicing flood hydraulic professional.

Specific Challenges Related to Mapping Urban Flood Hazard Risk

Although modeling urban stormwater inundation is becoming less cost prohibitive and more commonplace, it's costs may still exceed the limited resources of many communities around the country. There is also an array of other challenges, both technical and practical, with modeling urban flood risk:

- 1) **Cost and associated level of detail for flood modeling and mapping:** Urban flood risk modeling can be performed at a variety of levels and costs. Low resolution modeling to identify flood risk can be performed at a relatively low cost and in a timely manner. High resolution modeling requires detailed baseline data including detailed topographic mapping (typically LiDAR), building footprints, impervious footprints throughout the watershed, soils data, and detailed storm drainage infrastructure information. Not all local agencies have the detailed data necessary to perform complex hydrologic and hydraulic analyses, but there are options for agencies to consider, including:
 - a. **Basic Analysis:** An approximated flooding estimate based on ponding depths at sumps and collected complaint databases. This type of analysis would primarily be meant to begin identification of urban flood hazards but could not be used for damage estimates or to fully communicate flood risk.
 - b. **Better Analysis:** A basic 2-D model with large grids and without building detail or underlying infrastructure connectivity, i.e. storm drain systems. This type of analysis could provide a baseline for determining damage estimates and ponding depths but may not scientifically support local ordinances or development standards.
 - c. **Best Analysis:** A detailed 2-D model that computes both runoff from gridded cells and downstream hydraulics of stormwater flow through a watershed. These models can incorporate building footprints and stormwater infrastructure via a 1-D interface. 2-D rainfall/runoff models can be calibrated to gage data when additional datasets exist, such as gage adjusted radar rainfall and downstream peak flows. This type of mapping could be used to estimate flood damage and begin to set water surface elevations for enforcing local ordinances requiring minimum first floor elevations and freeboard.

All of the aforementioned methodologies can assist in the identification of urban flood risk and support the creation of inundation maps that can be used to educate the public and government officials. These analyses can also be used to estimate flood damages within a

watershed based on various assumptions about future weather events. This information is critical for decision-makers, especially when considering benefit/cost ratios of alternative strategies.

Urban flooding presents a “new” cost for budgets already strained by maintaining and upgrading legacy systems, and the cost of completing these analyses can vary widely.

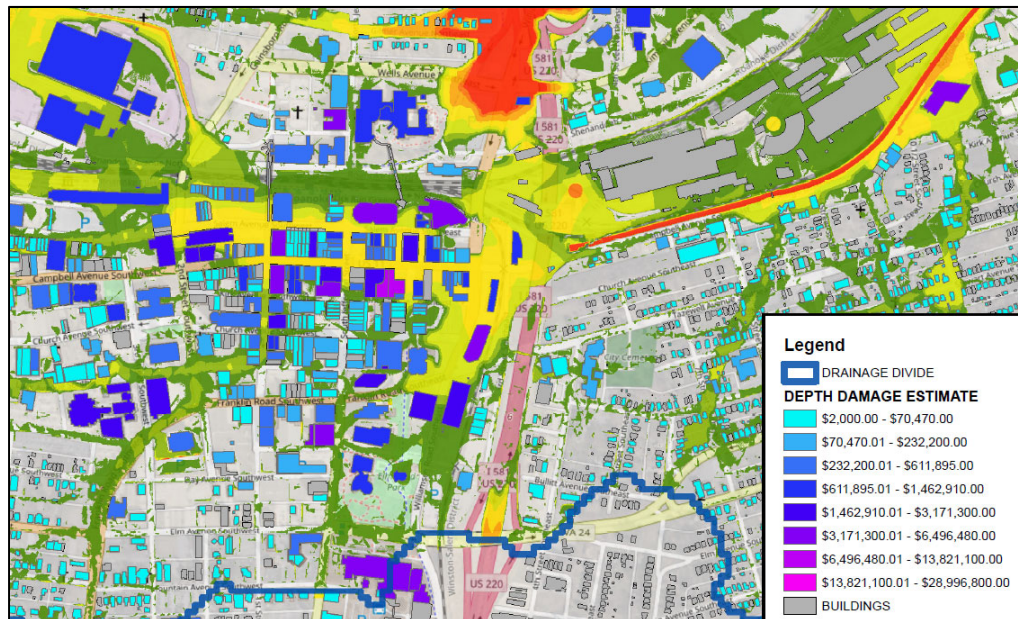


Figure 4: Screen Capture of Depth Damage Estimates for Buildings Affected by an Urban Flood Event

- 2) **Federal and local management of urban flood hazards:** Most urban flood inundation areas remain unmapped by FEMA. Some communities are developing local flood hazard maps for these areas but have not necessarily shared their mapping with FEMA to be incorporated into their FIRMs and the NFIP. Choosing to map and make publicly available previously unmapped urban flood risk zones comes with significant challenges including:
 - a. **Acceptance by the community that the risk exists.** Residents may be aware of flooding within their communities, but the fact that these flooding areas are not being mapped by FEMA can create suspicion regarding the purpose of non-FIRM urban flood maps. The public may perceive the mapping justifies a capital improvement project that benefits developers rather than homeowners and residents or has been developed to deny development permits within a flood hazard area. Maps representing inundation areas modeled for large weather events, such as the 50-year or 100-year flood events, may be so extensive as to be “hard to believe”. Communicating risk beyond annual or semi-annual rainfall events has historically proven challenging for riverine and coastal flooding; urban flooding brings even more nuance to flood risk communication because these areas are not necessarily perceived as flood conveyance areas.
 - b. **Willingness of elected officials to authorize sharing of flood data publicly.** Local government agencies may understand that urban flood risk exists, and may have already mapped that risk, but the data and mapping may not be made available to the public.

Reasons this mapping may not be made public include:

- i. Once the mapping is made public, residents believe their property values will be negatively impacted by the fact that the risk has been identified and published.
- ii. Perceiving that an identified flood hazard will negatively impact property values, homeowners and business owners may demand that the flooding issue be addressed immediately. Unfortunately, the cost associated with directly eliminating these flood hazards—if possible—is great and most capital improvement budgets are inadequate to address such needs.
- iii. Public perception can create political pressure for action to address these hazard areas, and meeting the costs associated with responsive activities may require unpopular tax increases or creation of special assessment districts to address urban flooding. Where funding mechanisms can be identified and implemented, the improvement projects—where feasible—are unlikely to be expedient.

If a local government agency can successfully navigate making the inundation data publicly available, the next question is whether the mapping should be regulatory, e.g., included under the NFIP and shown on FIRMs, or enforced by higher regulatory standards under a local ordinance. The positive outcome of making these maps regulatory is that the flood risk will be better understood and communicated with the public and private property owners may insure against future flood events. Potential negative outcomes may include negative impacts on property values in these areas and affordable flood insurance may be unavailable to property owners in an identified high-risk area. Regulatory maps may also remove leverage for local communities to address their urban flood hazards. For example, if flood risk is communicated to the public and alternatives to address the flooding—including mapping the area as a regulatory special flood hazard area, --are fully understood, residents may prefer to pool what resources might have gone to future flood insurance premiums and instead funnel that money toward infrastructure improvements to mitigate the flooding problem. If the risk is mapped as regulatory, incentives and opportunity to address the problem may be lost.

Directing resources towards mitigation may ultimately lead to more resilient communities and reduce future flood losses. As communities assess, identify, and plan to address their urban flood hazard, it's important to remember that different communities have diverse values, goals, and objectives and may choose to address their problems differently, but in a way that fits their vision of the future. Whatever the approach, community understanding of the risk and concerted action to address the hazard is a positive step towards resilience.

Another potential challenge of creating regulatory mapping of these urban inundation areas is map updates. Urban areas, by their nature, see physical change on a regular basis. For example, public works departments maintain streets and routinely implement pavement overlays. In addition, stormwater management improvements can be constructed locally or upstream within a basin that may directly impact the amount of flows entering a known hazard area. An area included in a FEMA FIRM would require that a Conditional Letter of Map Revision be completed followed by a Letter of Map Revision. Thus, in creating NFIP regulatory maps, local municipalities would face increased costs for maintenance of floodplain maps, stressing already underfunded public works CIP budgets. This issue may potentially be addressed by establishing comprehensive mapping standards, but the likelihood is that communities would be

expending more of their stormwater or floodplain management budgets on updating these regulatory maps.

- 3) **Standards for studies and mapping:** FEMA develops mapping standards and requirements for riverine and coastal flooding. To date, standards have not been created for urban flood hazard areas. As previously noted, the costs of mapping these areas has been historically prohibitive, but the entry point for mapping is decreasing on an annual basis. The mapping produced in urban flood hazard areas will typically involve 2-D modeling with numerous split flows at roadway intersections. Flood depths will be impacted by urban street features such as medians, curbs, raised crosswalks, traffic calming devices, and other related impervious transportation infrastructure. Future development or redevelopment of these areas will also directly impact flood depths. New building footprints will displace water, increasing depths or velocities elsewhere within the basin. How to best update inundation maps of these ever-changing urban environments is an unanswered question. Other questions related to regulatory mapping include:
- a. Whether to incorporate underground stormwater infrastructure designed for more frequent flood events. Including infrastructure increases model complexity and associated analysis and mapping costs.
 - b. Is stormwater infrastructure dependable to convey the water it is designed to convey, i.e. what if inlets or pipe systems become clogged? Conservative analysis might not consider underground systems for large events such as the 100-year but choose to include infrastructure up to a certain flood frequency.
 - c. What will trigger the need for a mapping update?

Mapping and modeling standards are necessary if urban flood inundation zones are to be regulatory. However, mapping standards should consider the cost implications to local governments and should be set up in such a way to encourage mapping and understanding of flood risk rather than creating a set of overwhelming and hard to implement rules and standards that make responsible preventative actions in these areas cost prohibitive.

CHALLENGES IN RISK COMMUNICATION AND EDUCATION

Risk communication and education come to the forefront following disasters in urban flood hazard areas. Events like Super Storm Sandy in 2012 that decimated the East Coast and Hurricane Harvey in 2017 that flooded large parts of Houston grab national lawmaker and media attention in the days and weeks immediately following the event. Those events are significant because they direct attention to flooding issues plaguing urban areas on a national level and provide an opportunity for other urban communities to discuss how those same flooding issues are also present in their communities. The problem has always been how local communities leverage that support into long-standing policy change and program initiatives when national and local attention wanes. Many communities have taken advantage of the opportunities to develop urban flood risk messaging and have established their own risk communication and outreach initiatives.

Outreach and Communication with the Public

Communicating urban flood risk to the public has many challenges including:

- 1) **A willingness on the part of local officials to make the flood risk data available.** As noted in the section on determining urban flood risk, although staff at local government agencies understand that flood risk exists and may have already mapped that risk, the data and mapping is not typically readily available to the public. Informing the public of the existing flood risk will certainly create unrest with watershed residents who have concerns about safety, property values, the potential cost of insurance premiums, and the expectation that someone address and eliminate the flood risk. Many local governments have chosen to make flood mapping data, including modeling, available to the development community on an as-needed basis, but have not always provided public maps showing the flood risk. Some communities are concerned that publicly making this data available will trigger FEMA to incorporate the mapping into NFIP FIRMs, limiting their options to address the risk in the future. The primary reason flood risk mapping in these areas is not shared is because of the public outcry that community officials believe will occur as a result. Communicating new understandings of flood risk requires intentional and well-thought out strategies within a framework of planning (to address the problem), and future implementation of capital improvements or ordinances/regulations that begin to address the problem. Communication of flood risk outside of a framework that involves addressing the problem leaves residents feeling uncertain and helpless about their future.
- 2) **Belief by the public that the risk actually exists.** The best flood maps detailing flood depths for various flood frequencies and depth-damage estimates do not immediately equate to public acceptance that a flood risk exists. The public often views new risk mapping with distrust. It may be perceived that showing this new risk is associated with a local government's desire to make room for new development or to devalue property in order to buy land for future projects such as parks or government facilities. Although many residents within a watershed may admit that flooding regularly occurs, they fear the outcomes of mapping that shows them living in an area that frequently floods. Questions such as, "How will this affect my property value? Is my home safe? Why hasn't my local government addressed this problem?" and, "FEMA doesn't identify this as a floodplain, so it cannot be a real flood risk," will be faced by every local municipality attempting to communicate risk about urban flooding. Communication of urban flood risk must start with the basics including how the flood risk came into being in the first place.

One invaluable tool for local administrators in communicating existing risk is historical evidence. Many of these urban flood hazard areas have a long-standing history of flooding. Researching news articles from local periodicals may turn up years of flood history that can assist in convincing the public that flood risk does indeed exist (see Figure 3).



Figure 5: Copy of news article in the Rocky Mountain News from 1953 regarding flooding in the Montclair Drainage basin. Additional research turned up articles from 1912, 1950, 2004, and 2011 for the same area. (Source: Colorado History Museum).

- 3) **An understanding of how the issue came into being.** Since urban flood hazard areas are not readily recognized as flood risks like riverine and coastal areas, some history is required to educate the public about why the risk exists. Explaining from an historical context how a city developed and the decisions that were made regarding development is critical to that understanding. Sharing historical maps prior to development can begin to enlighten residents that low lying areas before development conveyed runoff and were natural floodplains. Historical maps might include soils maps (see Figure 4) that indicate where streambeds previously existed; drainageway maps developed prior to development (see Figure 4) or city planning maps or plat maps that show how development occurred over time and at what dates natural drainages were filled in and/or replaced by stormwater infrastructure such as closed conduit pipe systems.

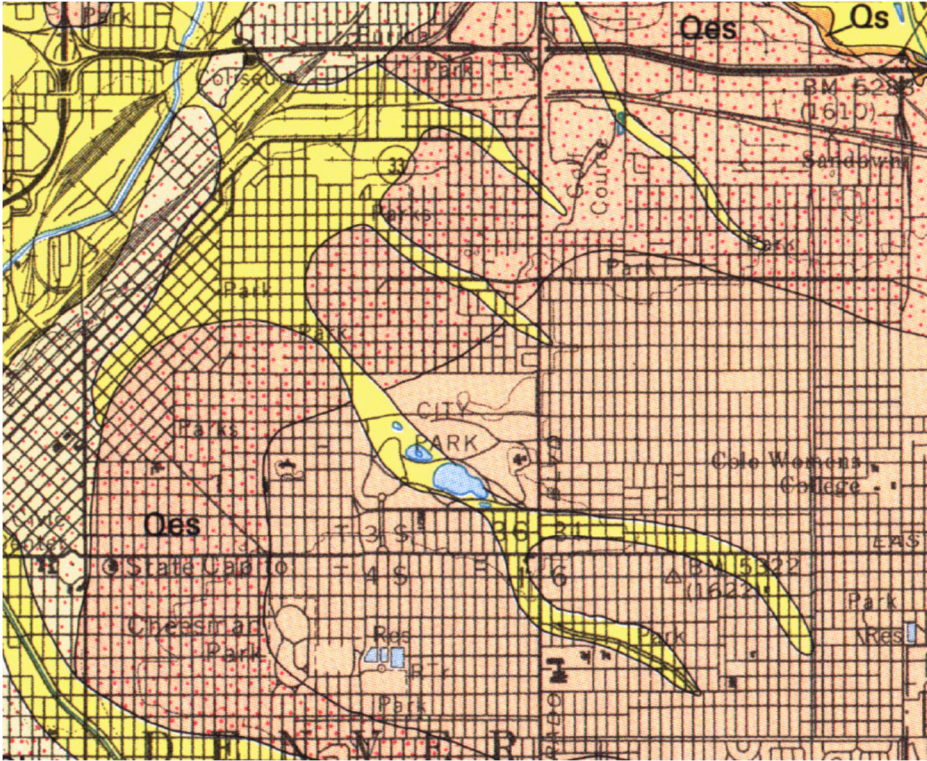


Figure 4: USGS soils map within the City and County of Denver showing alluvial stream deposits where historic drainageways used to exist.

- 4) **Why the issue hasn't been addressed by the local government agency.** Once residents understand and accept reality that urban flood risk does indeed exist, the next question that invariably will be asked is, "Why hasn't the issue been addressed by my local government?" This is an even more problematic issue when a local stormwater utility fee exists and the perception is that these types of issues should have been addressed with those monies. Government officials must often explain that routine maintenance and replacement of existing stormwater infrastructure consumes almost all of the funding available each year. Although capital improvements are identified in master plans, typically implementation of those plans is spread out over 10's of years. On top of that, most local stormwater master plans address conveyance for the 2-10 year events and don't directly address larger, less frequent flooding. Communication strategies to address this question must focus on what an agency is primarily tasked to do on an annual basis and the realities of available funding. In many cases, addressing urban flood hazard areas may require special districts or additional tax levies and municipal bonds due to the complexity and cost of addressing the specific problem.
- 5) **What living in these areas means for the local residents.** Residents who are educated about urban flooding want to understand what that means to them. Specifically, they want to know if they are safe or at risk, if they need to purchase insurance, what is being done to address the flooding and what they can do to address the problem. This is why communicating risk in a framework of planning and mitigation is critically important, i.e. just mapping risk leave the burden on local residents whereas involvement with planning and mitigation provides hope that the problem can be addressed, whether now or at some point in the future.

PLANNING AND IMPLEMENTATION STRATEGIES

Developing solutions to address urban flood risk is best addressed via a comprehensive and collaborative planning process that considers:

- Risk Identification and Mapping
- Risk Education and Outreach
- Community Goals and Objectives and a Strategic Framework
- Investigate, Identify, and Evaluate Solutions
 - Infrastructure Solutions
 - Non-structural, Planning, and Regulatory Solutions
- Development of a Strategic Implementation Plan and Community Toolbox

Development of a comprehensive plan is the crucial first step in addressing urban flooding, educating the public, and providing data and analysis to support proactive community action. A comprehensive plan will not only consider infrastructure type solutions but will seek to evaluate management and regulatory actions the community can take either in parallel with or separately from proposed capital projects. Nearly all problems in urban stormwater management are the result of land use and development policies and practice—or the unfortunate lack thereof. Gilbert White’s maxim that “Floods are ‘acts of God’, but flood losses are largely acts of man” is particularly instructive for planning. After all, water will find a way to flow and will take the path of least resistance in the process, regardless of whether that area is developed or in a natural state. Human-scaled disasters most frequently occurred in areas where land is developed.

Plans are informed by public outreach and participation, and planners have much to learn from residents, businesses, property owners, and other citizens. When design professionals lack information about stormwater and runoff problems, they can seek public input in order to get a better sense of stormwater problems than they would have otherwise. In many cases, those who live, work, and play in a community are more familiar with drainage problems, nuisance flooding, and local topography than are professionals working with those issues conceptually. However, members of the public with knowledge about these topics may not be engaged or share their insights.

A Collaborative Team

In order to deliver a comprehensive, collaborative, and resilient plan to address urban flood risk the right professionals must be in the room and leading the effort. Often, stormwater or drainageway planning efforts have been the realm of engineers who have focused on grey infrastructure type solutions, building on the hydrologic and hydraulic analyses that determine the quantity and extent of flooding in an area of interest. Communities must now move beyond that model and ensure that teams are made up of specialists with expertise in:

- Planning and education
- Public outreach and involvement (including interaction with elected officials)
- Urban design and planning
- Landscape architecture
- Hydrologic and hydraulic modeling
- Stormwater systems design

- Ecosystem evaluations
- Finance and development

The above list is a starting place only, and additional expertise is likely needed and warranted depending on the scope of a given project. The key takeaway is that addressing urban flood risk in a resilient fashion requires a team of professionals of varying expertise rather than a specialized group of engineers.

Risk Identification and Mapping

Mapping and identification of urban flood inundation areas should be the first step in any community's action plan in addressing urban flood risk. As previously mentioned, these inundation areas are typically known, at least anecdotally, via complaints databases, maintenance crew observations, or by news reports during previous storm events. Once a community has determined that they have one or more of these hazard areas, they can start the process of budgeting for a more detailed analysis that will provide mapping of the areas at risk. It's important for local managers to discuss this process with locally elected officials at the front end of risk identification so as not to "surprise" anyone as risk becomes better identified. Throughout the country, many of these areas have been mapped through local programs, but are often not shared with the public due to the fear of public outcry and lack of a plan to address the problem. That's why it is important that a full planning process that includes the support of elected officials be in place before beginning the education and outreach actions.

Risk Education and Outreach

Preparing to Be Share Urban Flood Inundation Maps with the Public

As a professional community focused on flood risk and education, we have learned that simple inundation maps do not often satisfy the demands of citizens or even other planning professionals in assisting with a complete understanding of flood risk. At the start of the inundation mapping efforts for urban flood risk, city managers, engineers, and planners should discuss work products that may be produced that better inform and educate the public regarding flood risk. Questions that should be asked might include:

- **How can we explain how this problem was created?** Taking the time to show the history of the city including historic development over time, i.e. what did this area look like prior to development? When did development occur? What was the thought process regarding stormwater and drainage at the time of historic development? What has occurred upstream since that time?
- **How might this problem have been avoided?** This is a good opportunity to show how current land development regulations prevent the filling in of natural drainageways and/or limit discharge from development to pre-development conditions. This is also a good time to show a timeline of when stormwater rules and regulations were developed and implemented.
- **How often will flooding directly impact citizens?** Providing inundation maps for a variety of runoff events will help explain the frequency of flooding that citizens might expect.
- **How much damage can be expected when it floods?** In combination with inundation maps, developing depth-damage estimates for a variety of events will begin to establish the serious nature of the problem and why it needs to be addressed.

- **What is the plan to address the problem?** It's important that citizens understand that the mapping effort is only the beginning of the planning process that they will participate in. Sharing with them that they get to participate and develop the solutions in partnership will give them ownership in the process.
- **What can be done right now?** Being able to share with citizens and managers that although an infrastructure solution might not be something that can be constructed today, there are proactive actions that can be taken now including the purchase of Preferred Risk Policies through the NFIP as well as the development of local ordinances and regulations to ensure the situation doesn't get worse as new development occurs.

The stormwater manager and risk communication team should prepare a full presentation with figures, charts and graphs, mapping, and fact sheets to answer the questions above as well as several others prior to presenting risk data to other city managers, elected officials, and citizens. Creativity should be encouraged in thinking about how to connect risk data to people. There are many examples of creative solutions throughout the country. Included here is an example from Toledo that is a web-based tool for visualizing flood data and flood losses on an interactive map.

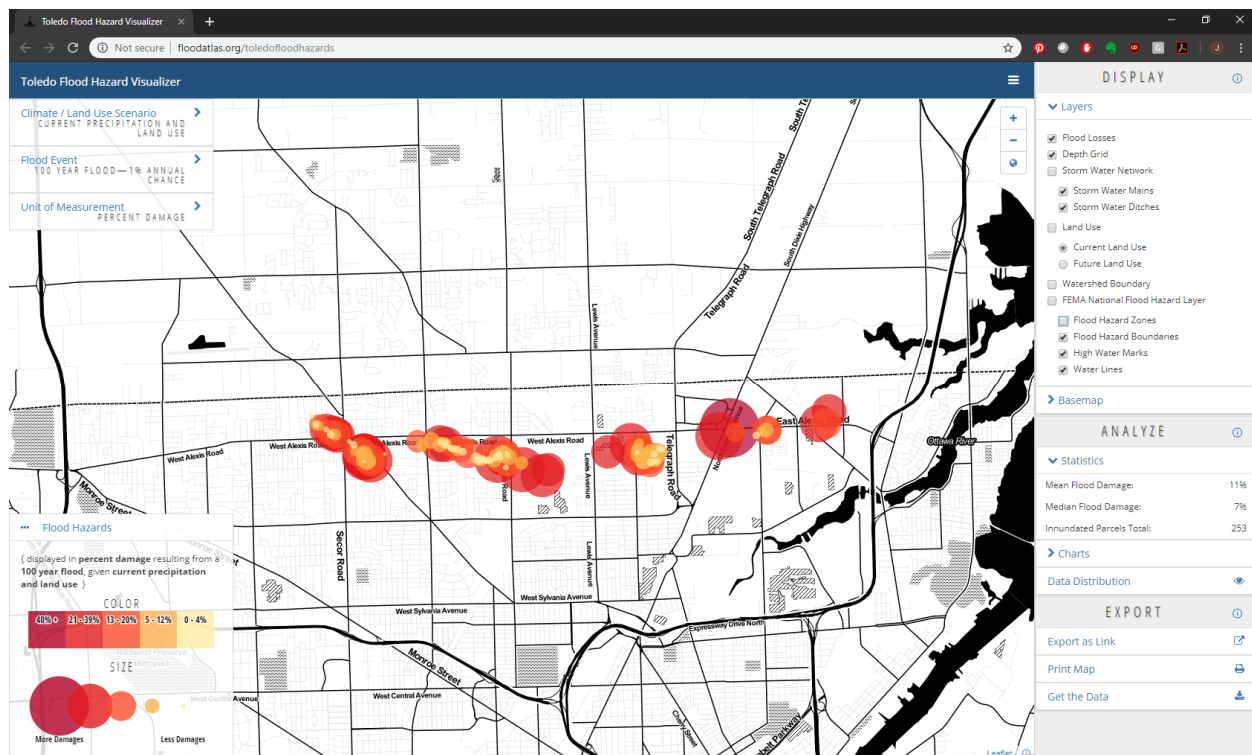


Figure 6: Toledo Flood Hazard Visualizer providing information regarding flood depths, potential flood losses, and regulatory floodplain data via the internet.

Communication with Municipal Managers

Once the hydrologic and hydraulic analyses have been completed and an inundation map(s) has been generated, a community's staff should sit down and thoroughly discuss the issue. These meetings should include transportation managers, stormwater engineers, city planners, parks and recreation staff, and zoning/development review professionals. The extent of the problem and its effects on city

infrastructure should be understood by all departments. The education of various departments regarding urban flood risk is foundational for future planning as a successful plan will address each one of these areas, not just stormwater or flooding. In other words, because of the nature of a city any one action will affect the function of another set of infrastructure. By engaging each different department, opportunities that may not have previously been considered may now become apparent. For example, a transportation plan may help inform locations where stormwater infrastructure may best be placed in the future and/or a parks and recreation plan might be integrated into a watershed-wide solution that includes green infrastructure implementation. While educating these departments about the extent of the problem early on is critically important, just as vital is their engagement in the overall planning process and in the development of goals, objectives, and solutions.

Communication with elected Officials

Local elected officials and decision makers typically take notice of urban flood risks following large flood events. Depending on geographic location and sensitivity to urban flood risk, some communities are likely to remain focused on these issues, for example communities at risk from hurricanes. Areas in the arid west, like Phoenix and Denver, may have a more difficult time maintaining the attention of elected officials when it comes to urban flood risks. Local stormwater and floodplain managers should take every opportunity they have to educate officials and other influencers regarding the importance of flood risk outreach and communication and how government regulations and policies impact that mission.

Upon developing the first inundation maps of these areas, it's important to engage and educate local elected officials regarding the problem. Because of the potential outcry from citizens when these areas are mapped, it is best to educate officials regarding how the problem came into being, how significant the problem is, and to explain the planning process to address the urban flood risk. Ultimately, these officials approve city budgets directly connected to any strategic plans that will be implemented and their ability to answer questions from their constituents will improve relationships and outcomes over time, i.e. they will know ahead of time what to expect and explain that they have proactively funded the planning process and support the long-term strategic plan developed by their public works staff in partnership with the citizens.

Communication and Partnerships with Other Jurisdictions within the Watershed

Many watersheds, both urban and rural, span multiple jurisdictions. This increases the number of challenges a local stormwater manager faces and limits their ability to directly regulate stormwater runoff that may be aggravating urban flood risk. As local managers educate various departments, elected officials, and the public, they must also reach out to adjacent jurisdictions, both upstream and downstream, in discussing and developing solutions to urban flood risk. Addressing urban flood risk and stormwater runoff will require a multi-jurisdictional approach. Such an approach to address, regulate, or manage stormwater can yield many benefits including being able to address water quality and quantity at a watershed scale. In some cases, development may be ongoing in an upstream jurisdiction and the ability to coordinate may provide opportunity to address excess stormwater runoff in a way that reduces, or at least doesn't make worse, existing urban flood inundation areas. The development of watershed coalitions, groups comprised of representatives from various watershed stakeholders, is one approach that local managers should consider. These coalitions allow for a broader context in which to evaluate solutions that will benefit all residents in a watershed, while also maintaining a philosophy of "do no harm" when it comes to ongoing and future development. Watershed coalitions have had

significant success in Louisiana and Colorado and may provide some guidance for local managers seeking to develop watershed solutions as part of addressing existing urban flood risk.

Communication with the Public

Due to the challenges previously stated, sharing urban flood risk with the public requires a well thought out strategy and plan to ensure local residents are not left feeling helpless once the information is shared. It's important that public works and floodplain managers already have a strategy in place to not only identify the areas at risk, but also have a follow-up set of specific actions to proactively address the identified problems. This is best done by a planning process that starts with one-on-one meetings with community leaders, such as neighborhood groups or homeowners associations, and builds towards smaller neighborhood meetings, and ultimately larger community meetings. The key to success in this type of outreach is to fully educate the public about the problem, how it came to exist, and what it means to them. Taking the time at the front end of the planning process to allow citizens to absorb the information is incredibly important. These are the places they live, work, and play and any future improvements will directly affect them, not only for the good, but in terms of construction impacts, land buyouts, right-of-way, community amenities, and so on. A successful implementation program will start with community trust building.

Many property owners think that because their property or neighborhood is located outside of the flood zone, they are immune to the effects of urban flooding. Road closures, infrastructure damage, limited access to emergency facilities due to urban flooding are some of the issues that should be taken seriously by all residents. Effective communication regarding the impacts urban flood hazards should be targeted to everyone within the watershed, not just people living in or near a flood zone. For example, flash flooding at low flow crossings are serious issues for residents and local officials in the Phoenix metro area. For a majority of the year, people drive through low flow crossings without fear of flooding. During the monsoon season, the low flow crossings become a serious hazard since flood waters rapidly rise in response to the flood events. Phoenix and the Flood Control District of Maricopa County post warnings at these crossings and continually remind residents of the flood hazards throughout the year – not just during the monsoon season. Communities might consider the installation of urban flooding signage that warns residents and visitors that streets may flood during storm events. Another idea might be to create a monument on the ground surface showing the primary flow path of flood waters through the basin during extreme events to serve as a reminder of the risk of flooding.

Using the fact sheets, inundation mapping, presentations and other materials, planners can communicate directly with citizens about urban flood risk. The importance of taking time to fully educate the public about urban flood risk cannot be understated. Jumping into the planning process before the community understands and takes ownership of the existing problem will likely lead to a flawed planning process with little to no public buy-in. Each community may choose to address their urban flood risks differently, so building a common understanding is paramount, and then building on that understanding a community can work together to develop goals and objectives that reflect community values. Ultimately, community members must be involved in the planning process from start to finish, from identification of the issue through strategic planning and long-term implementation. The success or failure of any plan is directly related to the amount of community support developed through the process.

Over time, regular and sustained communication with the public about these flood risks must be continued. Through the planning process and after, communities should develop communication plans that provide the most up to date hazard information and pending actions. This information might be tied to websites that already exist or be included in separate websites related directly to a specific neighborhood or community. Additionally, these websites should connect to already existing materials such as FloodSmart.gov that is recognized as having current, accurate information that is specifically geared toward use by the public. Communities that are successful at communicating urban flood risk use a variety of methods to convey those messages; websites, social media, newspapers, and local television stations are effective ways to deliver information. Personalized messaging for property owners is likely the best way to communicate urban flood risk. Local communities can initiate opportunities to remind people to ask about their flood risk by presenting at fairs, neighborhood meetings, schools, and like-minded organizations such as the state ASFP chapter. By becoming involved in residents' normal activities, local officials can integrate urban flood hazard messages in their daily lives. Mailouts¹ to inform property owners of changes in their flood risk are also effective. For specialized messaging like construction beginning on a new capital improvement project meant to alleviate flooding or a change in NFIP regulations, news releases in the newspaper or local television station may be required to relay this information to a wide audience.

Unfortunately, the same messages do not always necessarily reach renters of property in areas affected by urban flooding. Currently, property owners are not required to notify renters that there is a potential flood risk. Some cities in Texas are advocating that the state legislature pass reforms that require property owners to share flood risks with renters. Local agencies can develop local programs to provide information to the public or provide signs that indicate previous flood elevations in affected neighborhoods. Communities and organizations that provide information to renters include the City and County of Denver and Sacramento County. Other communities can take note of these actions and adopt them or modify to fit their local needs as necessary.

Community Goals and Objectives

Comprehensive planning must not only develop community goals and objectives that address urban flood risk, but those goals and objectives must meet the values of the communities at risk. Through a well thought out, process driven, and relatively time unlimited process of public outreach and education regarding the flood risk itself, planners can also begin to gather and compile a list of community values that may directly impact the outcome of a comprehensive planning process. This list of values very well may be unrelated to the urban flood risk but could affect proposed solutions. Some examples include:

- **Does a community desire more recreation or parks space?** This value might lead towards solutions that could be integrated with green infrastructure or traditional stormwater detention.
- **Is pedestrian or bicycle mobility within the community a significant concern?** This may be an opportunity to connect daylighting of storm drain systems with mobility solutions such as recreation paths along greenways.

¹ Metro Denver's Urban Drainage and Flood Control District sends a postcard to all property owners that are affected by changes in flood studies that may impact their flood hazard designation on the FIRMs. Property owners receive a postcard informing them if their flood risk has changed or remains the same.

- **How does the current land use within a neighborhood best meet the needs of citizens?** The values of the community might indicate that commercial development is not highly desirable. Alternatively, a community might determine that small commercial development connected by high mobility corridors could improve quality of life and reduce the need for driving.
- **Does the current transportation network meet future needs?** Varying street networks may provide opportunity to address urban flood risk in unique and creative ways and/or at least provide new corridors for pipe or stormwater infrastructure.
- **Is water quality a concern?** Communities that are directly concerned with water quality may determine that green infrastructure solutions are preferred as part of the long-term strategic plan. Additionally, these values could affect rules and regulations regarding future infill development.

This list of community values and priorities is almost endless. Thus, a planning team endeavoring to complete a comprehensive plan to address urban flood risk must start with determining a community's values and then integrating those with the goals and objectives that guide the alternatives development and overall planning process. As a starting place, the following guiding principals might be incorporated into the planning process to address urban flood risk:

- To minimize the impact of flooding associated with minor to moderate storm events;
- To think critically and creatively about stormwater resiliency in a built, urban environment;
- To increase public education and awareness role in adapting to flood conditions in the built environment;
- To examine basin characteristics as a test-case basin in order to identify implementable strategies that support a resilient community.

Ultimately, community engagement at multiple levels will determine the success of the developed plans to address urban flood risk. Developing an overall engagement plan that creates local ownership and understanding and establishes a systematic method of collaboration throughout the planning process is an important first step. Some suggested engagement strategies might include:

- Approaching neighborhoods with consistent, transparent, and responsive messaging and materials
- Creating opportunities for citizens to engage and collaborate with each other
- Convening a basin advisory group or working group that advises municipality on water related & community issues
- Coordinating with local business community

Investigate, Identify, and Evaluate Solutions

Historically, stormwater and floodplain management master plans have focused on infrastructure heavy solutions. Alternative screening often considered variations of the following:

- "Status Quo" – Maintain existing conditions
- Conveyance/capacity improvements
- Restoration of a natural type waterway
- Detention and/or water quality improvements
- Acquisition of flood prone properties

- Non-structural measures

While these alternatives are still valid and should be considered as part of every planning process, communities will want to consider how these alternatives integrate with a community's values and the goals and objectives developed at the front end of the planning process. Potential "add-on" considerations might include:

- Creation of new parks or open space in combination with acquisition of flood prone properties.
- Incorporation of green infrastructure on a local or regional scale that could affect streetscapes,
- Development of new greenway corridors in combination with restoration of natural drainageways.
- Restructuring of transportation networks or crossings that could create grade separated crossings for pedestrians and cyclists.
- Development of local land use regulations and ordinances as part of non-structural measures to limit or control development in a way that causes no adverse impact to existing flood risk.
- Flood risk zone mapping and/or special district assessments to help assist with future improvements.

A planner's toolbox is almost unlimited but must be informed by a community's desires and vision for the future. The following sections briefly discuss infrastructure solutions and local land use regulations that might be considered by planners, engineers, and managers addressing their urban flood risk. Also, because of the scale of improvements often required in areas of high urban flood risk, it's important to communicate with the public that it may take significant time to implement a full watershed level solution, i.e. one project is likely not going to solve the current urban flood risk issue. Explaining that there are multiple levels of implementation starting at the individual homeowner level (flood proofing and property improvements), moving up to the neighborhood level (neighborhood projects), and ultimately getting to the watershed/basin level (full-blown stormwater specific capital projects) will help citizens understand how improvements help to fix the problems that exist as a strategic plan is implemented.

A RESILIENT COMMUNITY



Figure 7: Graphic showing how a resilient community might address urban flood risk starting at the individual level up through watershed solutions.

Potential Capital Improvements to Address Urban Flood Hazard Areas

New or upgraded stormwater infrastructure to address urban flood risk almost always requires significant expenditure. These costs vary wildly based on size of the watershed and whether the facilities are within previously developed or undeveloped areas. For previously developed areas, like those affected by urban flood risk, adding pipes to address runoff from upstream or infill development after little or no standards have been in place for decades can be extremely costly if not completely unattainable. Local managers face a daunting task of attempting to establish a need for such facilities, developing an adequate plan to address the urban flood risk itself, and providing justification of the associated costs.

Communities faced with addressing existing urban flood hazards have a variety of potential infrastructure improvements they can use to mitigate the existing risk to structures and emergency access.

Increase the Size and Capacity of Existing Stormwater Infrastructure: Through the planning process, communities may determine that replacing or adding to existing stormwater infrastructure could reduce the impacts of urban flood inundation. These types of options seek to either replace existing pipes or

channels with ones that are larger in size and have more flow carrying capacity or ad parallel systems that convey additional stormwater runoff.

Daylighting/Drainageway Restoration: Restoring a natural conveyance system, that was previously filled in and/or converted to a piped conveyance system. The benefits of this type of solution include a return to a more natural flood conveyance system with more capacity than a piped system; the opportunity to provide community amenities such as trails and recreation areas; improved or recreated ecological function; and improved water quality.

Stormwater Detention/Retention: Traditional engineering strategy that seeks to store excess urban runoff volume, releasing runoff at historic peak rates. These facilities can reduce the peak flow rates entering downstream locations where existing stormwater infrastructure may be undersized or unable to handle large storm events.

Green Infrastructure (GI) or Low Impact Development (LID): Green infrastructure and low impact development seek to manage stormwater runoff via infiltration, mimicking natural systems that existed prior to development. These systems reduce peak runoff rates and volumes, increase infiltration and ground water recharge, increase evapotranspiration and reduce pollutants in-situ (Newcomer et al., 2014).

Property Buyouts and Greenway Development: City's may consider the purchase of properties within urban flood hazard inundation areas as an alternative to new stormwater infrastructure. In some cases, buyouts may prove to be more cost effective than new infrastructure. Buyouts provide opportunity for new public amenities such as parks or green space and/or may also be used to implement green infrastructure strategies.

All of these infrastructure solutions should be informed by other community plans related to transportation, mobility plans, parks and recreation, major utilities, and land use. Taking the time to ensure compatibility with future plans, community values, and goals and objectives to address flood risk will ultimately result in a plan that has more opportunity for implementation success.

Cost

Costs to implement infrastructure solutions to address urban flooding can be significant and potentially unattainable. When considering infrastructure solutions, it's important to develop a comprehensive benefit /cost analysis that can be used to make data driven decisions. To support this type of analysis, depth-damage estimates for a full range of storm events is critically important. Understanding the frequency and cost of flood damage should be a part of the inundation mapping effort on the front end of the planning process. The currently established methodology per FEMA Benefit Cost Analysis (BCA) is to assess damages using USACE Depth Damage Function (DDF) Curves. These DDFs assign a percentage damage relative to the depth of flooding and the value of the building and the contents. Although this approach can provide a good starting point for assessing damages, it does not allow for assessment of the many tangential costs for delivery of disaster recovery programs. It also doesn't consider benefits directly related to community values or lifestyle.

As an add-on to simply evaluating depth-damage estimates as part of the benefit-cost analysis, planners might consider the use of assigning value to ecosystem services that include such items as water quality, ecology, stream function, overall health within a community that is active vs. inactive, and values of

homes within a community as affected by local amenities. Additionally, some indirect economic benefits might include social cohesion, public safety and traffic reduction, mental health benefits from green space, and social equity considerations. How does one quantify ecosystem services benefits? It largely depends on the community priorities and on the regulatory atmosphere of the community. The ability for a community to quantify this cost is going to be very different in a community with a high degree of state and federal oversight vs a community that is mostly self-regulated, i.e. a community in Washington State is going to have more value associated with salmonid habitat preservation vs. a community in Texas where stormwater quality permits are mostly written and enforced at a community level with very little state oversight. Some professional groups have begun to assign values to ecosystem services that may be able to be used for planning studies. Through the planning process and as alternatives are developed, revised depth-damage estimates must be developed to understand the mitigation benefit of each proposed solution. Developed alternatives should include multiple scenarios, with different levels of protection, different long-term benefits, future maintenance considerations, and a buyout option that includes demo and relocations.

Finally, communities should consider multi-generational timeframes when considering benefit / cost analysis. Where urban flood risk exists and isn't addressed, flood damage will continue to occur generation after generation and at higher and higher costs due to inflationary pressures. Large scale projects that mitigate flooding for large storm events will have the long-term benefit of future generations being virtually free from costly flooding; ultimately creating a more resilient community.

Non-structural, Planning, and Regulatory Solutions

During the planning process and in working with community leaders, non-structural and regulatory solutions to address urban flooding should also be considered. If they haven't done so already, communities should adopt criteria and regulations regarding new development in the upstream watershed limiting site runoff to historic conditions. Additional regulations and non-structural solutions that should be considered include:

Local Floodplain Ordinances. Although urban flood inundation areas may not be mapped under the NFIP, nothing prevents communities from mapping and regulating these hazard areas. The City and County of Denver has created mapping for urban flood risk and designates those areas as Potential Areas of Inundation (PIA). In these areas the City has detailed 2-D hydraulic modeling and water surface elevation estimates. New development must be constructed so that the first floor elevation is either a minimum of 12" above the 100-year WSEL or at a level above 2 x100-year flow WSEL.

No Adverse Impact. Communities should specify that in areas of urban flood risk, any new development must not cause any adverse impact to other structures or public right of way. Practically, this means that new development would not cause any rise in WSEL on nearby structures and also wouldn't result in increased depths within the street right-of-way for emergency access considerations.

Insurance. Where urban flood risk exists, communities should encourage their constituents to obtain flood insurance from the NFIP. As originally noted, urban flooding has many causes such as overland ponding, inadequate sewer capacity, basement backups, and overbank flooding. Typical homeowner insurance policies do not insure against flood losses. Consequently, homeowners should consider purchasing flood insurance and additional relevant endorsements, i.e., a basement backup endorsement. Property owners should consider a holistic insurance approach to insure properties

against flood damages. Different types of water intrusion are covered by different insurance policies. For example, a basement backup endorsement may cover the loss caused by sewer backups and a flood insurance policy covers against flood losses. The insurance premiums for these areas are often less expensive than properties within SFHAs.

SECTION 4: RECOMMENDATIONS

Recommendation 1: Identify and Map Urban Flood Hazard Areas

Although many stormwater and floodplain managers know there are highly developed areas that flood on a regular basis and cause flood damage within their communities, these areas often remain unmapped and not completely understood. It's imperative that local communities understand the current risk of flooding in unmapped urban areas.

- Local communities should begin setting aside funds to study and map urban flood risk.
- FEMA and States should consider the creation of an incentive-based model to fund mapping and mitigation.
- Federal legislators should make federal funding available to assist local communities in mapping urban flood risk but should not necessarily be tied to NFIP mapping. Local communities can better understand their mapping needs and how developed data will be used.
- National organizations such as ASFPM and the National Association of Flood & Stormwater Management Agencies should partner with FEMA and local agencies in developing modeling and mapping standards for urban flooding. Those standards must be developed in full coordination with local government agencies to ensure their effectiveness and their acceptance over time. Identifying unmapped flood risk has many significant challenges, so not only developing standards, but effective policies for managing the newly mapped risk will be imperative for local stormwater and floodplain managers.

Recommendation 2: Communicate Urban Flood Risk

Inform the public that not all flood risk is mapped or understood. Citizens outside of SFHA's believe there is no real flood risk to them or their property because NFIP maps do not show flood risk in many non-riverine, non-coastal, urban areas. Communicating this flood risk through programs such as FloodSMART, state agencies, and local agencies should be a priority to insure at-risk homeowners and business owners.

- Communities must communicate with landowners about actual flood risk and recommend purchase of insurance in areas outside of the SFHAs, but near unmapped urban flood risk.
- Nationwide best practices for communicating and educating the public regarding urban flood risk must be developed to be used by local communities as part of comprehensive and collaborative urban flood risk mitigation planning. ASFPM may consider how to support these efforts in developing how to guides for local managers addressing urban flood risk.
- Communities should create awareness and develop policies to help residents understand how funding and design standards reduce risk, but also the real value in maintaining infrastructure and their role in supporting these efforts.

Recommendation 3: Develop Local Building Construction Standards

Communities should regulate new development and redevelopment within urban flood inundation areas. In addition to developing standards for elevating new construction above identified flood risk, communities should anticipate the geophysical impacts that climate change portends—and develop

strategies to respond to the variety of human decisions, perceptions, and reactions likely in post-disaster recovery and redevelopment scenarios.

Recommendation 4: Employ Multi-Generational Approaches to Implementing Improvements

Communities should consider long-term planning in urban flood zones that prioritizes buy-outs of flood prone properties over time, to support a strategy to restore the natural and beneficial functions of historic drainageways and provide for more resilient flood recovery. These buy-out properties can support various implementation strategies, including stormwater detention, green infrastructure, or daylighting or partial daylighting of pre-development drainageways. This approach will require communicating urban flood risk and limiting built environment engineering strategies such as increasing pipe capacity or elevating levees. Property buy-out may not occur before disasters, in the aftermath of which citizens are asking, “What’s next?” However, having resilient master planning documents that provide large-scale, comprehensive strategies is the first step to reducing losses due to urban flooding over time.

Benefit / Cost ratios should be considered over generations rather than just within one generation, one mortgage amortization, or one planning horizon. Communities that consider the cost of flood damage over an extended period can begin to realize the long-term cost to future generations and the potential savings from long-term future planning.

ASFPM should consider the development of how to guides that create a framework for local managers on how to manage urban flood risk addressing areas of identification, communication, planning, and implementation. Additionally, success stories from around the country could be made available on the internet through the Science Center in similar fashion to the Community Rating System success stories.

Recommendation 5: Identify Flood Mitigation Funding for Urban Flood Inundation Areas

Implementation costs for solutions to mitigate urban flood hazards are substantial. Before mapping these areas as part of NFIP, mitigation funding must be identified to reduce future flood damages and flood risk. Federal, state, and local government organizations have a duty to develop hazard mitigation programs and identify funding for implementing best management practices to reduce future damages due to urban flooding. This effort will involve numerous governmental and non-governmental organizations and will require the development of committees to capture ideas on how mitigation funding might be best created, combined, and distributed to communities addressing urban flood risk.

SECTION 5: RESOURCES

Section 1 References

The NFHL is made from effective flood maps and Letters of Map Change (LOMC) delivered to communities. NFHL digital data covers over 90 percent of the U.S. population.

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