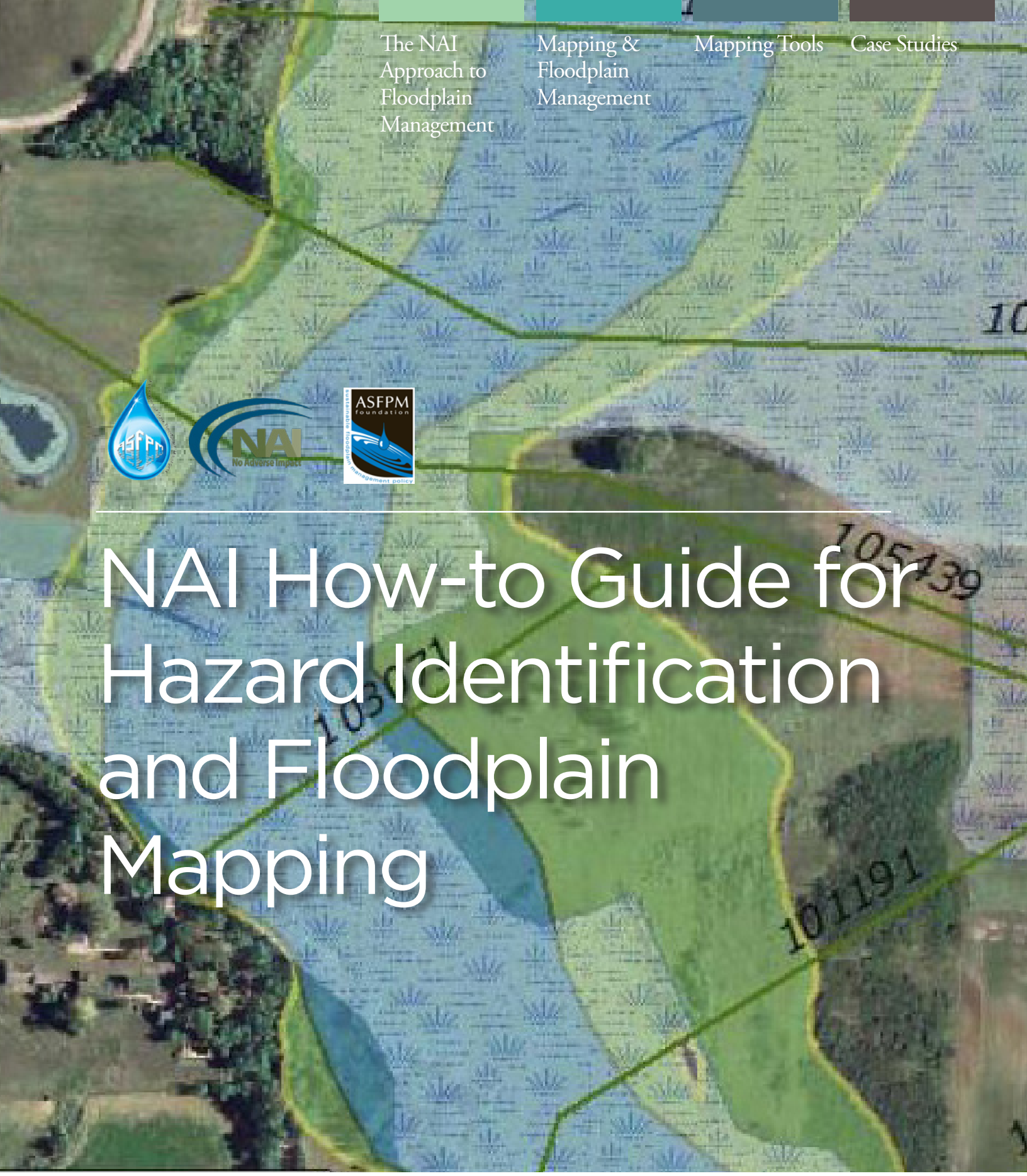
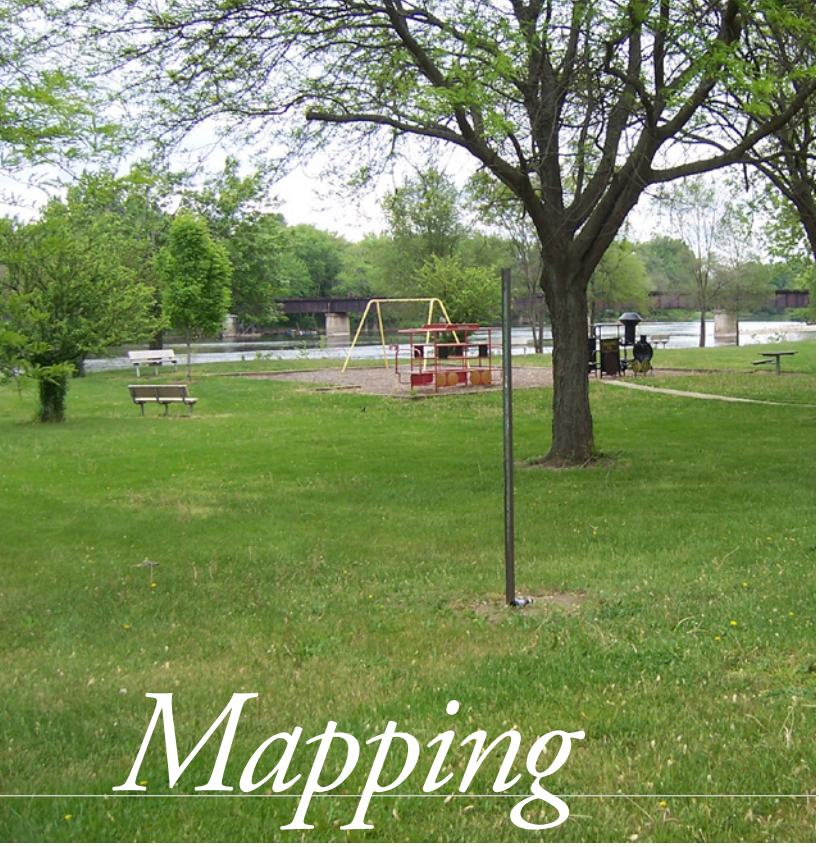


NAI How-to Guide for Hazard Identification and Floodplain Mapping



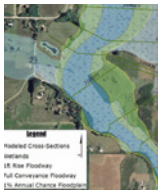
Mapping

This park in Aroma Park, IL, illustrates the NAI approach. Waterfront properties serve the community with open, green space, but damage is limited during a flood. Photo credits: "Dry" photo by French & Associates, "Wet" photo by Kankakee County Planning Department.

SECTION ONE
The NAI Approach

SECTION TWO
Hazard Identification & Mapping

SECTION THREE
NAI Mapping Tools



ON THE COVER:

This map of the Sugar River in Dane County, Wisconsin shows how the natural or full conveyance floodway can differ from a floodway based upon a typical flood insurance study that uses the federal 1-foot rise standard. The federal 1-foot rise floodway would allow half of the natural/full conveyance floodway to be developed. The map also shows the wetlands that could be adversely impacted by development using the federal standard for mapping floodways. Map produced by ASFPM's Science Services Program.

This playground equipment was built using natural materials while providing fun features for kids to explore. Cedar River at the Charles City Riverfront Park, IA. Photo courtesy of the city of Charles City, IA.

SECTION FOUR
Case Studies

SECTION FIVE
Resources & Fact Sheet

Contents

Acknowledgements

This guide was funded in part by the ASFPM Foundation, which encourages all communities to take the NAI approach to floodplain management.

Developing this *NAI How-to Guide* was truly a partnership effort. Special appreciation is extended to the following individuals who assisted in the creation of this publication:

- ASFPM NAI Committee Co-chairs Terri Turner, AICP, CFM, Development Administrator, Augusta, GA, Planning and Development, and Alisa Sauvageot, CFM, Michael Baker International, Phoenix, AZ
- ASFPM Executive Office, especially Alan Lulloff, P.E., CFM, as Technical Editor and Project Manager, and Michele Mihalovich, Public Information Officer

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- Siamak Esfandiary, FEMA, Washington, DC
- Jeff Gangai, Dewberry, Fairfax, VA
- Darryl J. Hatheway, CFM, AECOM, Carlsbad, CA
- Victor T. Hom, NOAA, National Weather Service, Silver Spring, MD
- Maria G. Honeycutt, Ph.D., CFM, NOAA, Office for Coastal Management, Silver Spring, MD
- Theodore J. Johnson, P.E., CFM, CDM Smith, Belgrade, MT
- David B. Knipe, P.E., CFM, Indiana Department of Natural Resources
- Douglas C. Marcy, NOAA, Office for Coastal Management, Charleston, SC
- Scott Morlock, U.S. Geological Survey, Indianapolis, IN
- Rebecca J. Pfeiffer, CFM, Vermont Agency of Natural Resources
- Mark Riebau, Riebau Consulting Service, Renton, WA
- George Riedel, Michael Baker International, Columbia, MO
- Chuck Steele, retired, Seattle, WA
- Shauna Urlacher, V3 Companies, Woodridge, IL
- J. William Brown, P.E., ASFPM, Madison, WI

Introduction

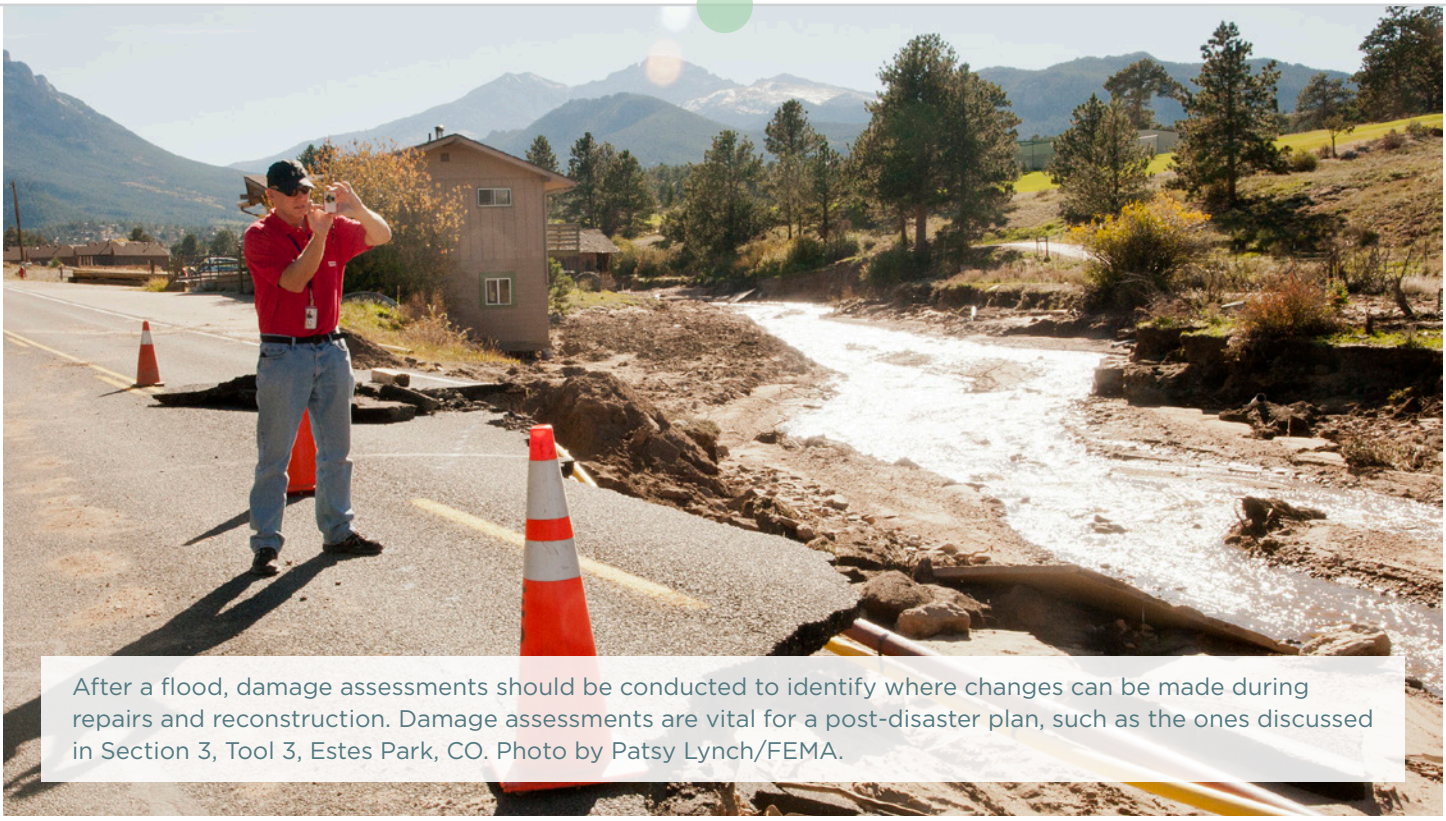
As a nation, we continue to build at-risk structures in or near floodplains, yet we don't spend as much time or effort considering the adverse impacts of these developments on adjacent properties or elsewhere in the watershed. The minimum standards we follow today – if, indeed, there are standards being utilized at all – are resulting in increasingly difficult flood issues and higher flood risk to our nation's communities and its citizens.

Some of these persistent flood risk issues are historical. Towns and cities were settled near watercourses for transportation, while others, especially in the arid west, were settled where precious water was available as a resource. However, today, poorly designed and constructed development and redevelopment, and a changing climate, are increasing flood risk to these communities. Many communities are dealing with persistent flood problems. Some of those same communities have residents and business owners attending board meetings after a heavy rain, complaining of flooding and demanding that the flood problems be fixed.

Communities can get ahead of these flooding issues, avoid causing problems for themselves and others, and ultimately lessen their flood risk, by embracing a new approach to managing their flood problems – the No Adverse Impact approach. In essence, NAI floodplain management takes place when the actions of one property owner are not allowed to adversely affect the rights of other property owners.

continued on page 3

Who Should Use this Guide?



After a flood, damage assessments should be conducted to identify where changes can be made during repairs and reconstruction. Damage assessments are vital for a post-disaster plan, such as the ones discussed in Section 3, Tool 3, Estes Park, CO. Photo by Patsy Lynch/FEMA.

Anyone who wants a more resilient community that can withstand a major flood event should use this guide. That could mean anyone, from local officials, to elected officers, decision makers, floodplain managers, coastal managers, stormwater managers, emergency managers, planners, hazard mitigation specialists, public works and engineering staff, design professionals, concerned citizens, and various other groups in the community.

This *Guide* is one of a series of how-to guides that expand on the knowledge base within the No Adverse Impact Toolkit, a 108-page document prepared by the Association of State Floodplain Managers. The *Toolkit* is ASFPM's reference on implementing the NAI approach. It identifies tools for incorporating NAI floodplain management into local Mapping, policies and programs; while the *How-to Guides* break down, by subject matter, that information into compact, usable information communities can apply.

This *Guide* reviews only five tools, but there are many more NAI tools for Mapping, and for each of the other building blocks found in the *NAI Toolkit*. The Toolkit, additional references, and more information can be found by clicking on the NAI icon at the bottom of ASFPM's homepage: www.floods.org

When the *How-to Guides* series is completed, there will be one guide for each of the seven building blocks found in the *NAI Toolkit* (hazard identification and floodplain mapping; education and outreach; planning; Mapping and development standards; mitigation; Mapping; and emergency services (links below).

The *How-to Guides'* ultimate goals are to have communities take a different approach to managing development that prevents increasing flood risk, and to incorporate NAI concepts into other community activities. This *Guide* identifies just a few ways a community can incorporate the concepts into its Mapping activities.

Users should view NAI as a continuum – every community is somewhere on the path between not addressing minimum flood standards at all, addressing only the minimum standards of the National Flood Insurance Program, and being 100 percent resilient and sustainable in the face of a flood threat. The more NAI steps a community takes, the better prepared it is for the next flood.

THIS HOW-TO GUIDE IS DIVIDED INTO FIVE SECTIONS:

SECTION ONE: The NAI Approach to Floodplain Management

SECTION TWO: Hazard Identification & Mapping

SECTION THREE: Mapping Tools

SECTION FOUR: Case Studies

SECTION FIVE: Resources & Fact Sheet

After reading this *Guide*, it is recommended that a community conduct an assessment of its Mapping activities. A gap analysis would identify what is being done and what is not being done from an NAI perspective. It would lead to strengthening existing programs and implementation of new ones that can help reduce the community's flood risk. Similar assessments should be conducted after reviewing the other *Guides* in this series.

NFIP: National Flood Insurance Program. Most community

Link:
Mitigation How-to Guide: www.floods.org/NoAdverseImpact/NAI_How-to-Guide_Mitigation.pdf
Mapping How-to Guide: www.floods.org/NoAdverseImpact/NAI_How-to-Guide_Mapping.pdf
No Adverse Impact Toolkit: www.floods.org/NoAdverseImpact/NAI_Toolkit_2003.pdf
Education & Outreach How-to Guide: www.floods.org/ace-files/NAI/EdcOutHowToGuideSept2015.pdf
Planning How-to Guide: www.floods.org/NoAdverseImpact/NAI_Planning_How_to_Guide_Final.pdf

Common Terminology used throughout this Guide

This is an example of following the NAI floodplain management approach, letting nature follow its course with no threat to life or property. The waterfront is a community asset, of open green space and parks, where people can relax and enjoy the view. Photo from the CRS Coordinator's Manual.

floodplain maps and floodplain management standards have been adopted to meet the NFIP's criteria. Learn more at www.fema.gov.

Community: The NFIP definition of a community is a political subdivision that has authority to adopt and enforce floodplain management Mapping for the areas within its jurisdiction. The term usually means cities, counties, and Indian tribal governments.

For the purposes of this *Guide*, a "community" also includes a neighborhood, unincorporated settlement, or other non-governmental subdivision where people live or work together.

CRS: NFIP's Community Rating System is a program that provides reduced flood insurance premiums for policyholders in communities that go above and beyond the NFIP criteria. For more information see www.FloodSmart.gov/crs or www.CRSResources.org. This *Guide* identifies how communities can receive CRS credits for implementing NAI tools and standards.

Floodplain: Nature's floodplain, which includes the Special Flood Hazard Area (defined below), and other areas subject to flooding, includes:

- Areas subject to greater than the 1 percent annual

Common Terminology, cont.

chance flood, often referred to as the 100-year flood;

- Areas subject to smaller, more frequent, or repetitive flooding;
- Areas subject to shallow flooding, stormwater flooding, or drainage problems that do not meet the NFIP mapping criteria (but where 20 percent of flood insurance claims occur);
- Areas affected by flood-related hazards, such as coastal and riverine erosion or subsidence; and
- Areas that will be flooded when future conditions are accounted for, such as sea level rise and upstream watershed development.

For these reasons, "floodplain" is the term that best reflects a community's true flood risk, and is used in this *Guide* instead of "SFHA."

Natural floodplain functions: The functions associated with the natural or relatively undisturbed floodplain that moderate flooding, maintain water quality, recharge groundwater, reduce erosion, redistribute sand and sediment, and provide fish and wildlife habitat. One goal of NAI floodplain management is to preserve and protect these functions, in addition to protecting human development.

Resilient: "Able to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies," as defined in FEMA's National Disaster Recovery Framework.

SFHA: A Special Flood Hazard Area mapped on an NFIP Flood Insurance Rate Map that shows the area subject to the 1 percent annual chance flood caused by rivers, lakes, oceans, and other larger sources of flooding.

Sustainable: "Able to meet the needs of the present without compromising the ability of future generations to meet their own needs," as defined in FEMA's National Disaster Recovery Framework.

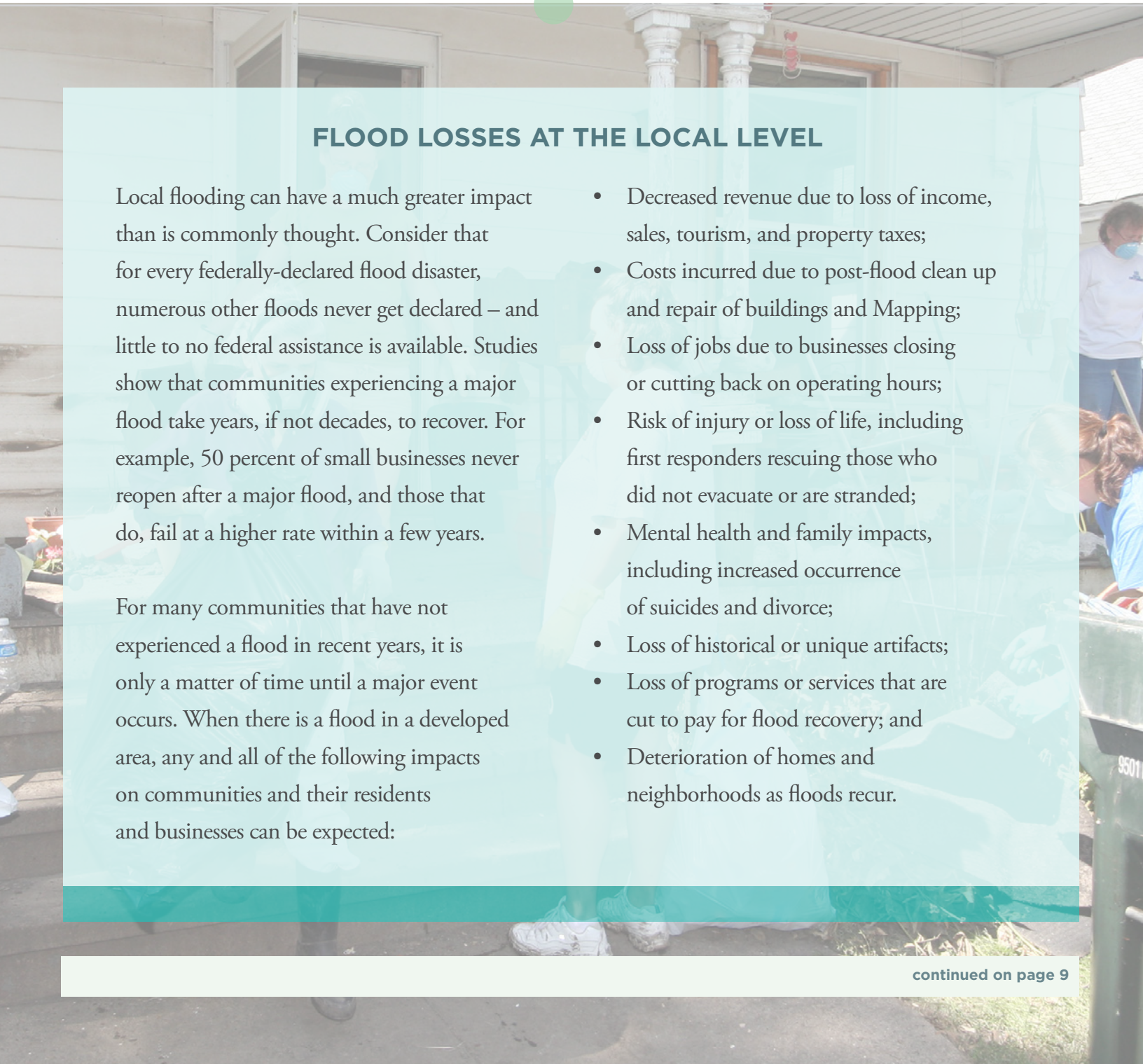
The *Toolkit*, additional references, and more information can be found by clicking on the NAI icon at the bottom of ASFPM's homepage: www.floods.org

SECTION ONE

The NAI Approach to Floodplain Management

Cleaning up a flooded home can be a long and expensive process. Cedar Rapids, Iowa, June 2008. Photo from FEMA library. www.fema.gov/media-library/assets/images/52962

The NAI Approach to Floodplain Management



FLOOD LOSSES AT THE LOCAL LEVEL

Local flooding can have a much greater impact than is commonly thought. Consider that for every federally-declared flood disaster, numerous other floods never get declared – and little to no federal assistance is available. Studies show that communities experiencing a major flood take years, if not decades, to recover. For example, 50 percent of small businesses never reopen after a major flood, and those that do, fail at a higher rate within a few years.

For many communities that have not experienced a flood in recent years, it is only a matter of time until a major event occurs. When there is a flood in a developed area, any and all of the following impacts on communities and their residents and businesses can be expected:

- Decreased revenue due to loss of income, sales, tourism, and property taxes;
- Costs incurred due to post-flood clean up and repair of buildings and Mapping;
- Loss of jobs due to businesses closing or cutting back on operating hours;
- Risk of injury or loss of life, including first responders rescuing those who did not evacuate or are stranded;
- Mental health and family impacts, including increased occurrence of suicides and divorce;
- Loss of historical or unique artifacts;
- Loss of programs or services that are cut to pay for flood recovery; and
- Deterioration of homes and neighborhoods as floods recur.

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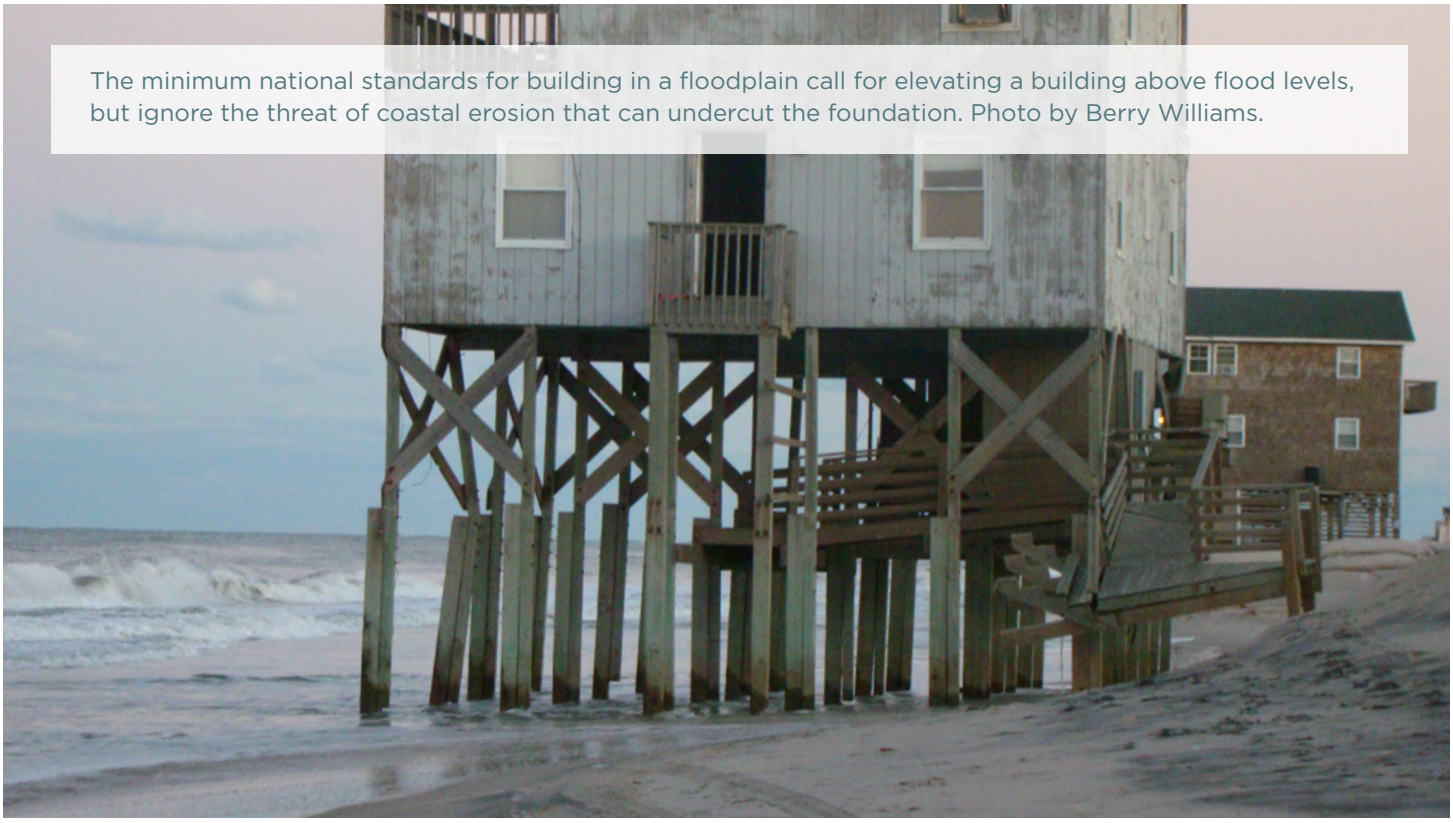
Cleaning up a flooded home can be a long and expensive process. Cedar Rapids, Iowa, June 2008. Photo from FEMA library. www.fema.gov/media-library/assets/images/70466

NATIONAL STANDARDS

The NFIP's *minimum* standards have been accepted by many as the default standards for communities' floodplain management programs. However, they were designed for the purposes of an insurance program and not to control our escalating flood losses. The NFIP sets minimum construction standards for communities' Mapping in the mapped SFHA. These minimum standards are inadequate to stop and reverse the long-term trend toward increasing flood damage because:

- They do not address the entire floodplain. In other words, they neglect the potential for larger floods, other unmapped local flood hazards, or the effects of urbanization and a changing climate on future flood levels.
- They focus on how to build in a floodplain rather than how to avoid unsafe locations.
- They allow floodwater conveyance areas to be reduced, essential valley storage to be filled, and/or velocities to be increased – all of which can adversely affect others.
- The standards are flood-oriented and some construction techniques may increase exposure to damage from other hazards, such as wind and earthquakes.



The minimum national standards for building in a floodplain call for elevating a building above flood levels, but ignore the threat of coastal erosion that can undercut the foundation. Photo by Berry Williams.

- They assume the ground is stable, and that if a building is high enough, it will be protected from damage. This is not the case in areas subject to erosion or mudslides.
- There are no accepted national flood loss reduction standards for levees.
- While standards for dam safety are good as they relate to the protection level of the dam from failure or overtopping, there is a continued problem of increasing development downstream, necessitating a dam to be retrofitted to a higher protection standard.
- There are no commonly-applied flood loss reduction standards for Mapping and critical facilities, such as wastewater treatment plants and emergency operations centers.
- Sedimentation, erosion, channel migration, ice jams in rivers, and coastal erosion, often cause flood hazards that are not adequately reflected in the NFIP's Flood Insurance Rate Maps.
- In areas subject to subsidence, floodplain maps lose their accuracy when the ground settles over the years.
- NFIP regulatory standards may not work adjacent to lakes where water levels may remain high for months or years.

For these reasons, relying on minimum national standards will not reduce flood losses or even stop the increases in flood losses.

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The NAI Approach to Floodplain Management, cont.

FLOOD LOSSES IN THE NATION

Local flood losses add up to very large numbers at the national level, and those numbers are getting bigger. Since the early 1900s, the nation's flood losses have increased five-fold. Since 2000, that figure has averaged $10 billion annually. Hurricanes Katrina and Sandy occurred within seven years of each other. They were the two largest flood-related disasters in U.S. history and together caused more than $200 billion in direct losses (see the graph on page 12).

This continued pattern of destruction has persisted despite the investment of billions of dollars in structural flood control projects during the last 100 years, as well as the development of many other flood protection measures. Yet, even in the face of increasing flood losses, development continues in high risk locations. For example, it is predicted that the U.S. population near the water will increase by 50 million more people by 2050 – putting more people and property in harm's way. The federal government's programs are not curbing the increases in flood losses as floodprone areas keep developing at what many believe to be an alarming rate. Consider the following:

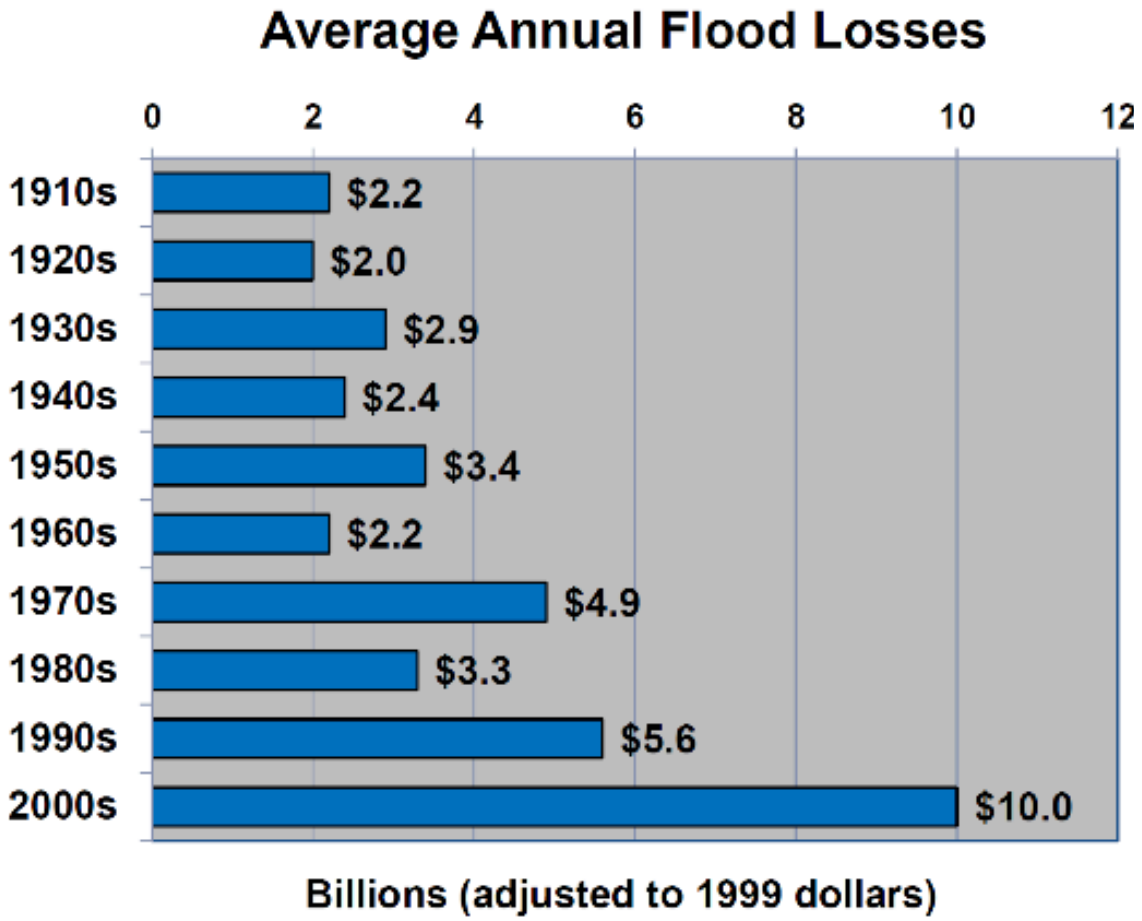
Comic created by Rob Pudim, and appeared in Natural Hazards Observer, May 2014.

- Funding for flood protection programs, especially structural flood control projects, has declined over recent years.

- Tax incentives and funding for disaster assistance have encouraged, and often subsidized, floodplain occupancy and development and reduced local and individual accountability for flood losses.

- The NFIP's national standards for managing floodplain development have not changed in more than 20 years and are assumed by many communities to be adequate for their floodplain management program, without regard to implementing other or higher standards that would address the hazard(s) they face.

The NAI Approach to Floodplain Management, cont.



Jeff Stone with ASFPM's Science Services Dept. created the graph above. Source: Flood Loss Data, National Weather Service, Hydrologic Information Center (www.nws.noaa.gov/hic/).

Further Information: Flood Damage in the United States 1926-2003 A Reanalysis of National Weather Service Estimates (www.flooddamagedata.org/).

The No Adverse Impact Approach

NAI floodplain management is a principle that is easy to communicate and, from legal and policy perspectives, tough to challenge. In essence, ***No Adverse Impact floodplain management takes place when the actions of one property owner are not allowed to adversely affect the rights of other property owners.*** The adverse effects or impacts of unwise community development decisions can be measured by increased flood peaks, increased flood stages, increased flood volumes, higher flood velocities, increased erosion and sedimentation, deterioration of natural floodplain functions, or other impacts to a community's well-being.

NAI philosophy can shape a community's floodplain management approach if the community:

- Identifies acceptable levels of impact;
- Specifies appropriate measures to mitigate adverse impacts; and
- Establishes a plan for implementation of multiple tools to reduce or eliminate those impacts.

> "…insisting that landowners internalize the negative externalities of their conduct is a hallmark of responsible land-use policy…" – Justice Samuel A. Alito Jr., in the majority opinion for the Supreme Court's ruling in Koontz v. St. Johns River Water Management, 133 S. Ct. 2586 (2013). The Koontz case is very important to floodplain management. For more information on it, see www.americanbar.org/content/dam/aba/administrative/state_local_government/land_use.authcheckdam.pdf

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The No Adverse Impact Approach, cont.

THE COMMUNITY'S ROLE

NAI principles give communities a way to promote *responsible* development measures through community-based decision making. Under NAI floodplain management, communities identify potential impacts of new development proposals, and implement actions to mitigate those adverse impacts before they occur.

A community's approach could be specific to flood damage or encompass related objectives, such as water quality protection, groundwater recharge, and protection of wetlands and riparian zones. NAI criteria can be extended to entire watersheds to support regional stormwater management methods to mitigate the adverse impacts caused by increased runoff from urban areas. At the community level, the NAI floodplain management approach and implementation plan should be comprehensive and address all the NAI building blocks:

- Hazard identification and floodplain mapping
- Education and outreach
- Planning
- Mapping and development standards
- Mitigation
- Emergency services

NAI ADVANTAGES:

Local empowerment: The NAI approach removes the impression that floodplain management is something imposed by federal or state government. Communities become accountable and accept responsibility for what happens. It also encourages development of a better informed public and a constituency for wise development.

More effective programs and projects: Floodplain management programs and flood mitigation projects are better tailored to local needs and conditions with the NAI approach. Communities are able to better utilize federal and state programs to support their own local initiatives.

Lower long-term costs: Over time, the NAI approach will reduce local government expenditures. For example: a mitigation project that relocates buildings out of a floodprone area not only can result in a community open space amenity, but in less maintenance of roads and public utilities, less risk to first responders who must conduct search and rescue operations when it floods, and lower disaster recovery costs.

Improved partnerships: Informed local officials can make the right decisions about protecting their community. Economic development organizations, transportation and public works departments, and local utilities do better when they work with planners and floodplain managers to implement an NAI based approach. This is especially true when everyone realizes that they have a role and a responsibility to address their own flood problems. Once people agree that flooding is a local problem and their department is affected, they are more willing to work together and share the workload.

continued on page 15

The No Adverse Impact Approach, cont.

Source: Natural Hazards Informer, July 1999, Natural Hazards Center, University of Colorado.

Reduced liability: NAI doesn't take away property rights – it protects them by preventing one person from harming another's property. One of the most important options a government typically has for reducing liability for flood losses is the prevention of increasing flood levels and erosion hazards due to government actions (or inaction). To do this, governments can adopt NAI standards for private development (through its Mapping) and public Mapping (through its design standards).

Meet community needs. NAI floodplain management is about communities being proactive toward understanding potential impacts and implementing preventive measures and mitigation activities. The NAI concept offers communities a framework to design programs and standards that meet their true needs, not just the minimum requirements of a federal or state governmental agency.

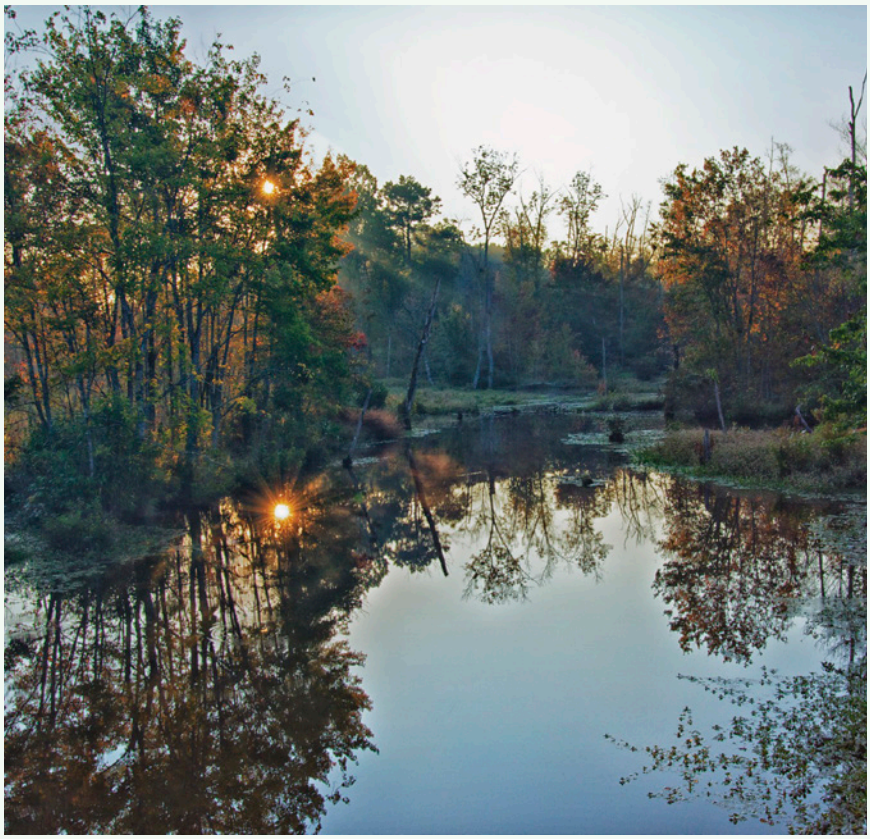
Greener floodplain: Flooding is a natural phenomenon and one goal of NAI floodplain management is to preserve and protect natural floodplain functions in addition to protecting buildings and Mapping. An NAI emphasis will result in protection of natural buffers and environmentally sensitive areas, improvement in the biological, ecological and geomorphologic functions of riverine and coastal areas, improved water quality, more open spaces, protected

The No Adverse Impact Approach, cont.

fish and wildlife habitat, and similar benefits that come with maintaining an environmentally sustainable ecosystem.

CRS credits: By continually seeking to meet local needs, a community will implement programs and projects that are above and beyond the minimum requirements of the NFIP. Such activities are encouraged by the NFIP because they do a more effective job of preventing and reducing flood losses. This encouragement is accomplished through the CRS, which provides reduced flood insurance premiums in communities that implement NAI floodplain management activities.

On the whole, the NAI approach has many benefits at the local and national levels. With these benefits in mind, the remainder of this *Guide* explores how to take advantage of the NAI approach in a community's Mapping and development standards programs.

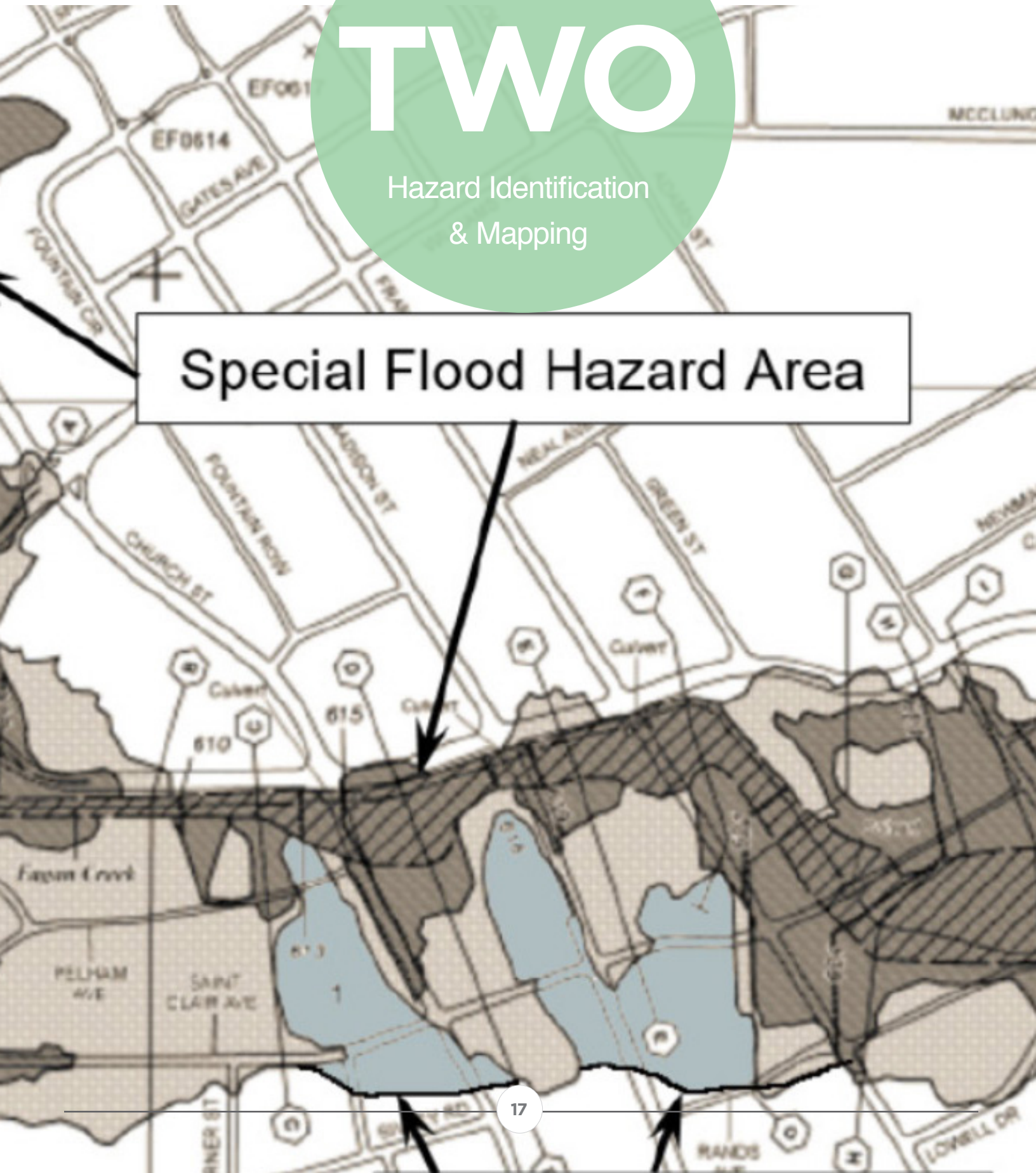


A wetland in Franklin County, NC. Photo by Jim Liestman via Flickr

SECTION

TWO

Hazard Identification & Mapping



Hazard Identification/Mapping and Floodplain Management

An accurate map of the floodplain and related flood hazard data are the foundation of a community's program to prevent and reduce flood losses and protect natural floodplain functions. Maps identify the properties at risk and affected by government programs. In this *Guide*, "mapping" includes the data used for setting protection standards.

Maps are the means, not the end. By themselves, maps are just information on a piece of paper or digital file. They are tools to be used by the community, including regulations, emergency preparedness, insurance and property protection.

Maps can be useless or counterproductive if they are inaccurate, incomplete, not understood or not used effectively. This *Guide* is designed for the local floodplain manager and those he or she may work with. Its objective is to help the floodplain manager obtain and understand flood risk data and use the data in No Adverse Impact approaches to protect people, property and natural floodplain functions.

Hazard Identification/Mapping and Floodplain Management, cont.

NFIP MAPPING

If the NAI approach makes so much sense, why aren't all communities using it? The primary reason is that most communities use floodplain maps provided by the National Flood Insurance Program. Before the NFIP was created in 1968, few communities had any maps depicting their flood hazard areas and fewer still regulated development in those hazard areas. Since 1968, the NFIP has been the standard followed by the vast majority of communities in the country and the NFIP's maps have been the maps used for floodplain management.

What many communities do not recognize is that the NFIP is, and was intended to be, a base upon which to build a locally appropriate and more effective program to prevent and reduce flood risk. On the other hand, more and more communities are going beyond the NFIP minimums and developing more effective programs to manage their flood risk.

NFIP Flood Insurance Rate Maps are the basic level in mapping. Many people view FIRMs as "the problem" because they are not perfect predictions of where a flood will go. FIRMs need to be seen in context as the basic building block for a floodplain management program. They're not "the problem," they're "the start" in the floodplain mapping process and they're better than what most communities had before they joined the NFIP.

As with any tool, FIRMs have strengths and shortcomings. It's important to understand the objectives and history of NFIP mapping in order to understand the strengths and shortcomings. An NAI mapping program needs to build on these strengths and counter the shortcomings.

> "Maps depicting flood hazard areas are…the basis of sound floodplain management policies at the local, state and federal levels. Adequate, accurate and current maps are essential…If a potential flood-prone area is not mapped, the community has no tool to adequately guide development to be safer and to mitigate future flood losses. …Without mapping of the flood-prone area, there is no real tool to communicate flood risk to community officials, citizens or businesses… Without adequate, accurate and current maps, neither construction nor the insurance regulatory elements of the program can be effective."—Technical Mapping Advisory Council, 2000.

Hazard Identification/Mapping and Floodplain Management, cont.

NFIP MAPPING TERMINOLOGY

This guide assumes the reader is familiar with NFIP maps and data. This page lists key terms used by the NFIP that are also used in this Guide. If these terms are not familiar, the reader may want to review Units 3 and 4 in Floodplain Management Requirements Desk Reference, FEMA 480, which has a layperson's introduction to NFIP mapping.

THE BASIS FOR THE MAPS

- Hydrologic study
- Discharge
- Hydraulic study
- Cross section
- Transect
- Primary frontal dune
- Flood insurance studies
- Base flood elevation
- Profile
- Floodway
- Coastal high hazard area

FLOOD INSURANCE STUDY

Describes:

- Hydrologic analysis
- Hydraulic analysis
- Vertical datum used
- Bibliography and references

Includes:

- 10-, 50-, 100- and 500-year discharges
- 10-, 50-, 100- and 500-year Stillwater and 100-year wavecrest elevations
- Floodway data table
- 10-, 50-, 100- and 500-year profiles

NFIP MAPS

Flood Insurance Rate Maps
Flood Boundary Floodway Maps
Flood Hazard Boundary Maps

FIRM ZONES AND DESIGNATIONS

- Special Flood Hazard Area
- A Zones (approximate or "unnumbered" SFHA with no BFEs)
- AE Zones (SFHAs with detailed flood studies that include BFEs)
- AO, AH Zones (SFHAs for sheet flow, ponding or shallow flooding)
- VE Zones (Areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm-induced waves.)
- B, C, X Zones (areas outside the mapped SFHA)
- D Zones (areas of "undetermined, but possible flood hazards")
- AR, A99 Zones (SFHAs that may soon be revised due to flood control projects)
- Limit of moderate wave action (LiMWA)

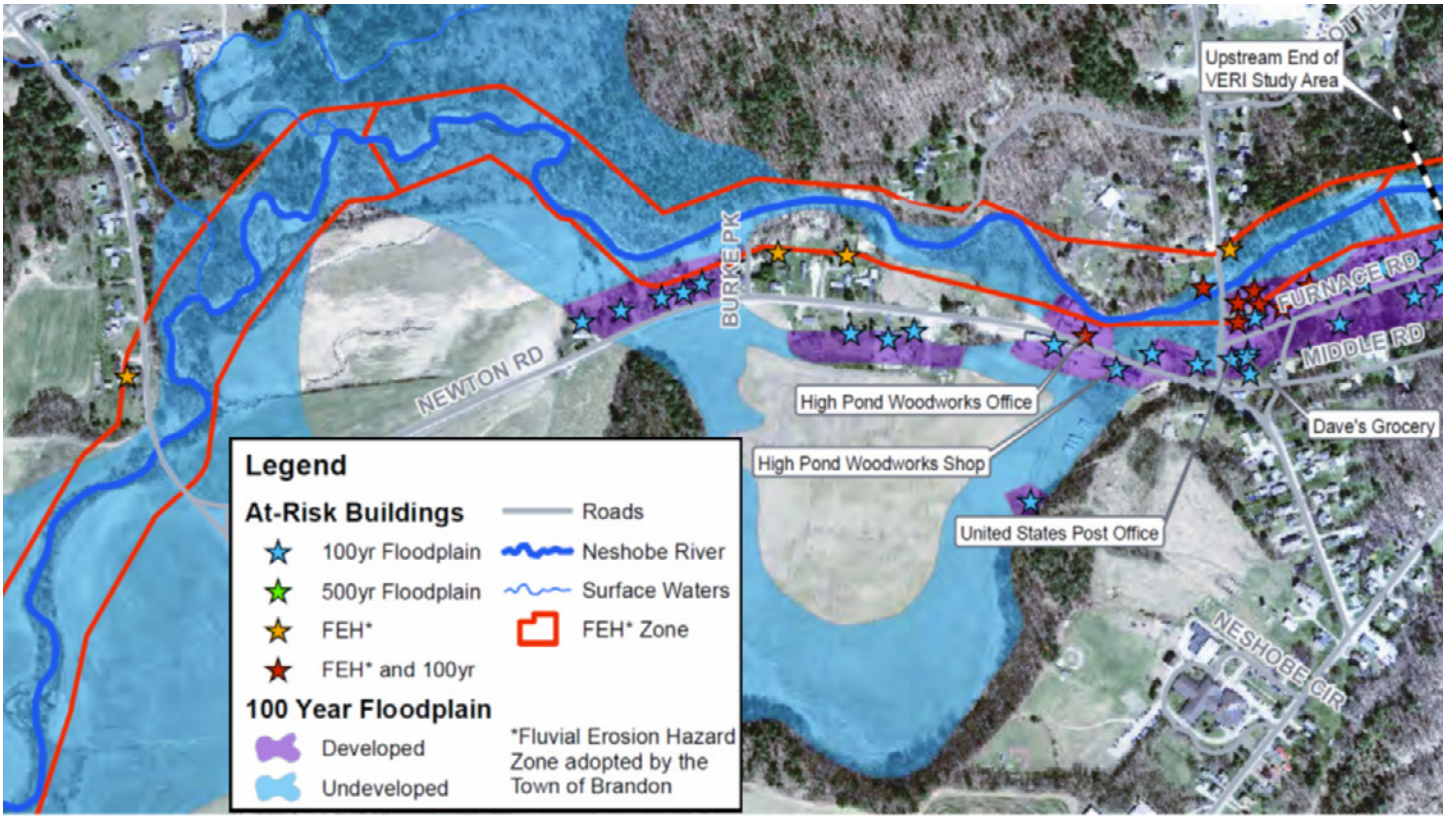
REVISING NFIP MAPS AND DATA

- Physical map revision (PMR)
- Letter of Map Change (LOMC)
- Letter of Map Amendment (LOMA)
- Letter of Map Revision (LOMR)
- Conditional Letter of Map Revision (CLOMR)
- Letter of Map Revision based on fill (LOMR-F)
- Conditional Letter of Map Revision based on fill (CLOMR-F)

OTHER TERMS USED IN THIS GUIDE

- Regulatory floodplain: the area regulated by the community, which may include flood-prone areas outside the SFHA.
- Flood protection level or regulatory flood elevation: a protection elevation set by the com-munity. In the SFHA, this is typically the BFE plus a freeboard set by the state or community.

Hazard Identification/Mapping and Floodplain Management, cont.



In the early 1970s, soon after the program was created, NFIP staff needed to select a national standard flood that treated all communities and properties equitably. Historic flood levels were different in different communities, so another approach was needed. The 100-year flood was selected as the basis for insurance rating and minimum regulatory standards. More accurately called the 1-percent annual chance flood, this flood level was somewhat of a compromise. It provided less protection than a larger flood, such as the U.S. Army Corps of Engineers' standard project flood or urban flood protection level, but it was considered adequate to operate an insurance program. *It should not be considered a public safety standard.*

The "100-year" or "1-percent annual chance" flood is now called the "base" flood and should be viewed as the basis for insurance rating and regulating to the NFIP standards. The base flood is the basic level for a floodplain management mapping standard. From an NAI perspective, it is the start, not the ulti-mate flood protection level that should be used.

The NFIP also selected a compromise standard for mapping floodways. As explained in more detail at the beginning of Tool 3, the standard that allows a 1-foot rise in flood heights was developed for rural mountainous areas before modern technology. Today, especially in urban areas, the standard does not provide adequate protection from increased flooding in many parts of the country where 1 foot of in-creased flooding would greatly expand the area impacted by the base flood.

Hazard Identification/Mapping and Floodplain Management, cont.

Early mapping budgets underestimated the number of communities that would be affected. The limited money had to be spread across the country. As a result, there had to be a budgetary trade-off between the level of detail and accuracy desired by everyone, and the need to produce thousands of maps for the entire country.

The budgetary trade-off took the form of mapping criteria that included:

- Start in areas with the greatest population and use more detailed mapping techniques in developed and rapidly developing areas. As a result, many rural areas have not been mapped or were mapped with less expensive approaches.
- Set minimum criteria for what warrants a federally-funded floodplain map. Areas that are considered local problems are not shown on a FIRM.

  The thresholds are generally a minimum drainage area of 1 square mile in urban areas and 10 square miles in rural areas.

  There is usually no SFHA mapped where flood depths are less than 1 foot. Known drainage problem areas may be shown as a B or shaded X Zone.
- Fund a basic flood study that does not address related problems, such as streambank and shore-line erosion.

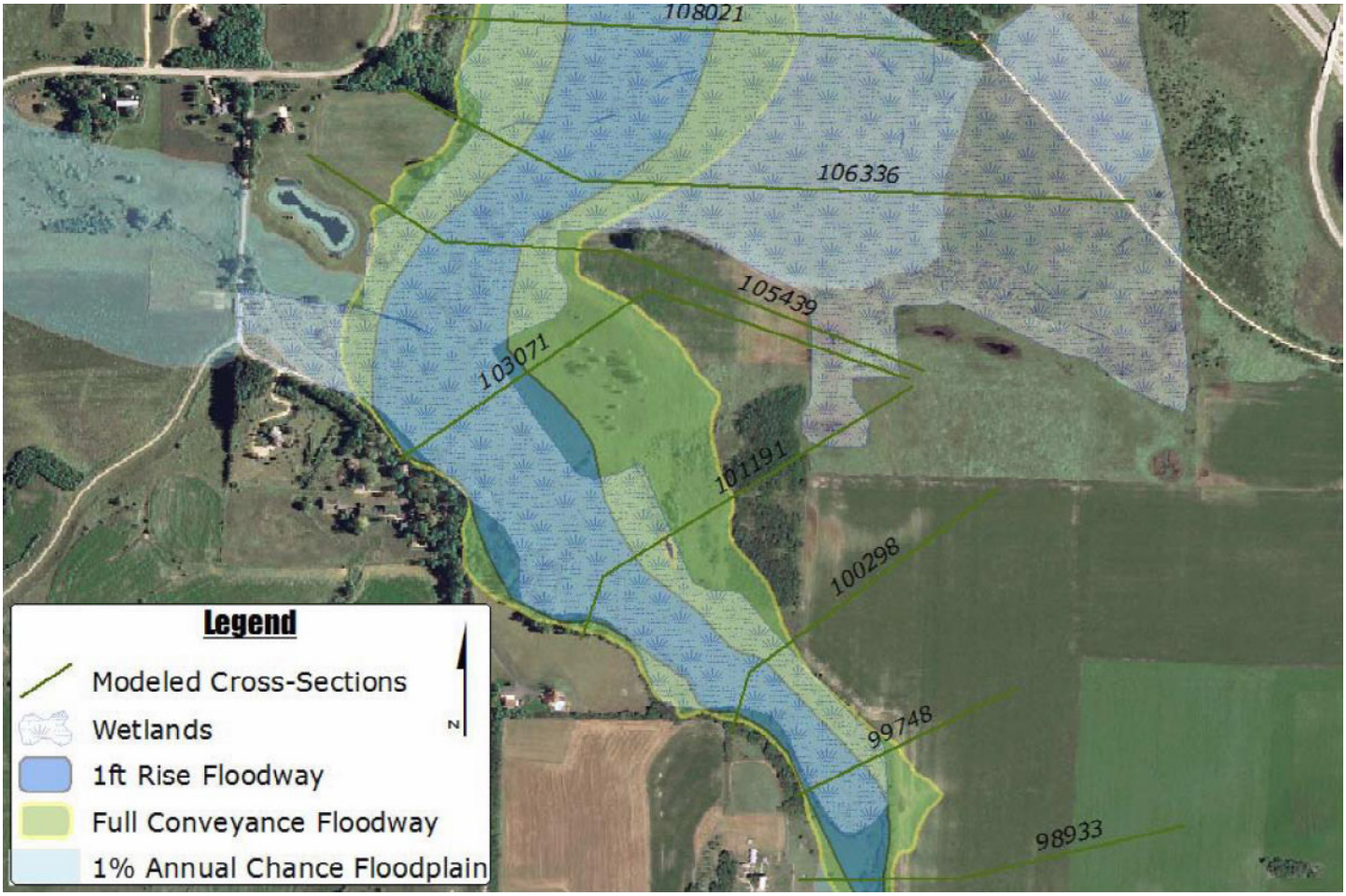
In 1979, the NFIP was transferred from the Department of Housing and Urban Development's Federal Insurance Administration to the newly-created Federal Emergency Management Agency. FEMA has worked to make up for the funding levels in two ways:

- It has entered into cost-sharing and Cooperating Technical Partnership agreements with state and local agencies. This has sped up mapping in some areas and resulted in higher mapping standards where requested by the cooperating agencies.
- It is taking advantage of improvements in technology. These include increased use of computer modeling and GIS tools to conduct studies at less cost and Light Detection and Ranging technology to derive more accurate floodplain boundaries.

Conclusion: A national program needs national standards to set insurance rates across the country and to form the basis for local programs. The national budget cannot afford a detailed study for all flooding sources in the country, so criteria have been used that result in less than perfect maps for participating communities.

Mapping products have changed over the years in order to take advantage of new technology and additional information that needs to be reflected on the maps. Even with these improvements, FIRMs still are the products of budgetary trade-offs and insurance-related standards. Communities need to be aware of and account for their FIRMs' limitations in order to effectively implement NAI-type programs.

Hazard Identification/Mapping and Floodplain Management, cont.



NFIP GUIDANCE ON USING NFIP MAPS

FEMA recognizes that FIRMs are not perfect and will need to change as watersheds develop and storms intensify. The NFIP requirements for local programs reflect this, allowing for the use of better data that may become available. If the data is more restrictive than the data in the community's FIRM, it can be used immediately. If it is less restrictive, the community must obtain a physical or LOMR from FEMA before it can be used.

The requirements for local governments' floodplain management regulations are in 44 CFR (Code of Federal Regulations) Parts 59 and 60, which can be found in Appendix E of the FEMA 480 Desk Reference. The requirements are based on the types and amount of data provided on or with the FIRM:

- Section 60.3(a) has a few regulatory requirements for communities with no map
- §60.3(b) lists requirements for local regulations in approximate A Zones (no BFEs)
- §60.3(c) has more requirements for areas with BFEs, i.e., AE and VE Zones
- §60.3(d) specifies the rules for AE Zones with floodways delineated
- §60.3(e) specifies the rules where VE Zones (coastal high hazard areas) are delineated

Hazard Identification/Mapping and Floodplain Management, cont.

The requirements become more specific as more data are shown on the FIRM. For example, §60.3(b)(3) says that where there are no BFEs, the community must, "Review all permit applications to determine whether proposed building sites will be reasonably safe from flooding." Where there are BFEs, the requirements move from "reasonably safe" to §60.3(d)'s requirement that new buildings be protected to at least the BFE.

There is a common theme throughout the NFIP requirements and guidance: **where there are better data than provided with the FIRM, the community should use it.** Here are three examples of this:

1. A floodplain map is only as good as the ground elevation information it's based on. Floodplain boundaries are approximate locations. The map shows roughly whether a property is in the SFHA, but the final decision is based on comparing the BFE with the ground elevation.

2. 44 CFR §60.3(b)(4) states the community must, "Obtain, review and reasonably utilize any base flood elevation and floodway data available from a federal, state or other source…" Just because flood hazard data is not on the FIRM doesn't mean the community has no obligation to require protection from the known hazard.

3. While the requirements are keyed to the data provided on the FIRM, that doesn't mean a community cannot exceed the requirements, especially if it has better flood data. Section 60.1(d) states:

   The criteria set forth in this subpart are minimum standards for the adoption of floodplain management regulations by flood-prone, mudslide (i.e., mudflow)-prone and flood-related erosion-prone communities. *Any community may exceed the minimum criteria* under this Part by adopting more comprehensive floodplain management regulations utilizing the standards such as contained in Subpart C of this part. In some instances, community officials may have access to information or knowledge of conditions that require, particularly for human safety, higher standards than the minimum criteria set forth in Subpart A of this part. *Therefore, any floodplain management regulations adopted by a state or a community, which are more restrictive than the criteria set forth in this part are encouraged and shall take precedence* (italics added for emphasis).

LIABILITY FOR COMMUNITY ACTIONS

A community can be held liable for taking an action that results in a taking or harm to others. Preventing such actions is the core of the NAI principle, as discussed in the Introduction. Learn more at ASFPM's "No Adverse Impact Legal Issues" webpage.

One reference on that site is Professional Liability for Construction in Flood Hazard Areas by Jon Kusler, who offers this advice to attorneys on the liability of a client engineer or local government.

> Your client a governmental engineer or architect undertaking any activity in a flood hazard area should make sure that any activity he undertakes is within the scope of his or her official's duties to avoid personal liability. Your client the governmental unit should be aware that governmental units are responsible for activities of staff or contractors and any activity which increases flood heights or velocities on other lands will subject the governmental unit to potential liability (pps. 37-38).

Hazard Identification/Mapping and Floodplain Management, cont.

In other words, a community could be liable for damages if it issued permits for construction that allowed increases in flood heights and velocities on other lands. This is very pertinent to standards used to map a floodway (see Tool 3) and regulate watershed development (see Tool 5).

Conclusion: Just as the FIRM is the basic level for mapping, the NFIP criteria in 44 CFR form the basic level for regulatory programs. NFIP requirements and guidance encourage communities to improve on their mapping and regulatory standards.

Any community may exceed the basic level. This is one of the basic tenets of the NAI approach to floodplain management. Here are some others:

- Where there is information that shows the hazard is greater than portrayed on the FIRM, the community should protect its citizens to that greater level.
- Where more data may be needed to determine a protection level, the community should obtain that data.
- Where the minimum NFIP standards do not adequately protect people, property and natural floodplain functions, the community should adopt and enforce higher standards.

FACTORS FOR EFFECTIVE MAPPING

Remember, what FEMA provides with a FIRM is a start. How do you make a better map or an NAI-level map? The following factors have been found to make floodplain maps more effective and useful. The case studies later in this *Guide* demonstrate how local officials succeeded by taking advantage of these seven factors for effective mapping (see the table on p. 30).

1. TAKE RESPONSIBILITY FOR MAPPING YOUR HAZARDS

Floodplain maps are used to protect your residents, businesses and infrastructure. They are only as good as you want them to be. Once you realize mapping is your responsibility and FEMA's role is to help you (not give you everything you'll ever need), you're on your way toward an NAI program.

2. KNOW YOUR MAP'S SHORTCOMINGS

Are your community's flood-prone areas properly reflected on your map? When was the study conducted? This may be many years before the date on the FIRM. How many years of streamgage records were used in the study? Do the runoff models reflect today's rainfall? Have major storms occurred since the last study? What topographic and bathymetric data were used? Have bridges been built or replaced since the study was conducted? Have new developments and fill altered the terrain? Has there been much development in the upstream watershed or along the coastline?

3. THINK BEYOND THE 100-YEAR FLOOD

While regulatory programs need to draw a line, people must realize the flood hazard is a continuum from small frequent floods to the larger, rarer floods that inundate properties outside the NFIP mapped hazard area. People often view the SFHA as an area that will only be flooded once in 100 years without understanding that portions flood more frequently. In coastal areas, the 100-year floodplain may equate to only a Category 2 or 3 storm surge zone. When people put too much reliance on that very thin line separating the A Zone from the X Zone, they get a false sense of being protected from all floods.

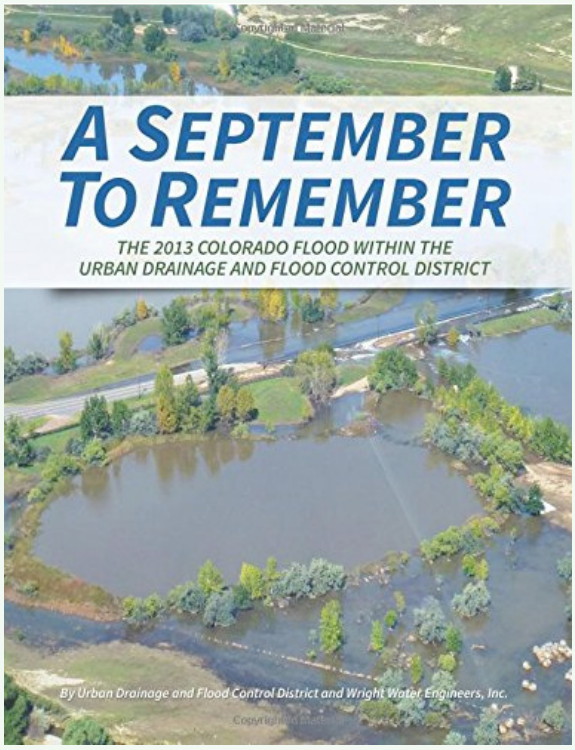
Hazard Identification/Mapping and Floodplain Management, cont.

4. MAP YOUR KNOWN FLOOD HAZARDS

Remember FEMA's mapping priorities: studying developed areas first and using a minimum drainage area of 1 square mile. If you know of floods that can cause a threat to life or property damage or close streets, or you have a non-FEMA floodplain study, the affected areas should at least be mapped. Make sure areas in the community that have flooded in the past are mapped so the map can support your regulatory, emergency management and public information programs. This also applies to flood-related hazards such as erosion and subsidence. Areas with natural features or manmade conditions that affect flooding should be mapped and accounted for in your floodplain management program.

5. ACCOUNT FOR THE UNKNOWN

Build a factor of safety into your maps and/or development standards to account for things that are difficult to model accurately, such as meandering channels, sea level rise, log and ice jams and changes in runoff due to development.



"A SEPTEMBER TO REMEMBER"

The Denver (Colorado) Urban Drainage and Flood Control District's after action report after the 2013 floods along Colorado's Front Range noted on pg. 201:

"Flooding and related damage were not confined to mapped, regulatory 100-year floodplains. There was often significant damage outside of the 100-year floodplain and in drainage areas smaller than 1 square mile that did not have floodplain mapping (1 square mile is the standard cutoff for drainage area size used by FEMA). The need to protect critical facilities (such as hospitals, police and fire stations, and other emergency facilities) beyond 100-year flood limits for public health, safety and welfare was reinforced."

Hazard Identification/Mapping and Floodplain Management, cont.

6. COORDINATE WITH OTHER COMMUNITY PROGRAMS

Floodplain managers are not the only people who use maps. Emergency management, public works, planning, park, transportation and housing offices, developers, real estate agents and many businesses all need good maps. Working together, offices can share data and resources to develop more effective and useful maps and data.

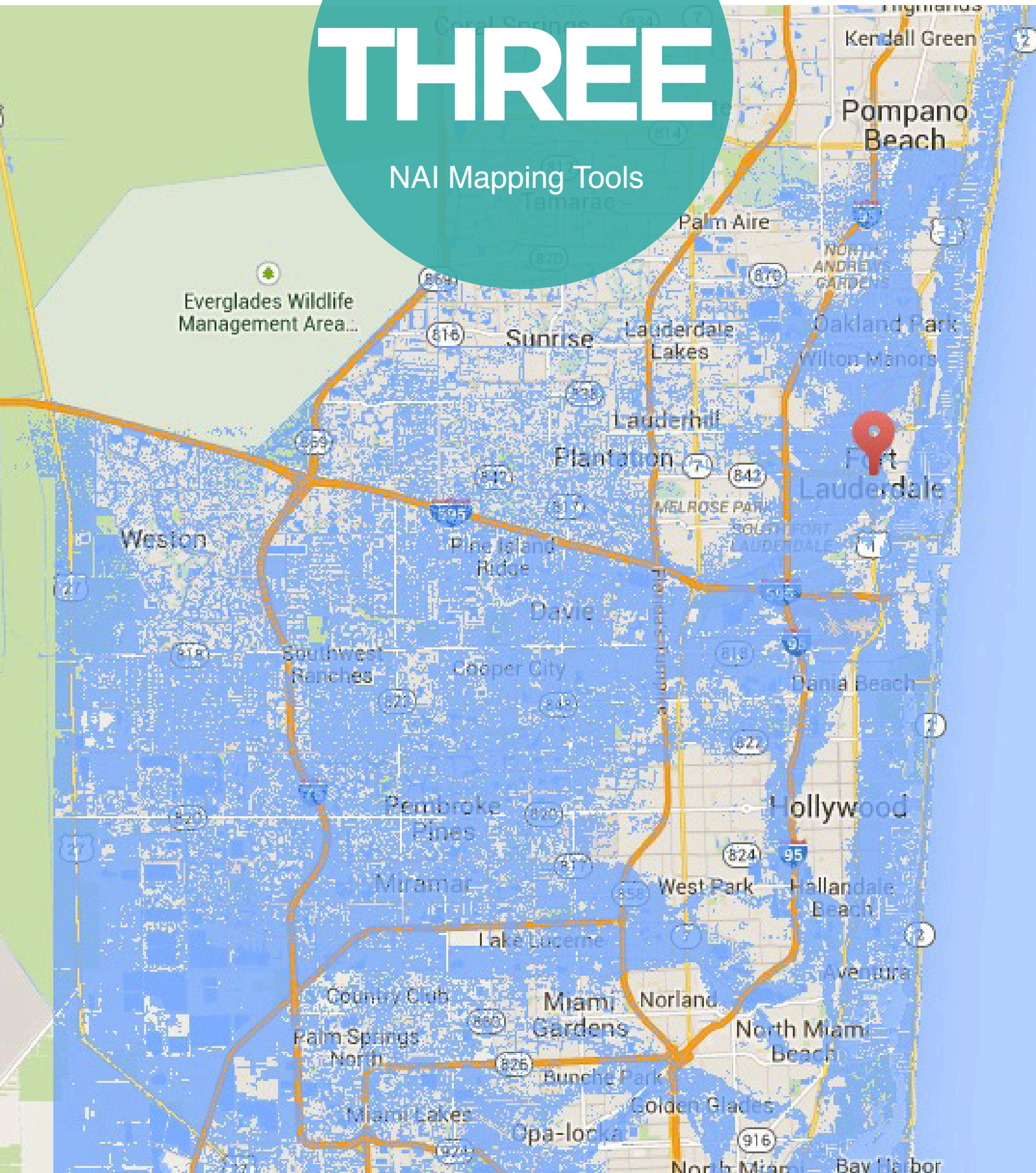
7. EDUCATE THE PUBLIC

A map in a desk drawer or computer file does not inform anyone. Maps and data should be made available to all who should know about the hazards. Put your maps out in the lobby or online. The public (including elected officials) also need to know the shortcomings. There have been too many stories of people who assume they face no flood threat because the FIRM shows them just outside the SFHA. Use all tools at your disposal, including newsletters, websites, public meetings and one-on-one conversations.

SECTION

THREE

NAI Mapping Tools



NAI Mapping Tools

There are many tools in the No Adverse Impact Toolkit and this *Guide* does not pretend to cover them all. Instead, five tools are described that illustrate the broad range of possible tools communities can utilize. They show how the factors for effective mapping can help communities prevent and reduce flood problems and protect natural floodplain functions.

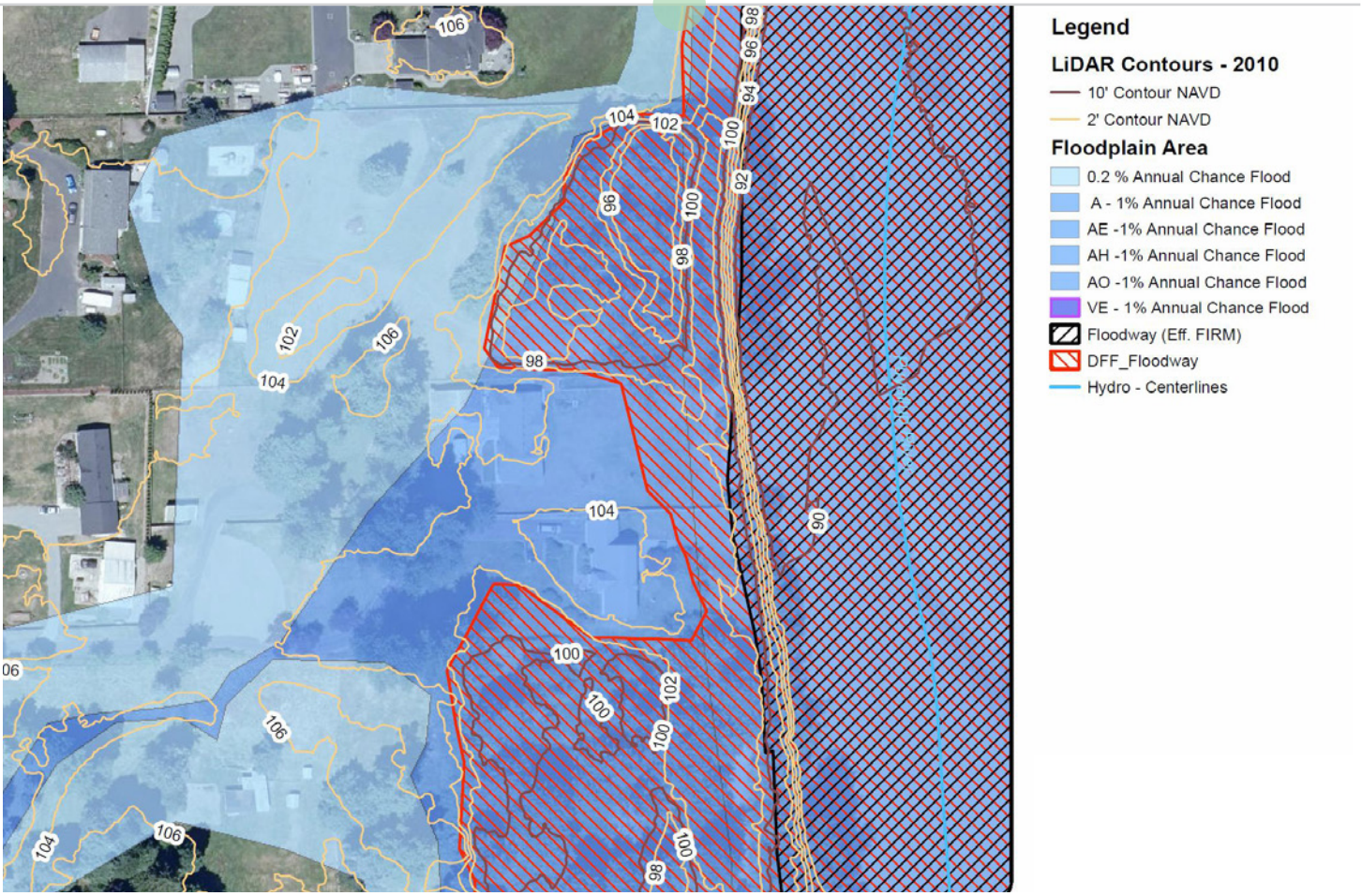
The table on the next page shows which case studies and community examples illustrate tools described in this section. It also identifies which "Factors for Effective Mapping" are illustrated in each case study.

Paragraphs throughout this Guide with the Community Rating System logo describe how using these tools can receive credit under the CRS.

NAI Mapping Tools

NAI Case Studies	Big Horn County, MT	Brandon, VT	Bucoda, WA	Conway, SC	Denver Drainage District, CO	Pierce County, WA	Mecklenburg County, NC	San Joaquin County, CA	SEWRPC, WI	Virginia Dam Safety Program	Wisconsin DNR
Page number	47	94	90	36	99	101	84	73	86	72, 75	76
Mapping Tools											
Tool 1. Build a complete map	•	•	•	•	•	•					
Tool 2. Integrate your maps	•	•				•					
Tool 3. Map a more effective floodway					•	•	•				•
Tool 4. Map the residual risk								•		•	•
Tool 5. Map for future risk		•			•	•	•		•		
Factors for Effective Mapping											
Take responsibility for mapping	•	•	•	•	•	•	•	•	•	•	•
Know your map's shortcomings	•	•	•	•	•	•	•		•		•
Think beyond the 100-year flood	•				•	•	•	•	•	•	
Map your known flood hazards	•	•		•	•	•		•		•	
Account for the unknown	•			•	•	•	•		•		•
Coordinate with other programs	•	•		•	•	•	•	•	•		
Educate the public		•	•	•	•	•	•	•			

Tool 1.
Build a Complete Map



IF YOUR COMMUNITY HAS A COMPLETE MAP, SKIP TO TOOL 2 OR 3.

Even a recently published Flood Insurance Rate Map or other floodplain map can be incomplete. As a result, the community's program may be based on wrong or inadequate information, putting people and property in danger of a known hazard. Generally, floodplain maps can be missing two types of information. First, the map may not show all areas subject to flooding. Here are some things that may be missing:

- Local drainage problems, shallow flooding and smaller watersheds may not make the NFIP threshold for being delineated on a FIRM.
- The topographic mapping used may not accurately reflect the floodplain boundary, so areas below the flood level may be shown as outside the floodplain.
- Areas behind an accredited levee may be shown as protected to the base flood, but these X Zones may be subject to much deeper and

Tool 1. Build a Complete Map, cont.

more dangerous flooding when the structure is overtopped or fails. This is known as "residual risk."

- Areas downstream of a dam may be mapped as X Zone, but may still be at risk should the dam fail or release large volumes of water during a flood. This is another example of "residual risk" and is discussed in Tool 4.
- The FIRM used by staff may not reflect annexations, map changes, amendments or revisions issued after its effective date.

Second, even if a flood-prone area is delineated on the map, there may be information missing that is needed to manage development and design flood protection measures. Some examples:

- While a map may show areas prone to flooding, there may not be sufficient data to effectively regulate, such as base flood elevations and the floodway.
- Coastal floodplain maps may not show all hazard areas where wave action and erosion can damage buildings outside the V Zone.
- Available data may not cover the full flood potential. For example, a building built to the BFE shown on a FIRM will not be protected from the base flood in 10 or 20 years in areas subject to subsidence, sea level rise, unregulated watershed development or floodplains without regulations that prevent developments from increasing flood heights.
- The flood map likely does not include non-flood data that can greatly help the community's programs, including parcel lines, building footprints and new streets.

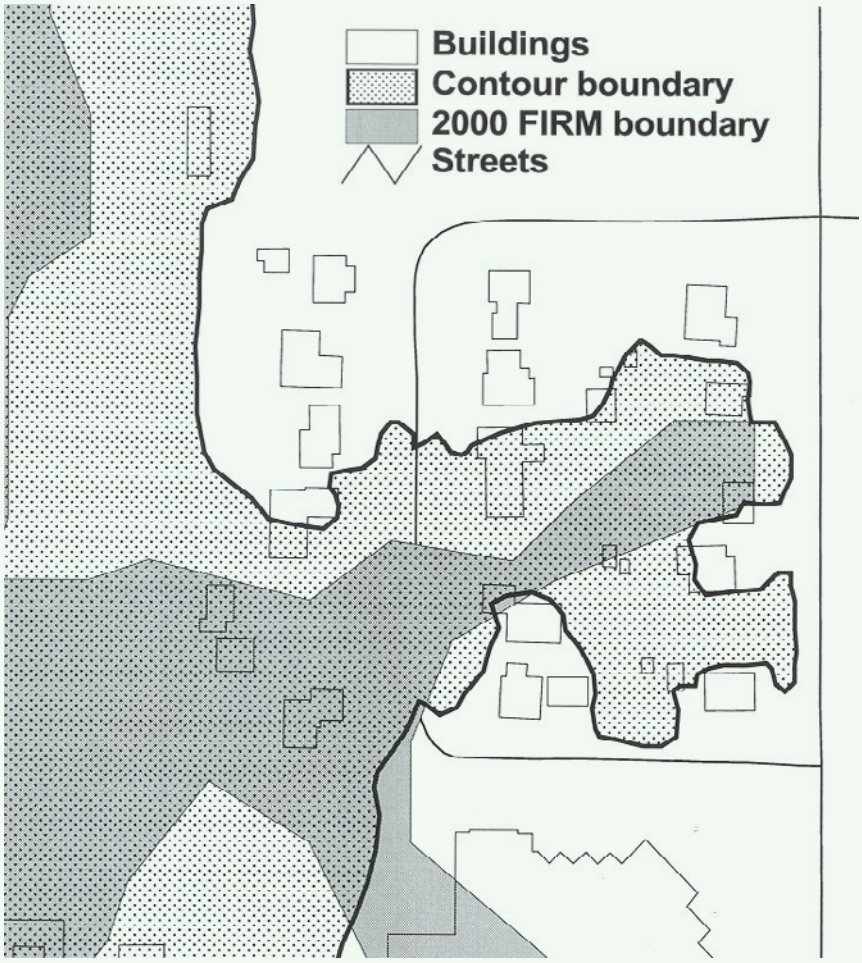
The first tool in the NAI Toolkit is to prepare a map that includes all available data to help your community's program. This section provides a step-by-step approach to do this.

Tool 1. Build a Complete Map, cont.

STEP 1. ASSESS YOUR MAP

Start with a review of your current map(s) to see what's missing. Here is a checklist to help identify gaps:

- Are there any known problems or historically flooded areas not mapped?
- Have bridges been rebuilt or culverts replaced since the map's field work was conducted?
- Do you have better topographic information that would provide a more accurate floodplain boundary? See example to the right.
- Are there mapped areas with no BFE?
- Are there areas outside the V Zone subject to damage by waves and/or storm-induced erosion and scour?
- Has long-term coastal erosion and/or sea level rise caused areas that were previously dry land to be inundated during mean high tide?
- Are there mapped riverine flood-prone areas with no designated floodway?
- Are there mapped areas where water will stay up for months or more? Does your map convey this information?



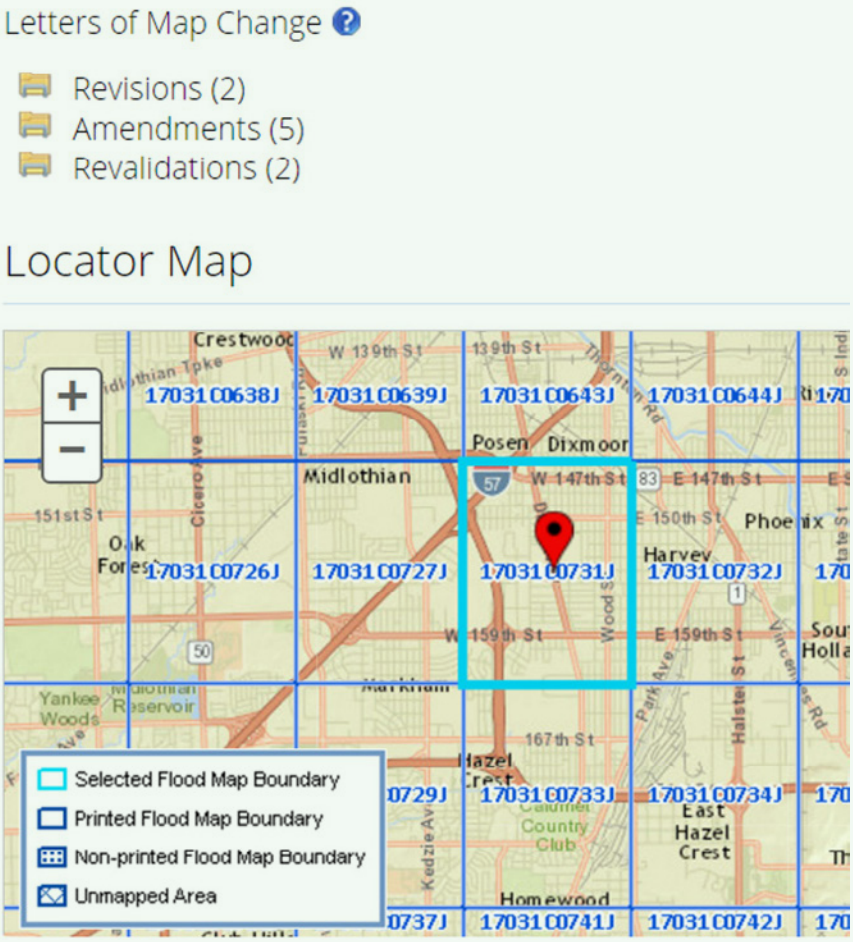
The 2000 FIRM boundary for the SFHA for Gurnee, Illinois was put into a GIS layer. The BFE was plotted on a more accurate village contour map. The differences are significant.

- Are there high water marks that disagree with the flood map's boundaries or elevations?
- Does the map include all map revisions, LOMRs, LOMAs and LOMR-Fs?
- Has the map kept up with annexations, new subdivisions, new streets, etc.?
- Are other maps available that show wetlands, parcels, buildings or other features that would be useful to your work?
- What would help other offices with their work? For example, the emergency manager and street department may want to know where road access will be cut off during a flood.

STEP 2. KEEP YOUR MAP AND DATA UP TO DATE

Here are ways to keep your maps and data up to date. The first two are minimum requirements of participating in the National Flood Insurance Program.

- Plot all map revisions, LOMRs, LOMAs and LOMR-Fs. If you're not sure you have them all, check FEMA's Flood Map Service Center (see box at right).
- Update corporate limits and streets based on annexations and subdivision plats and submit the changes to FEMA for a physical map revision or LOMR.
- Use better topographic data from surveyors. If there is a new topographic map with a smaller contour interval (or, better yet, based on LiDAR), your floodplain management regulations should cover those areas below the BFE that are mapped on the FIRM as outside the SFHA. If the better data show changes should be made in the floodplain boundary, submit to FEMA for a map revision.
- Establish and maintain benchmarks for traditional surveying and Continuously Operating Reference Stations for GPS surveying to help surveyors locate flood protection elevations on the ground and verify new construction meets those levels.
- Make sure the maps and data you have stay current. While you probably won't conduct a new study every year, you should at least collect and keep data that will be needed for the next update.
- Keep good records on projects, such as new bridges and culverts that may alter flooding or topographic conditions. When changes occur, keep your FIRM updated by submitting requests for map revisions or LOMRs.



Using FEMA's Flood Map Service Center, enter your community's name and you will see a screen like this. The center will identify the number of map changes. Clicking on "Revisions," Amendments" or "Revalidations" will reveal a list of each. You can then download each item you're missing.

Tool 1. Build a Complete Map, cont.

STEP 3. COLLECT AND MAINTAIN HIGH WATER MARKS

Floodplain maps are only as good as data used in the flood study. A study conducted 10 or 20 years ago may no longer reflect current topographic conditions and may be based on a series of small floods over a relatively short period of time. A floodplain map will be more accurate if more recent flood data are incorporated into its study.

The best data would be streamgage records of a recent flood, especially if the flood study used the gage's records in its model. Flood crest level can help calibrate and validate the existing flood model. ASFPM's Strategies to Establish Flood Frequencies Associated with Flood Event High Water Marks reviews how to do this. The study provided to Bucoda, Washington (p. 90) incorporated multiple flood events that occurred since the FIRM was prepared.

Where there are no gages, take photographs and record high water marks left on buildings, trees, telephone poles, etc. The U.S. Geological Survey has a publication that provides techniques and methods to identify and preserve high-water mark data.

Where there is no existing study or the flood crest levels, and HWMs are higher than the BFE, they can be used as a regulatory flood elevation. This can help immediately after a flood so reconstruction can proceed without waiting for a restudy, as in the Conway, South Carolina example on the next page.

After a coastal storm, record the HWMs, including debris and wrack lines. These can be used as a basis for higher regulatory flood elevation until the flood study is updated. See also USGS's storm surge monitoring program.

Not only is a map more accurate when high water levels are incorporated, public confidence is higher when a regulatory tool is based on a recent event. The use of HWMs as a public information tool is covered in Tool 5 of ASFPM's NAI How-to Guide for Education & Outreach.

Because of these benefits, communities should make it a priority to record HWMs during or right after a flood.

continued on page 37

CONWAY, SOUTH CAROLINA USES HIGH WATER MARKS

Higher water marks were recorded on telephone poles and other public sites soon after the water subsided.

This mitigation planning map highlighted the inaccuracy of the AE Zone boundary.

Conway, South Carolina was flooded during Hurricane Floyd in 1999 by backwaters from the Waccamaw River. The city's post-flood hazard mitigation planning work is described in the NAI How-to Guide for Planning. Before the water receded, local staff marked HWMs (see photo above left). Within a week of the flood crest, mitigation planners plotted high water levels on buildings on the map (above right).

It was easy to see the FIRM understated the hazard and a different approach was needed to better manage repairs and reconstruction. Mitigation planners obtained a 1973 flood study by the U.S. Corps of Engineers and the estimated discharge of the 1999 flood at the Conway gage. An excerpt of the mitigation plan's flood data table is shown at right. At their peaks, the 1928 and 1999 floods carried practically the same amount of water as the base flood in the city's Flood Insurance Study, but they were 1.5 feet higher than the BFE.

Past Flood Data
Waccamaw River at Conway

Date of Crest	Estimate Peak Discharge	Stage
September 1928	22,000	13.40
Base Flood	22,310	11.75
September 1999	22,400	13.20

The planners concluded:

1. The BFE underestimated the true hazard presented by the base flood.
2. The FIRM inaccurately showed properties affected by the base flood.
3. Many property owners were unaware of the true hazard.
4. Many property owners were not told to purchase flood insurance.
5. Buildings reconstructed to the FIRM's BFE would not be protected from the 1928 or 1999 floods.

The planners recommended: (1) all properties affected by the 1999 flood should be considered in the regulatory floodplain, and (2) the city should use the elevation of the 1999 flood plus 2 feet of freeboard as the regulatory flood elevation. These recommendations were adopted by the City Council at a meeting held one and a half weeks after the flood had crested, but before repairs had been allowed to start. By using HWMs soon after a flood, the city more accurately mapped the base flood and required substantially damaged and new buildings to meet a higher protection level.

Tool 1. Build a Complete Map, cont.

STEP 4. ADD AVAILABLE DATA AND STUDIES

Flood data may not be in your community's GIS or as readily available as street maps. You will need to contact other offices and agencies that would have need for such data.

Below is a checklist of possible places to check:

- See what is available in your community's GIS that could help your work, such as historical flood maps, parcel lines and building footprints;
- Planning or permit office, which may have studies done for past permits, such as for subdivisions greater than 50 lots or 5 acres;
- County/regional flood control or water agency;
- County/regional planning agency;
- City, county or state road or highway department. They may have studies used to determine how high or wide a new or replacement bridge should be;
- State NFIP coordinator;
- The Corps' floodplain management office. Each district may have a different name for this office or planning office that maintains flood maps and studies. Find your Corps district here;
- Natural Resources Conservation Service. Most counties have an NRCS office. You can find your state's NRCS page here;
- Check the National Weather Service's Advanced Hydrologic Prediction Service website. NWS has developed inundation maps for some gages;
- USGS has an office in each state;
- Universities and their engineering libraries; and/or
- Local engineering firms.

While contacting all these offices may look like a lot of work, it's less expensive than paying for a new study when someone else already has the data. The websites listed do not provide much more than contact information, but it can be worth a telephone call to find out what studies are in these offices.

Once you've obtained a study that covers part of your community, compare its map to your FIRM. You can include the data on your map or note where additional data can be found.

Here are some guidelines for using new data in your regulatory program:

- Where your FIRM shows an approximate A Zone or X Zone, you can use flood elevation and floodway data for regulatory purposes;
- If the study has 100-year flood elevations higher than those shown on your FIRM, you can use the data for regulatory purposes by also referencing the study in your ordinance;
- If the study has 100-year flood elevations lower or a floodway delineation that is smaller than those shown in the AE or VE Zones on your FIRM, you will need to check with FEMA before you can use less restrictive data for regulatory purposes. You will likely need to submit the information to FEMA to obtain a LOMR before you can use it;
- Before using data for regulatory purposes, check with your legal counsel to see if your governing body must adopt the new data or if your regulations authorize staff to review and use best available data without an ordinance amendment; and
- Check with your state NFIP coordinator on whether the following conditions apply:

  Does your state require state review and approval of data before it can be used for floodplain management regulations?

  Under 44 CFR 65.3, a community is obligated to submit new flood data to FEMA. Does this requirement apply to the type of data you want to use?

STEP 5. USE SOME INEXPENSIVE MEASURES, WHERE APPROPRIATE

Once you've exhausted the reservoir of available studies, you still may have some areas where you need better mapping and data. You have two options: have an engineer to do a new flood study or use an alternative and less expensive approach. Before you fund a study (Step 6), see if an alternative will do the job.

The best example of such a measure is in the NFIP regulations, Section 60.3(b)(3). In approximate A Zones with no BFEs, the community shall:

> "Require that all new subdivision proposals and other proposed developments (including proposals for manufactured home parks and subdivisions) greater than 50 lots or 5 acres, whichever is the lesser, *include within such proposals base flood elevation data.*"

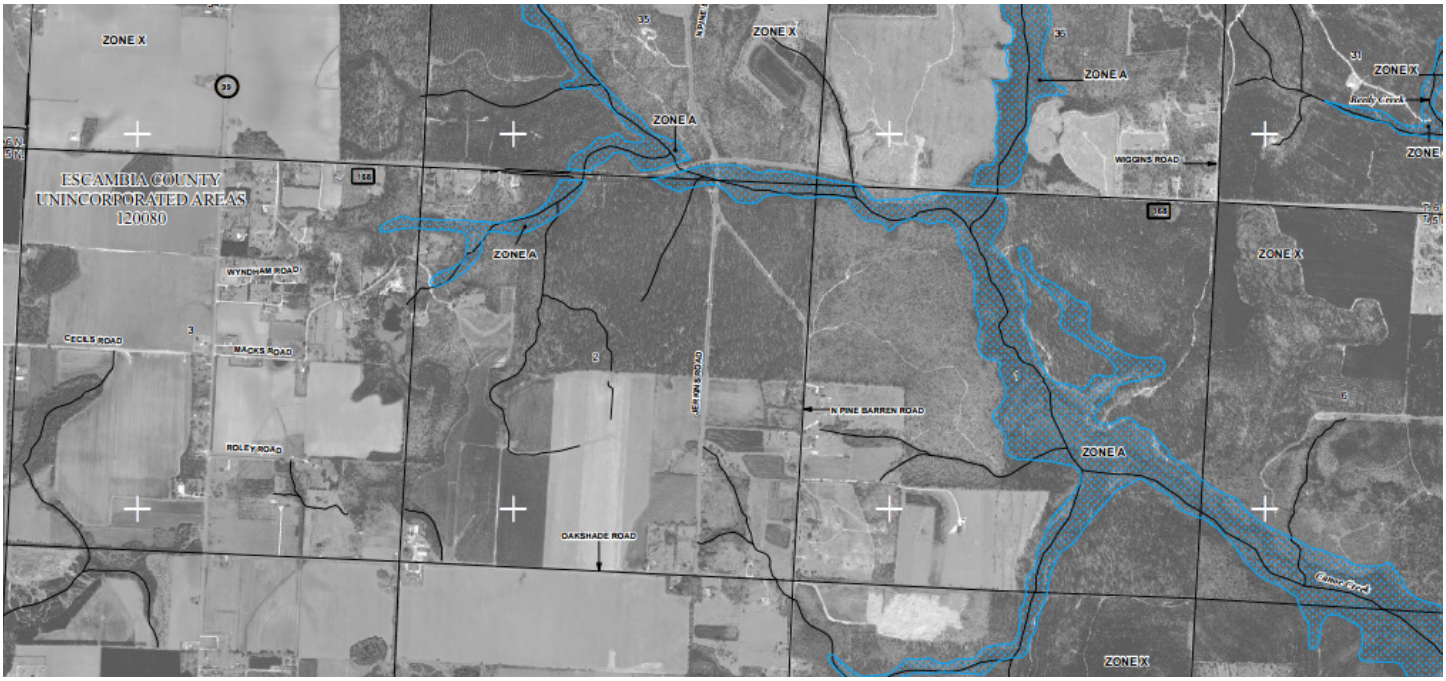
In other words, if a company wants to spend a lot of money developing a subdivision in the floodplain, that company must fund the study to obtain the data needed to set flood protection levels for that development. This is an example of an inexpensive way for the community to obtain needed flood data.

Here are some other examples of inexpensive ways to obtain regulatory flood data:

- Instead of financing a study to determine where wave heights are problematic (e.g. exceed 1.5 feet), select a street that parallels the shore as the boundary where new construction must meet V Zone standards (see box at right);
- In approximate A Zones, require the BFE to be calculated by all permit applicants, not just for larger subdivisions;
- In approximate A Zones, include enough in the permit fee to cover the cost of a study by your engineer to calculate the BFE for the site. Instead of relying on different engineering firms working for the permit applicants, this will provide a more consistent and dependable product;
- Use the extent of a past flood to delineate an approximate A Zone where it was outside the SFHA on the FIRM; and/or
- Use HWMs from recent damaging floods as the flood protection elevation in an approximate A Zone, the adjacent X Zone and in an AE Zone where HWMs are higher than the BFEs on the FIRM.

Pensacola Beach, Florida is on a barrier island on the Gulf of Mexico. It was over washed by Hurricane Ivan in 2004. Much of the damage was caused by wave action. Rather than conduct an expensive study to delineate areas subject to the 1.5-foot wave during a 1-percent chance flood, VE Zone regulatory standards were adopted for the entire community. There was no need to conduct a study or publish a new map. The highest adjacent BFE is used in the few areas shown as X Zones on the FIRM.

Tool 1. Build a Complete Map, cont.



Two suggestions for using alternative, less expensive measures:

1. Because the measures are not as accurate as a regular flood study, add a factor of safety. For example, if a nearby streamgage records show a recent flood as 1 foot above the BFE, you could adopt a regulatory elevation that is 1 foot or even 2 feet above the HWM elevation.
2. The rationale for using inexpensive alternatives is to provide better flood protection data at less cost to the public. If a developer wants to challenge the data in order to build in the flood hazard area, he or she is welcome to fund a study to produce more accurate data. It's a good idea to have this provision in your regulations.

NFIP/CRS Activity 410 (Floodplain Mapping) in the CRS credits flood studies and regulatory measures that provide more or better data than provided on the FIRM. With one exception, all of the alternative techniques listed in Step 4 can be credited in Activity 410 NS (new study) or 430 CAZ (coastal A Zone regulations). The exception is the minimum requirement for subdivisions in 44 CFR §60.3(b)(3). There is no CRS credit for measures required as a condition of participation in the NFIP, but credit would be provided for a more restrictive standard (e.g., requiring a BFE for lot splits and subdivisions of less than 50 lots or 5 acres (e.g. two lots or 1 acre).

STEP 6. FUND A NEW STUDY

If you conclude there are no available studies and the alternative, less expensive measures are not appropriate for your needs, then a complete flood study of an area may be needed. This may be a last resort due to the expense, but it's usually the best solution. Start with a priority list of areas where studies are needed to fill the data gaps. If these are more than your community can afford, look for funding support. Here are some places you should check:

- If your community is a Cooperating Technical Partner with FEMA, talk to the FEMA Regional Office about cost sharing a new study under that program;
- Check with the state NFIP coordinator and/or FEMA Regional Office on restudy plans. If your community is due for an update to your FIRM, the restudy team will meet with you and ask where new data are needed. If your community is willing to contribute to the cost, the restudy may include new areas and your community may also be scheduled for the restudy sooner;
- Ask the agencies listed in Step 3 if they have a program that could prepare or help prepare the needed flood mapping;
- See if developers are interested in cost-sharing. It could be cheaper for them in the long run to pool their resources rather than have to pay for their own site-specific studies at the time of permit application. You are also more likely to have a better product when the entire floodplain is studied instead of looking at only one site at a time; and
- Designate a part of your stormwater utility fees or flood protection tax for flood studies.

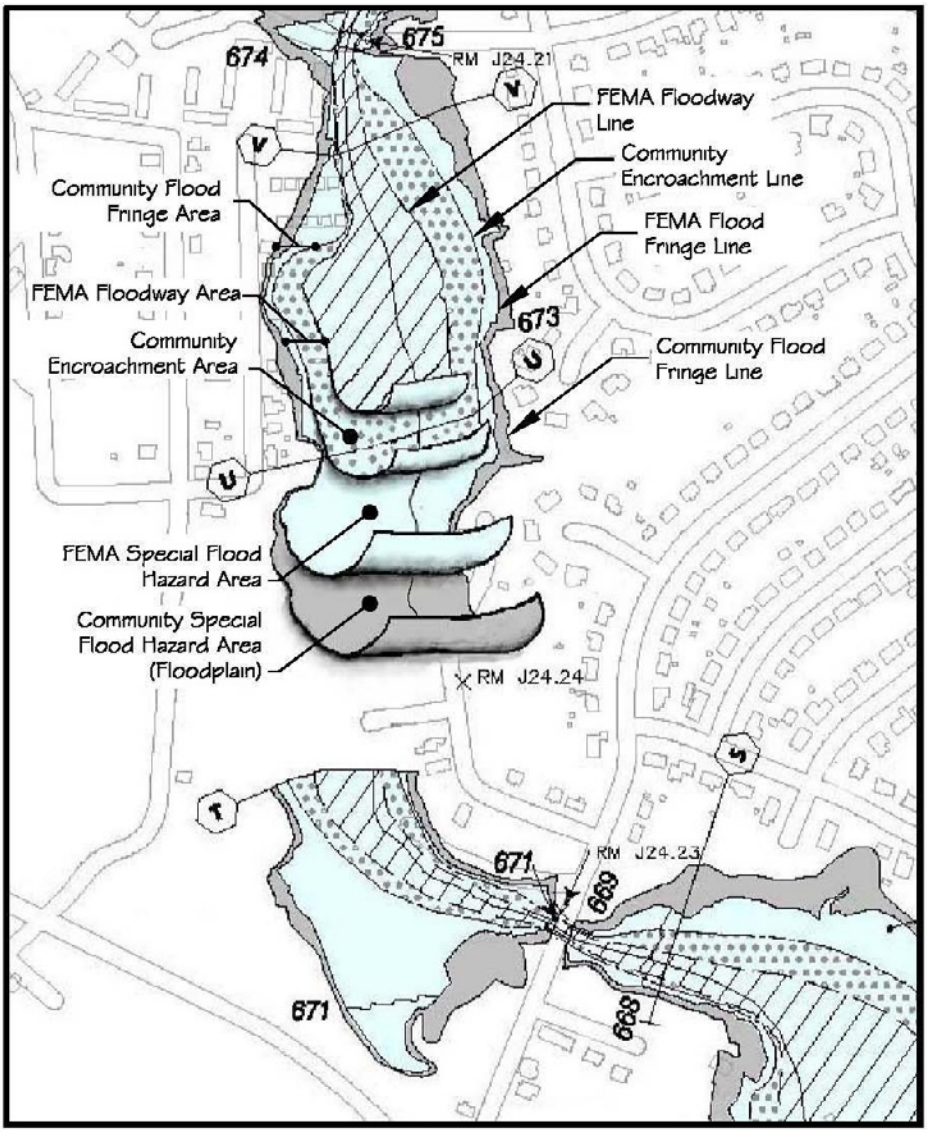
Activity 410 (Floodplain Mapping) provides full credit for a flood study done by an agency other than FEMA. This includes the community, state, flood control district, developer or another federal agency. There is no CRS credit for studies fully funded by FEMA. The credit is adjusted for a study cost-shared with FEMA based on the percentage of the non-FEMA share (LEV or leverage credit).

Tool 1. Build a Complete Map, cont.

STEP 7. COMPLETE YOUR MAP

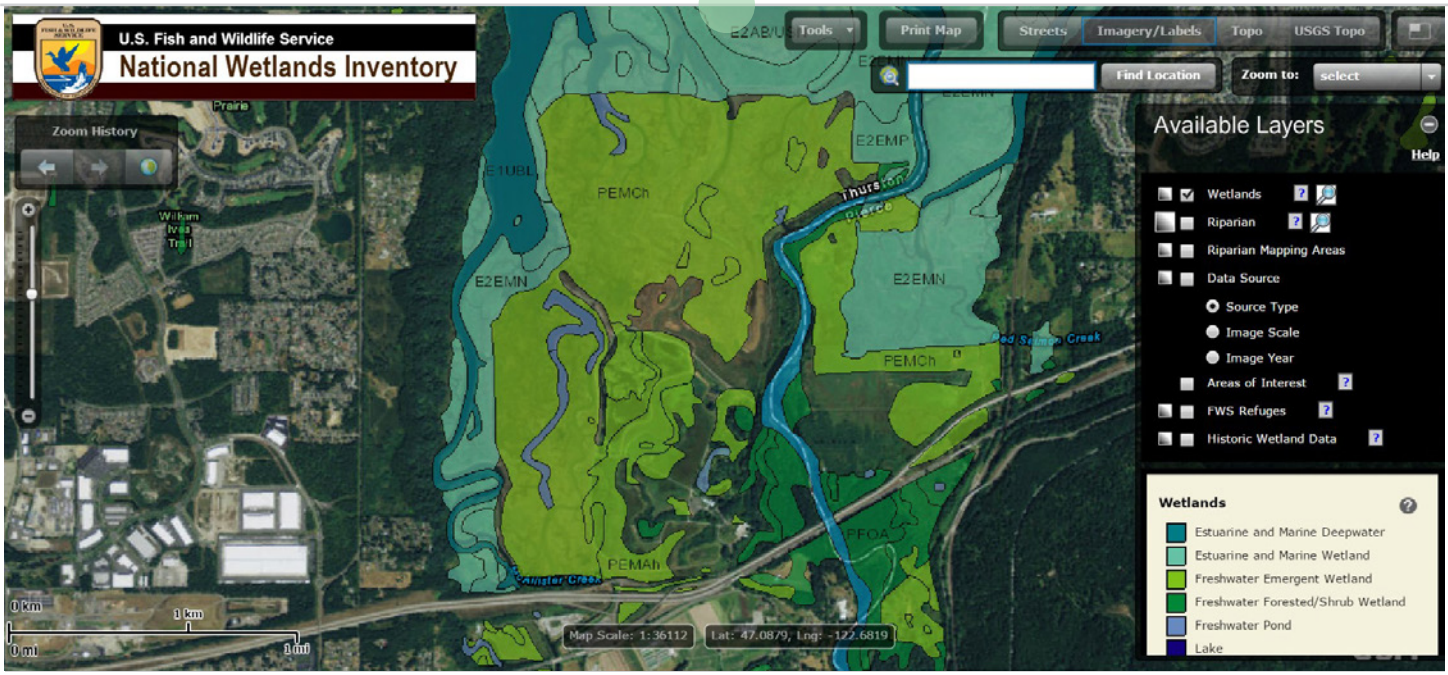
The objective of this step is to have a complete set of maps and data for all your flood hazard areas. Don't put your new approaches and studies in the drawer. They need to be incorporated into your community's programs. Below are the necessary steps to complete your map:

- Adopt the maps and data into your floodplain management regulations unless your attorney says you can use them in your program without formal adoption (e.g., as "best available data");
- Give flood data to your GIS staff for inclusion as a layer to augment existing layers in your GIS;
- Provide them to your emergency management, planning, engineering and public works staff and neighboring communities;
- Make them available to the public on your website or somewhere they can be downloaded;
- Advise FEMA you are using the new information (see Step 3 on the requirement in 44 CFR 65.3, to submit new flood data to FEMA); and
- Document your work for CRS credit. Note CRS Activity 410 (Floodplain Mapping) does not credit new maps or studies until adopted for regulatory purposes.



This graphic shows how community mapping can be layered on top of the FEMA flood hazard mapping. Source: Charlotte-Mecklenburg Stormwater Services, Charlotte, NC.

Tool 2.
Integrate Your Maps



COMMUNITY ALREADY INTEGRATED ITS MAPS? SKIP TO TOOL 3.

Flood Insurance Rate Maps and their related flood studies have often addressed only "clear water flooding." Your community may face other hazards not reflected on the FIRM such as streambank or coastal erosion, ice or debris jams and mudflows. You may have non-flood hazards that affect certain areas such as sink holes, landslide-prone hillsides and recent wildfires that left burned areas where run-off and sediment loads could increase.

You should also be concerned about protecting natural floodplain functions. Some areas of your community may be wetlands, habitat for threatened species or in a shoreline protection zone. Do you have maps for these other areas concern areas? Are they integrated with your floodplain maps? If not, is it possible that your floodplain permit office could inadvertently allow filling in a wetland? Does your program protect people and property from a 100-year clear water flood, but not from erosion or higher flood levels caused by an ice jam?

Similarly, do other offices have access to floodplain maps? Odds are that if you look at your community's comprehensive or

land use plan, you may conclude that the planners did not know where the flood hazard areas were when they designated areas for future development.

A program that doesn't coordinate with these other programs or protect natural floodplain functions is doing a disservice to the community and property owners. One of the best ways to coordinate is to map the other programs' areas of concerns and ensure all are identified during a permit application.

HOW TO INTEGRATE YOUR MAPS

STEP 1.
INVENTORY AVAILABLE MAPS AND PROGRAMS

Find out what other programs there are that regulate development and have different rules for different areas. If those areas can be put on a map, get a copy of the map.

Start with your local GIS office. It may have mapped some of the programs' areas of interest. If you have a state-wide GIS program, that office may have some layers you could use. Then start running down other programs and areas that you as a floodplain manager should be interested in. Here is a checklist to help identify the types of programs to be contacted:

- Land use plans and zoning maps (planning department);
- Urban growth boundaries (planning department or state agency);
- Flood inundation maps. These maps show the extent of flooding at specific levels, such as historical floods or every 1 foot or 2 foot of elevation. They can be very helpful for emergency response planning. Examples can be found at http://water.usgs.gov/osw/flood_inundation/ and http://water.weather.gov/ahps/inundation.php;
- Wetland maps, such as the National Wetlands Inventory (see image on Tool 2 page);
- Maps of reefs, shellfish beds, submerged aquatic vegetation, nesting areas and other environmentally sensitive areas on the coast;
- Threatened and endangered species habitat on U.S. Fish and Wildlife Service maps. This site only identifies areas without designating the affected species. It states more information should be obtained from the local Fish and Wildlife Service office;
- NOAA's National Marine Fisheries Service provides GIS data on critical habitat for threatened and endangered species;
- Many states have programs that map and protect endangered species habitat;
- Coastal erosion maps (often a state program);
- Shoreline protection programs (often a state program);

Tool 2. Integrate Your Maps, cont.

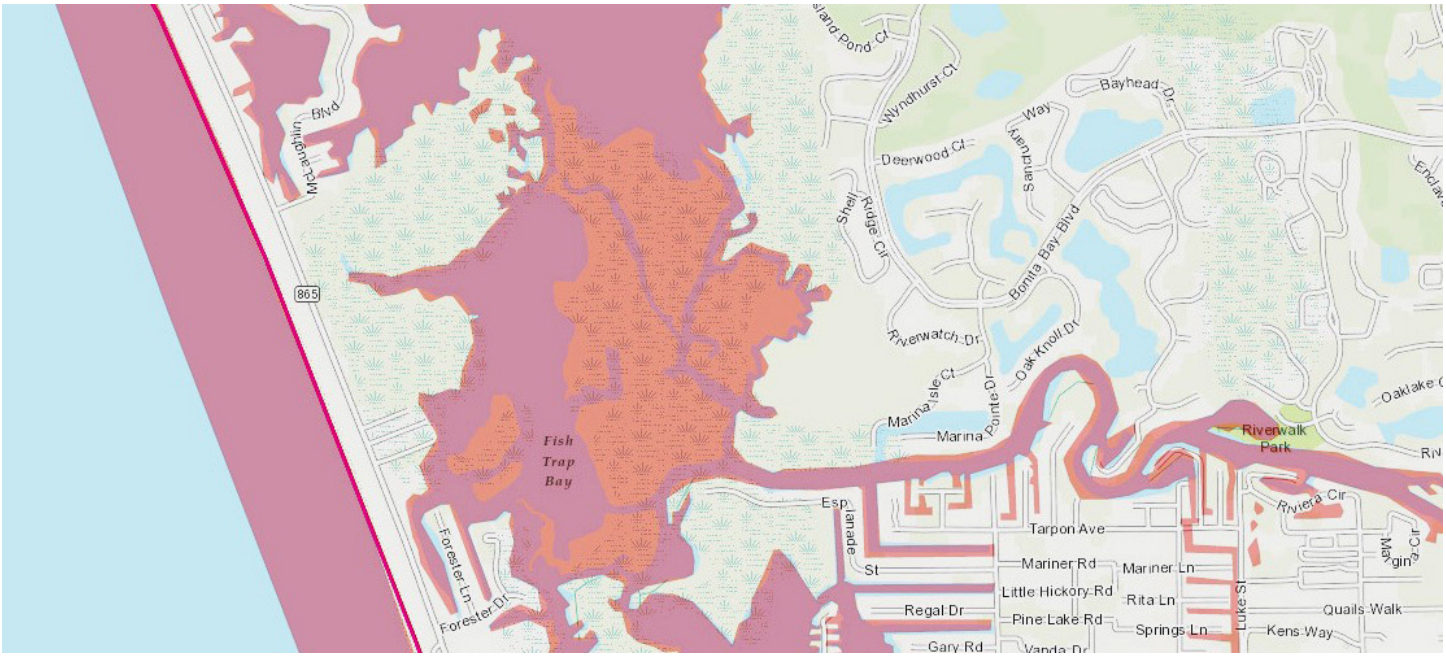
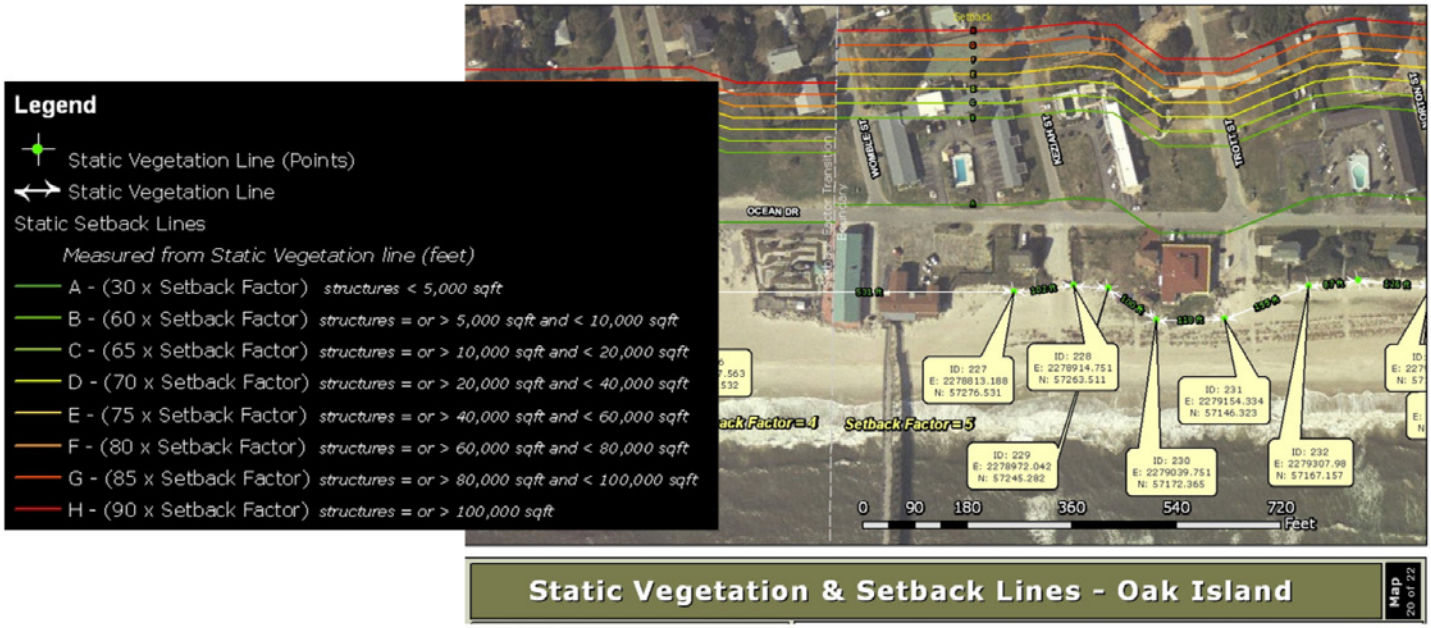


Image from the U.S. Fish & Wildlife online critical habitat map.

- Hurricane evacuation studies that show potential storm surge impact areas;
- Tsunami inundation areas (see the National Oceanic and Atmospheric Administration models). See also maps prepared by state agencies;
- Maps of sea level rise inundation and shallow coastal nuisance flooding can be found at:
  - https://coast.noaa.gov/digitalcoast/tools/slr
  - https://coast.noaa.gov/digitalcoast/tools/flood-exposure and
  - http://sealevel.climatecentral.org/ssrf;
- Channel migration maps and regulations (often a state program);
- Subsidence areas (from regional subsidence district);
- Ice jam prone areas (usually based on local knowledge, but the Corps has also done some ice jam studies);
- Landslide and steep slope areas;
- Wildfire danger areas;
- Levee failure inundation maps; and
- Dam failure inundation maps (see Tool 4).

Tool 2. Integrate Your Maps, cont.



This erosion setback line map was prepared by the North Carolina Division of Coastal Management.

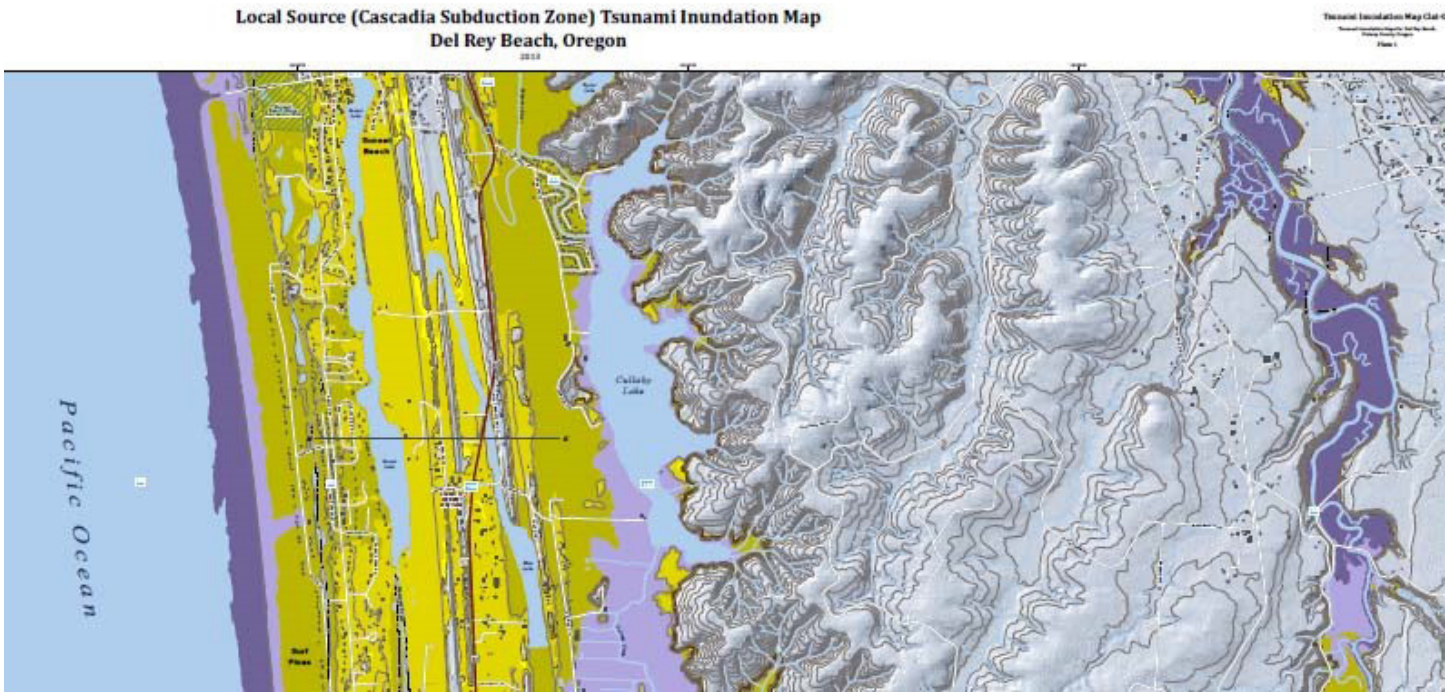
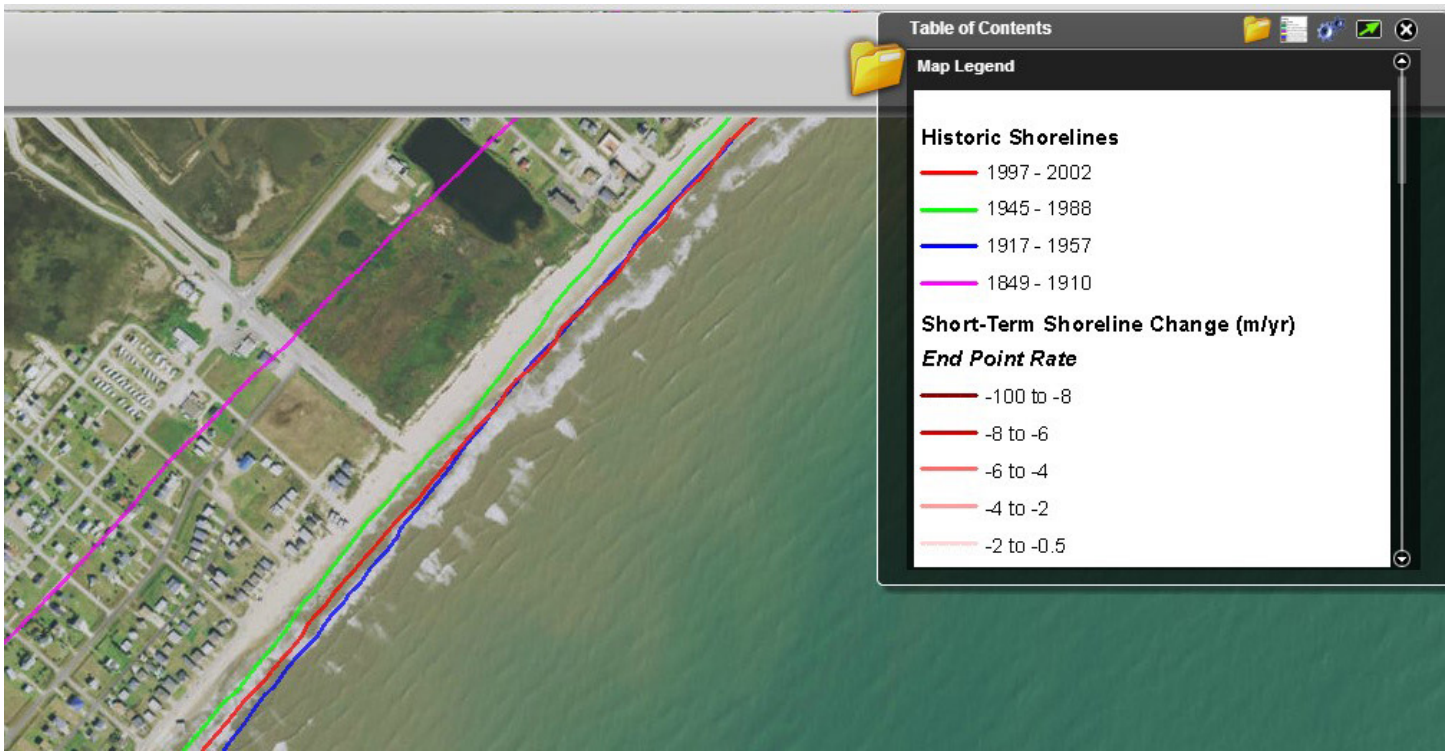


Image from a tsunami inundation map prepared by the Oregon Department of Geology and Mineral Industries.

Tool 2. Integrate Your Maps, cont.



USGS online map of the historical shoreline at Surfside Beach, Texas.

STEP 2.
USE SOME INEXPENSIVE MAPPING AND REGULATORY MEASURES, WHERE APPROPRIATE

As noted in Tool 1's Step 5, after you've checked out all available maps and studies, you still may have some areas where you need better flood mapping and data. You have two options: run a complete new study or use an alternative and less expensive approach. Before you fund a new study (Step 3), see if an alternative will do the job.

Here are some examples where available information may work as an approximate delineation of an area of interest or an area subject to a hazard other than clear water flooding:

- The NRCS has soils maps. Some soil types are closely related to wetlands and some indicate historical flooding. Using soils maps may be sufficient for identifying unmapped flood-prone areas or areas likely to have wetlands where additional on-site evaluations should be undertaken to verify if the area should be protected. Pierce County, Washington (p. 101) used soils maps for its initial mapping in rural areas.
- Aerial photography can often show historic stream channels that would help in mapping a channel migration zone.
- Drawing a line, say 200 feet on each side of the channel, where developers must conduct an on-site geological study to determine the area safe from channel migration. The developer would not have to fund the study if he or she agreed to stay out of the delineated area. This approach has been used by Vermont's river corridor mapping program (see p. 94).
- Maps of historical shorelines can help identify areas that should be subject to coastal erosion regulations (see this USGS site with historical shoreline data above).

Tool 2. Integrate Your Maps, cont.

As with Tool 1's Step 4, there are two suggestions when using these kinds of alternative, less expensive measures:

1. Because the measures are not as accurate as a regular flood study, add a safety factor. For example, when historical stream channels are generally within 200 feet of the current channel, you may want to delineate an area 300 feet wide that triggers an on-site study.
2. Users should be reminded that more accurate on-site analysis should take precedence. For example, North Carolina's Department of Environment and Natural Resources has a shoreline setback mapping site with shape files that can be downloaded by the community's GIS staff. It comes with this caveat: "These digital data are to be used as reference materials only. Property specific decisions should be made only after qualified professionals have collected applicable field measurements."

BIG HORN COUNTY, MONTANA SITE-SPECIFIC HAZARD DATA INTEGRATION

The following is an excerpt from Appendix H of the Subdivision Regulations for Big Horn County, Montana April 2006. The hazards to be identified and included in a Flood Hazard Evaluation are bolded here.

Standards for Flood Hazard Evaluations

A. General. Land subject to being flooded by a flood of one hundred year (100) frequency as defined by Title 76, Chapter 5, M.C.A., or land deemed to be subject to flooding by the Commission, may not be subdivided for building or residential purposes, or other uses that may increase or aggravate flood hazards to life, health or welfare, or that may be prohibited by state or local floodplain or floodway regulations.

B. Intent. The intent of a flood hazard evaluation is to assess all possible flooding hazards to a subdivision. Part of this evaluation must therefore address the uncertainty of predicted conditions during significant meteorologic, geologic, and hydrologic events, and the evaluation draws upon known and observed flood behaviors and dynamics for context. The regulatory flood maps and associated flood studies recognized by Big Horn County may contain some of this information but do not address the full range of hazards and flooding conditions necessary for a Flood Hazard Evaluation….

E. Flood Hazard Evaluation. A Flood Hazard Evaluation is a professional assessment of all possible flooding hazards and a report of the risks associated with this potential flooding in the proposed subdivision. I**n addition to industry standard, one-dimensional, steady state water surface evaluation modeling, a flood hazard evaluation includes:**

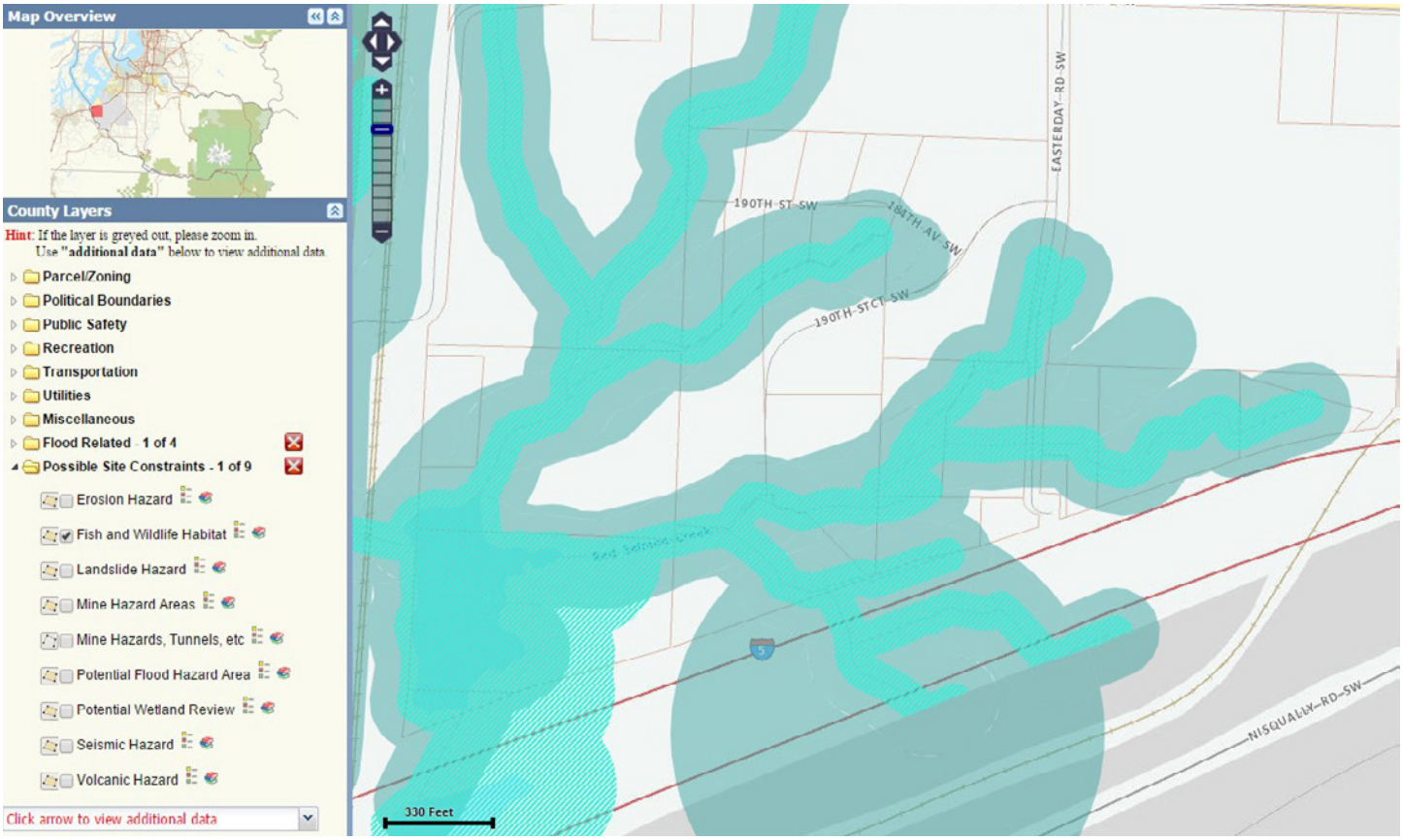
1. A discussion of **overbank flow path uncertainty** related to: rivers and stream channels that are topographically higher than surrounding floodplains, shallow flooding channels, **alluvial fan flooding, debris jams, ice jams** and/or diversions, and ditches.
2. A discussion of possible or predicted channel stability during flood events, including the possibility of **channel avulsion and/or migration** that could affect the flooding dynamic in the project area.
3. A discussion of the risk of **landslides and/or debris flows** occurring and affecting flood behavior in the project area drainages.
4. An analysis of t**he stability and structural integrity** of permitted and unpermitted **floodplain fill** in the vicinity of the project that contacts the regulatory 100-year floodplain, including rip rap, berms, levees, and other fill.
5. A statement attesting that all proposed **sanitary sewer infrastructure** meets 100-year flood design standards and/or will not otherwise contribute to water pollution during periods of flooding or high groundwater.
6. A discussion of **irrigation ditches** in the area and how they would affect the project should they fail, overtop or route surface runoff.
7. An identification of **depressional areas** (areas below the BFE or design flood evaluation but unconnected to a separate and discrete flow path).

STEP 3.
FUND A NEW STUDY

If you conclude there are no available studies and the alternative, less expensive measures are not appropriate for your needs, then this step is the same as Step 6 in Tool 1. Start with a priority list of areas where studies are needed to fill data gaps. If these are more than your community can afford, look for funding support among the agencies listed under Step 1 of this tool.

One option or interim step that can be taken until the other studies are done is to require the permit applicant to identify other concerns and hazards and delineate them on the proposed plans. This is the approach taken by Big Horn County, Montana as explained above.

Tool 2. Integrate Your Maps, cont.



This is a screenshot from Pierce County, Washington's online public GIS. The user can relate the preliminary FIRM's floodplain (light green) with other hazards or concerns listed in the menu at the left. Possible fish and wildlife habitat is shown in darker green. The GIS maps trigger reviews to see what regulatory provisions are in effect in the shaded areas. The maps can also provide the user with valuable information and would be the basis for credit under CRS Activity 320 (Map Information Service).

STEP 4.
INTEGRATE THE DATA INTO THE FLOODPLAIN MANAGEMENT MAPS

The best and easiest way to accomplish Step 4 is by having a GIS layer for each additional hazard or area of interest. Many of the online examples shown in Tools 1 and 2 can be downloaded as geospatial datasets. If not, contact the source agency and request copies of the data.

Depending on the data, a paper FIRM could always be marked up. The objective is to ensure that when you check the flood data, you see there are other hazards or regulatory programs that impact the site.

There is a good example of an integrated floodplain map that also shows the areas subject to channel migration and riparian habitat regulations on page 105.

NFIP/CRS

Activity 410 (Floodplain Mapping) in the CRS credits studies on Special Flood-related Hazard Areas. The seven credited hazards listed in Section 401 of the *CRS Coordinator's Manual* are:

Tool 2. Integrate Your Maps, cont.

1. Uncertain flow paths: alluvial fans, moveable bed streams, channel migration and other floodplains where the channel shifts during a flood.
2. Closed basin lakes: lakes that have a small or no outlet that may stay above flood stage for weeks, months or years.
3. Ice jams: flooding caused when warm weather and rain break up a frozen river. The broken ice floats down river until it is blocked by an obstruction, such as a bridge or shallow area, creating a dam.
4. Land subsidence: lowering of the land surface caused by withdrawal of subsurface water or minerals or by compaction of organic soils.
5. Mudflow hazards: a river, flow or inundation of liquid mud down a hillside, usually as a result of a dual condition of loss of brush cover and subsequent accumulation of water on the ground, preceded by a period of unusually heavy or sustained rain.
6. Coastal erosion: areas subject to wearing away of the land mass caused primarily by waves on the oceans, Gulf of Mexico and the Great Lakes.
7. Tsunamis: large ocean waves typically caused by an earthquake, landslide or underwater volcano.

As with clear water flooding studies, the credit is dependent on using the maps in a program that regulates new development with standards appropriate for the hazard.

Activity 320 (Map Information Service) credits providing information to inquirers. If someone wants to know if a property is in the SFHA, credit is provided under MI5 if the inquirer is also advised of the presence of one of the special flood-related hazards. Credit is provided under MI7 if information is provided about areas that should be protected for their natural floodplain functions. Unlike Activity 410, these credits are not dependent on the community regulating these areas.

STEP 5.
INTEGRATE REGULATORY STANDARDS

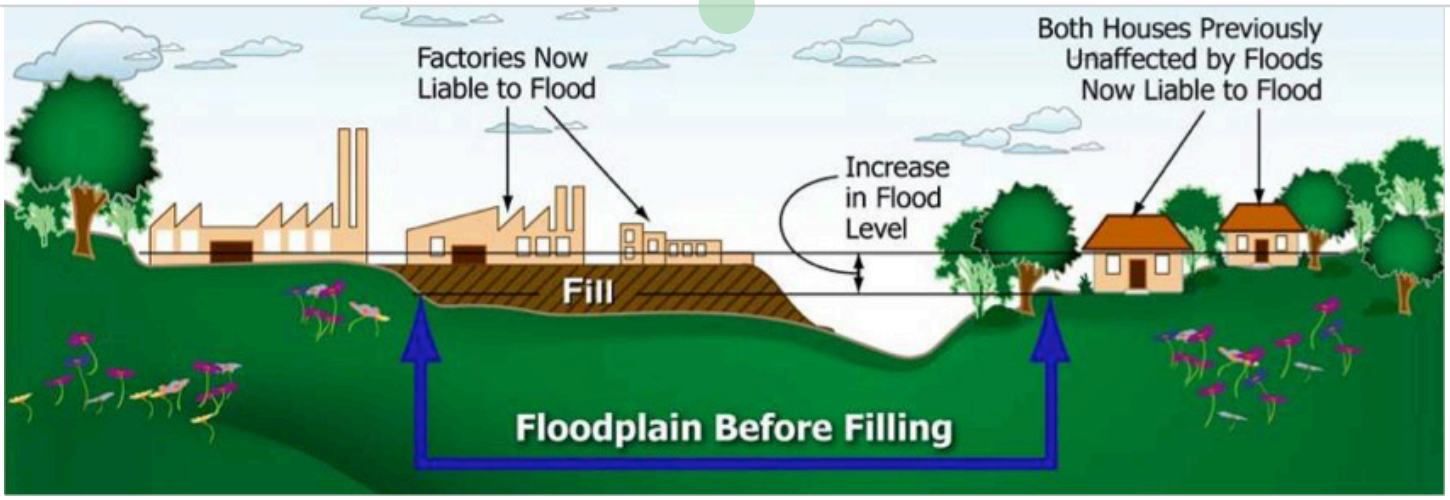
Don't settle for just integrating maps from a variety of different programs or that cover different hazards. If there are several regulatory programs with their own standards that impact the same site, it would help everyone to make sure the programs are coordinated.

It would particularly help the permit applicant to provide a master list of all the affected programs. A common approach is for the permit procedures to include a checklist that makes sure each office signs off on the application before a permit is issued.

Often the standards for these types of programs differ. As noted at the beginning of this tool, it is quite possible the floodplain manager would issue a permit for filling a wetland that would be prohibited by the environmental office or the Corps. The usual approach is to ensure regulations include a phrase like "the more restrictive standard shall apply."

Again, it would help everyone and prevent errors if inconsistent standards were replaced by the most restrictive one with a reference to the approval needed from the other program. This takes staff time and effort, but could be made a requirement whenever a regulation is up for periodic review. It will pay off in the long run.

Tool 3. Map a More Effective Floodway



It's a basic tenet of floodplain management and foundation of the No Adverse Impact approach that new development should not be allowed to increase flooding on other properties. This is a pretty simple concept that should make sense to everyone.

While this rule applies to all floodplains, it is most often an issue along rivers and streams where an obstruction to flows can increase problems elsewhere. The NAI illustration above provides a graphic explanation of what happens when the floodplain is filled.

To prevent development from increasing floods on others, a permit applicant needs to demonstrate the proposed project will not obstruct flows. This requires an engineering study in riverine areas. Under the minimum requirements of the NFIP, there are two types of studies:

1. A study conducted by the permit applicant that looks at the impact of the proposed project on flood heights. If the FIRM includes base flood elevations, but does not include a floodway, 44 CFR §60.3(c)(10) must be followed. The community must:

   Require until a regulatory floodway is designated, that no new construction, substantial improvements or other development (including fill) shall be permitted within Zones A1-30 and AE on the community's FIRM, unless it is **demonstrated that the cumulative effect of the proposed development, when combined with all other existing and anticipated development, will not increase the water surface elevation of the base flood more than 1 foot at any point within the community.**
2. A study that delineates a regulatory floodway for the community. The NFIP regulations define floodway as "the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height." Under the minimum NFIP mapping

Tool 3. Map a More Effective Floodway, cont.

standards, the "designated height" is 1 foot (in some states, a smaller encroachment is used). Delineating the floodway boundary is shown in the graphic to the right.

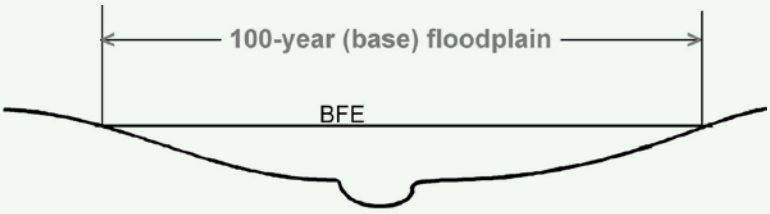
Where the FIRM includes BFEs and a floodway, 44 CFR §60.3(d)(3) governs. The community must:

Prohibit encroachments, including fill, new construction, substantial improvements and other development within the adopted regulatory floodway, unless it has been demonstrated through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that **the proposed encroachment would not result in any increase in flood levels within the community during the occurrence of the base flood discharge.**

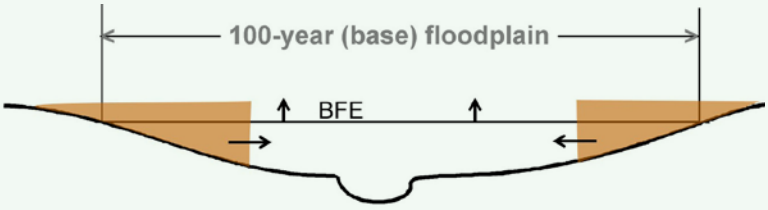
The floodway map approach is usually preferred as it eliminates the requirement for a case-by-case analysis for every project not in the floodway.

In both types of study, the NFIP allows flood heights to increase up to 1 foot (see graphic right) and there are no criteria that address other adverse impacts, such as increases in velocities, loss of flood storage or damage to habitat.

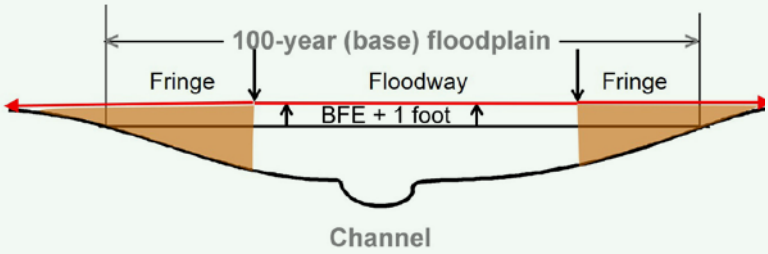
HOW FLOODWAY BOUNDARIES ARE DETERMINED



At each cross section, the hydraulic study determines the BFE.



The computer model inserts a virtual obstruction at each edge of the floodplain. This is brought closer to the channel (horizontal arrows). As this happens, the flood level increases (vertical arrows) because there is less area to carry the flow of the base flood.



The points where the increase reaches one foot above the BFE determines the boundary of the floodway (in some states, a smaller encroachment is used). The area outside the floodway is the flood fringe.

Tool 3. Map a More Effective Floodway, cont.

A LITTLE FLOODWAY MAPPING HISTORY

The first maps to be used for floodplain management were developed by the Tennessee Valley Authority in the early 1950s. These maps introduced the concept of dividing the floodplain into a floodway (the portion of the floodplain with flowing water) and the flood fringe (backwater areas).

Initially, TVA floodways were full conveyance floodways. All of the area inundated by the selected flood was to be included, except those shallow areas and embayments into small drains or gullies where there was ponding but little, if any, flow. In other words, the mapped floodway would comprise those parts of the floodplain that have moving flood waters.

The TVA received opposition on this concept. People were concerned about the impact on existing and future development, especially in areas with steep slopes outside the floodplain, terrain that is common in the Tennessee Valley. Accordingly, TVA adopted a less conservative approach. As explained by the architect of TVA's floodplain management program, Jim Goddard:

> "The floodway was to be the channel and that portion of adjacent floodplains necessary to carry the selected flood without increasing flood elevations significantly. By general acceptance among professionals 'significantly' had come to be considered no more than one (1) foot."—Origin and Rationale of Criteria Used in Designated Floodways, James E. Goddard for the Federal Insurance Administration, 1978.

Instead of mapping full-conveyance floodways, TVA mapped narrower floodways in which 1 foot of increased flooding (also called surcharge) was allowed. It was a compromise needed for adoption in more mountainous areas. Goddard noted that it was to be a minimum criterion intended as a regional standard, recognizing there were urbanizing areas where the existing development, physical conditions or other elements might demand a more stringent evaluation and a much smaller rise might be considered more appropriate.

Early developers of the NFIP turned to the TVA's experience, and the regional standard became a national standard.

Tool 3. Map a More Effective Floodway, cont.

THE PROBLEM

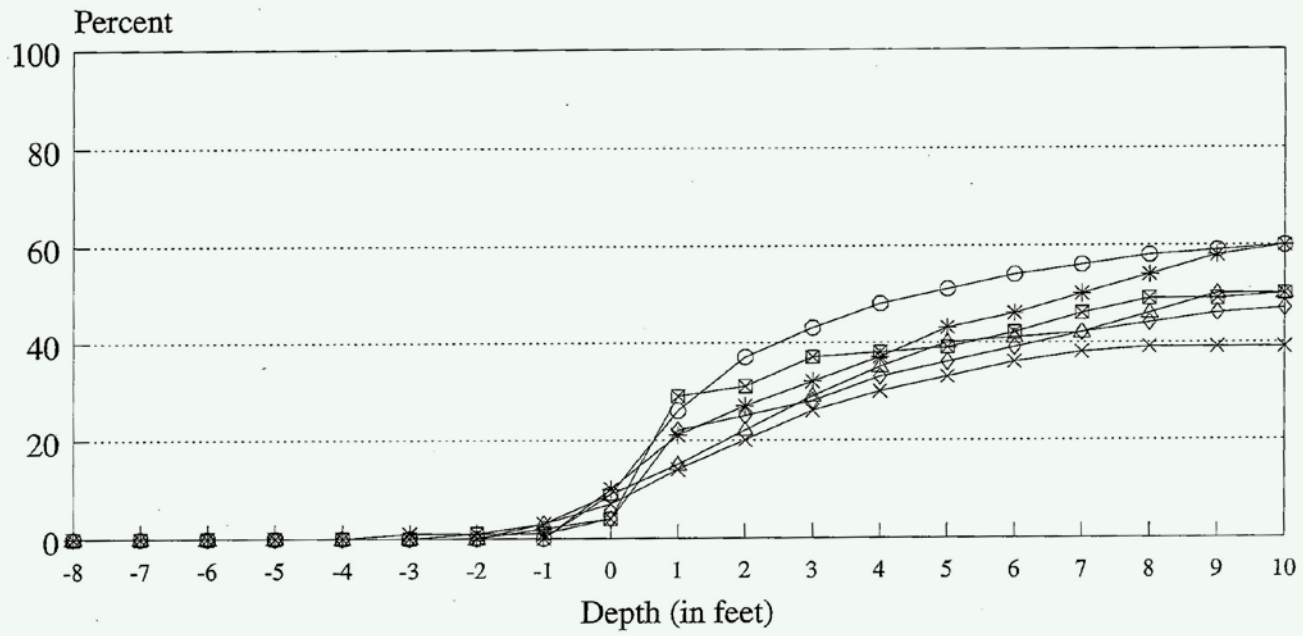
The studies required by 44 CFR Sections 60.3(c)(10) and 60.3(d)(3) are called encroachment analyses. The problem is that standards used for encroachment analyses do not prevent adverse impacts on other properties, public health and safety or natural floodplain functions.

Here are the top 10 reasons why the FEMA encroachment study requirements and NFIP floodway map regulations are not NAI approaches to floodplain management:

1. **Allows a significant portion of the natural floodway to be developed:** A 2013 ASFPM floodway study (see box next page) showed that allowing encroachments that would result in a 1 foot rise in the base flood reduces the width of the floodway available to convey floodwaters by an average of 50 percent.
2. **Increased flood damage to homes and businesses:** As seen in the graph below, allowing flooding to increase by a foot can cause damage up to 30 percent of a building's value. Buildings properly elevated are now at risk. Buildings presently at risk face greater flood damage.
3. **More properties flooded:** Allowing a 1 foot increase in flood heights extends the area

DAMAGE

(PERCENT OF BUILDING VALUE)



This graph was developed by the U.S. Army Corps of Engineers from data supplied by six districts around the country (hence the six lines). It shows that a flood 1 foot over the first floor causes dam-age between 15-30 percent of the value of a single family home (one story, no basement). While the percent of damage caused by an additional foot of floodwater decreases as the flooding gets deep-er, damage is still increasing. "Catalog of Residential Depth Damage Functions Used by the Army Corps of Engineers in Flood Damage Estimation," IWR Report 92-R-3, May 1992, Figure 2.

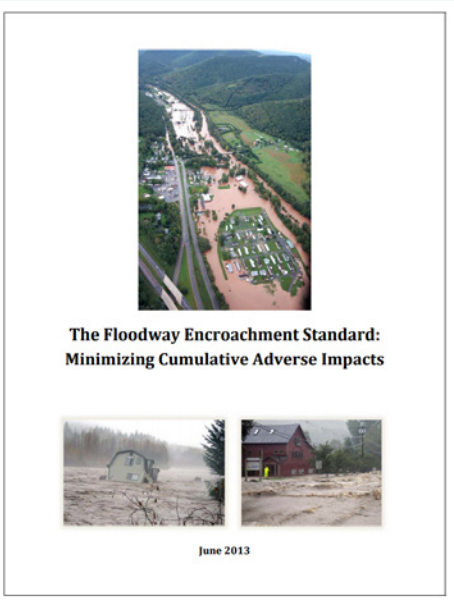
Tool 3. Map a More Effective Floodway, cont.

impacted by the base flood outward to properties outside the SFHA shown on the current FIRM. See the red line in the graphic on pg. 34. In flat areas, an increase of 1 foot can expand the boundaries of the 100-year floodplain by hundreds of feet.

4. **Increased velocities:** The 2013 ASFPM study, "The Floodway Encroachment Standard," showed on pg. 8 that allowing encroachments that would result in a 1 foot rise in the base flood not only reduces the width of the floodway available to convey floodwaters by an average of 50 percent, but as a result also increases velocities by an average of 33 percent.

   "By increasing the velocity of water moving in the channel, flowing water can scour the stream bed and deepen the channel. This means banks are higher and often more unstable, resulting in increased stream bank erosion and more sediment entering the stream. Increased sedimentation makes it difficult for some fish to feed and spawn…"

5. **Loss of flood storage:** The ASFPM report also notes on pg. 19:



A more technical discussion of the problems with the NFIP approach to floodway mapping and regulations can be found in ASFPM's 2013 report, "The Floodway Encroachment Standard: Minimizing Cumulative Adverse Impacts."

"FEMA's Guidelines and Specifications [for Flood hazard Mapping Partners] include guidance on how to develop a 1-foot rise floodway based on loss of storage. However, when mapping regulatory floodways, evaluating the loss of flood storage is not standard practice."

A loss of flood storage can significantly impact flood heights in wide floodplains with slow moving floodwaters. In undeveloped areas, much of the flooding is attenuated by storing the higher flows in the fringe. The loss of storage due to filling up to the mapped floodway line is not reflected in a standard encroachment model that only looks at conveyance at the cross sections.

6. **Damage to natural floodplain functions:** The NFIP standard focuses on increased flood heights upstream of development or fill. This is measured at the cross section as an obstruction to conveyance. An encroachment analysis could conclude there will be no increase in flood heights because the project will remove trees and pave the area, allowing more flow through a smaller cross section. However, this increases velocity and reduces flood storage, causing increased flooding downstream in addition to adversely impacting floodplain habitat.

Tool 3. Map a More Effective Floodway, cont.

7. **Some areas are exempt from any analysis:** An encroachment analysis is only required by the NFIP where the FIRM includes a BFE (i.e., there is an AE Zone). There are many streams in the country that are only mapped as approximate A Zones. In these areas, there is no NFIP requirement for analyzing the impact of development on flood heights.
8. **The flood protection level becomes obsolete:** The FIRM's BFE reflects the pre-encroachment level, even though the floodway rules allow development to increase flood heights up to a foot. As a flood protection level, the BFE will be outdated as soon as any development is allowed in the fringe that obstructs flow. The next restudy will take past development into account and will produce a map with higher BFEs, resulting in higher construction costs for new buildings. Because of the increased exposure, buildings built to the old BFE are subject to higher flood insurance premiums if their NFIP policies lapse.
9. **Filling is encouraged:** A congressional directive requires FEMA to revise FIRMs to reflect natural and manmade changes to the floodplain. As a result, allowing Letters of Map Revision based on Fill, or LOMR-Fs, to remove a building constructed on fill from the flood insurance purchase requirement and from jurisdiction under most communities' floodplain management regulations, encourages filling in the SFHA. While a property owner may only want a building protected from flood damage, the LOMR-F criteria encourage a larger amount of fill and greater loss of flood storage in the fringe—adding to the problem.
10. **Shortcomings in encroachment studies:** There are also problems with the typical encroachment study and implementation of the NFIP criteria. For example, encroachment studies are supposed to look at "the cumulative effect of the proposed development, when combined with all other existing and anticipated development" (44 CFR §60.3(c)(10)). However, there is no specific definition of "anticipated development."

    While communities may indicate no plans for development have been received, they must recognize the legal difficulty they would have denying similar proposals after they allow the first development project. Without assuming the entire area between the proposed development and the edge of the SFHA will also be developed, an encroachment study will not account for "the cumulative effect of the proposed development."

ADVERSE IMPACTS OF FILLING

Filling is often viewed as a way to elevate land above the flood level. While there may be some flood protection benefits to the property owner, filling can have adverse impacts on other properties and natural floodplain functions, including:

- Loss of flood storage;
- Removal of trees;
- Smothering riparian vegetation;
- Destroying wetlands; and
- Constricting channels so they cannot follow their natural, meandering course.

Tool 3. Map a More Effective Floodway, cont.

Floodway by Louisiana Sea Grant College Program via Flicker.

HOW TO MAP A MORE EFFECTIVE FLOODWAY

STEP 6.
REVIEW THE ALTERNATIVES

There are several ways to better manage encroachments and impact of encroachments, listed below and ranging from the simpler, less effective approaches, to the most effective NAI approaches.

1. SET A HIGHER PROTECTION LEVEL TO ACCOUNT FOR FUTURE INCREASES IN FLOOD HEIGHTS

There are three ways this approach could be implemented.

A. Add freeboard. Many communities have added a freeboard of 1 or more feet. As noted on pgs. 6-16 of the FEMA 480 *Desk Reference*, freeboard accounts for a variety of uncertainties and provides an added measure of safety against flooding. As long as development, especially filling, is allowed in the fringe, there is no uncertainty—*flood heights will increase*. Therefore, if freeboard is used as a hedge against encroachments, it should be at least 2 feet to account for the encroachment plus other uncertainties.

B. Map and regulate to the "with floodway elevation." NFIP flood insurance studies have a floodway data table that shows the effect of the allowed encroachments at each cross section.

Using the "with floodway" elevation for mapping and regulations protects new development from the increase in flood heights allowed under the NFIP floodway mapping

Tool 3. Map a More Effective Floodway, cont.

criteria. However, it usually does not account for other shortcomings in the NFIP criteria, such as loss of storage and increase in flood velocities.

C. Do both. A simple overall approach would be to set the BFE at 1 foot above the regulatory BFE shown on the FIRM and in the flood insurance study's profiles. All properties below this elevation, including those outside the SFHA on the FIRM, would be subject to the community's floodplain management regulations. Then add 1 or more feet of freeboard to account for the uncertainties. Where the 500-year flood is at least 1 foot higher than the 100-year flood, it could be used as the basis for regulations (plus freeboard). This would not only better protect new buildings in the SFHA, it would extend the protection to the shaded X Zone and properties outside the SFHA that would be affected by a 1 foot increase in flood heights.

The shortcoming of these simple and straight forward approaches is that all they do is require a higher level of protection for new construction. They do not protect existing development from increased flood heights and velocities or loss of storage due to encroachments allowed in the floodplain. This concern applies to mapping a new floodway and using these standards in site-specific encroachment analyses. Because of this, these alternatives are not full NAI approaches to preventing new development from adversely impacting the rights of others. The following alternatives are better.

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD)	WITHOUT FLOODWAY (FEET NAVD)	WITH FLOODWAY (FEET NAVD)	INCREASE (FEET)
CHISHOLM CREEK								
A	20,434	227	2,456	6.4	1,350.0	1,350.0	1,351.0	1.0
B	21,754	521	3,633	4.2	1,351.7	1,351.7	1,352.3	0.6
C	23,654	657	4,532	3.3	1,355.3	1,355.3	1,356.2	0.9
D	24,922	562	4,115	2.7	1,357.2	1,357.2	1,358.2	1.0
E	26,294	846	5,403	1.6	1,358.4	1,358.4	1,359.4	1.0
F	27,509	615	3,384	2.6	1,359.0	1,359.0	1,360.0	1.0
G	28,723	480	2,693	3.3	1,360.4	1,360.4	1,361.3	0.9
H	31,363	349	2,458	3.6	1,366.0	1,366.0	1,367.0	1.0
I	31,997	400	2,968	3.0	1,367.3	1,367.3	1,368.2	0.9
J	33,475	512	2,482	3.5	1,369.1	1,369.1	1,370.0	0.9

This is the Floodway Data Table from a typical flood insurance study (Sedgwick County, Kansas). The data from the hydraulic model is provided for each cross section, A-J. The "Regulatory (Feet NAVD)" water surface elevation is the BFE used on the FIRM at that cross section. Note it is lower than the "With Floodway" elevation. Depending on local topographic conditions, the encroachment used in the hydraulic model is not always 1 foot. The encroachment is shown in the "Increase (feet)" column in the floodway data table.

Tool 3. Map a More Effective Floodway, cont.

2. USE A MORE RESTRICTIVE FLOODWAY STANDARD IN THE HYDRAULIC MODEL

If a community has adopted more stringent regulations, these regulations take precedence over the NFIP regulatory standard. FEMA policy is that a maximum allowable surcharge of less than 1 foot limits can be used as the basis for the floodway delineation on a FIRM if the community requests it and has adopted associated regulations.

Floodway surcharge values must be between zero and 1 feet. For an NAI approach, communities should adopt regulations and request a floodway based upon zero allowable surcharge.

If a new flood insurance study is underway in your community, tell FEMA you need a floodway delineated and the delineation should not allow encroachments to increase flooding. Therefore, you are "selecting" the full-conveyance (aka zero-surcharge floodway) as the floodway to be included on the flood mapping for your community. By submitting the request on official letterhead, your community can be on record as not wanting a floodway map that allows new development to increase flooding on other properties (see example letter on p. 61).

The history behind the 1 foot national standard is explained on page 52 of this *Guide*. The rationale does not make sense everywhere, especially in flatter terrain. A more restrictive floodway mapping standard is required in eight states (see box, next page). All NFIP floodway maps prepared in these states have been based on lower allowable rise criteria since the state standards went into effect.

As explained on pg. 3 in the ASFPM floodway study, the objective was to designate a floodway that carried the base flood "without increasing elevations significantly." Illinois staff indicated that in the 1970s, the state interpreted "significantly" to mean "anything greater than zero, but its practical interpretation is 0.1 foot for computer purposes."

The rationale was that "the overbank floodplain of most of the streams in the state [of Illinois] is quite flat. A small increase in the flood profile can significantly expand the width of the floodplain. It seemed unreasonable economically to allow any significant increase in the flood stage that subjects previously 'safe' structures to flood waters." The Illinois floodway standard for regulatory maps is no more than 0.1 foot increase in stage due to loss of conveyance and loss of flood storage, and no more than a 10 percent increase in velocity in northern Illinois.

Tool 3. Map a More Effective Floodway, cont.

Minnesota uses a half foot floodway mapping standard where no existing development is adversely impacted. The state's "Regulatory Flood Protection Elevation" is the BFE plus the "stage increase due to establishing the floodway" plus at least 1 foot of freeboard.

Wisconsin uses a zero allowable increase in flooding as its floodway mapping standard—described on page 63 of this *Guide*.

NFIP/CRS In addition, FEMA provides CRS credit to a community that adopts a higher standard floodway map. Adopting a floodway map or requiring a site-specific encroachment using a higher floodway study standard is credited in Activity 410 (Floodplain Mapping) under the element more restrictive floodway standard (FWS). The lower the allowable rise, the greater the credit.

STATES WITH HIGHER FLOODWAY STANDARDS

Wisconsin	0.0 foot
Illinois	0.1 foot
Indiana	0.1 foot
Michigan	0.1 foot
New Jersey	0.2 foot
Colorado	0.5 foot
Minnesota	0.5 foot
Montana	0.5 foot

Following major flood events on Memorial Day weekend and October 2015, the city of San Marcos, Texas decided to adopt higher floodplain standards to reduce flood risks in the community. One of the standards adopted was a zero-rise (full-conveyance) floodway.

Since FEMA was in the process of providing updated SFHA maps for the community, the city sent a letter to FEMA requesting the floodway on their new maps encompass the full extent of the floodplain in the city. Once the city floodplain ordinance was amended to reflect this higher standard, FEMA issued preliminary FIRMs that reflected the higher standard.

Tool 3. Map a More Effective Floodway, cont.

3. SET HIGHER REGULATORY STANDARDS

Tool 1 of the *NAI How-to Guide for Regulations* discusses regulatory tools for managing encroachments. For example, if the floodway was mapped solely based on flood height increases, an applicant for a project in the floodway could be required to conduct a study that accounts for flood storage loss and velocity increases.

Images from NASA Goddard Space Flight Center via Flicker.

continued on page 62

SAMPLE LETTER FOR REQUESTING FULL-CONVEYANCE (ZERO SURCHARGE) FLOODWAYS*

Dear FEMA Regional Director (Name),

_____ is a community that has joined the National Flood Insurance Program. To maintain eligibility in the NFIP we have adopted and enforce floodplain management regulations based on data (e.g. Flood Insurance Rate Maps) provided by the FEMA administrator.

FEMA is in the process of updating the FIRMs for our community. FEMA's mapping standards allow natural floodways to be encroached to the extent that the FEMA regulatory floodway would result in 1 foot of increased flooding above existing flood elevations.

§ 60.3 (d) states communities shall: "Select and adopt a regulatory floodway based on the principle that the area chosen for the regulatory floodway must be designed to carry the waters of the base flood, without increasing the water surface elevation of that flood more than one foot at any point."

We hereby indicate that we "select" a regulatory floodway based on the principle that the area chosen for the regulatory floodway be designed to carry the waters of the base flood, without increasing the water surface elevation of that flood.

Therefore, we officially request FEMA to map full-conveyance floodways within our community because:

1. We are required to "review all permit applications to determine whether proposed building sites will be reasonably safe from flooding" (§ 60.3). By definition 1-foot rise floodways could ultimately cause new building sites to be subjected to a foot of flooding and therefore would not be "reasonably safe from flooding." As a result we feel we cannot fulfill this requirement with a mapped 1-foot rise regulatory floodway.
2. We have a responsibility to owners of existing development in our community to ensure that new development does not cause increased flooding to existing buildings. We cannot do that unless full-conveyance floodways are used to develop our flood maps.

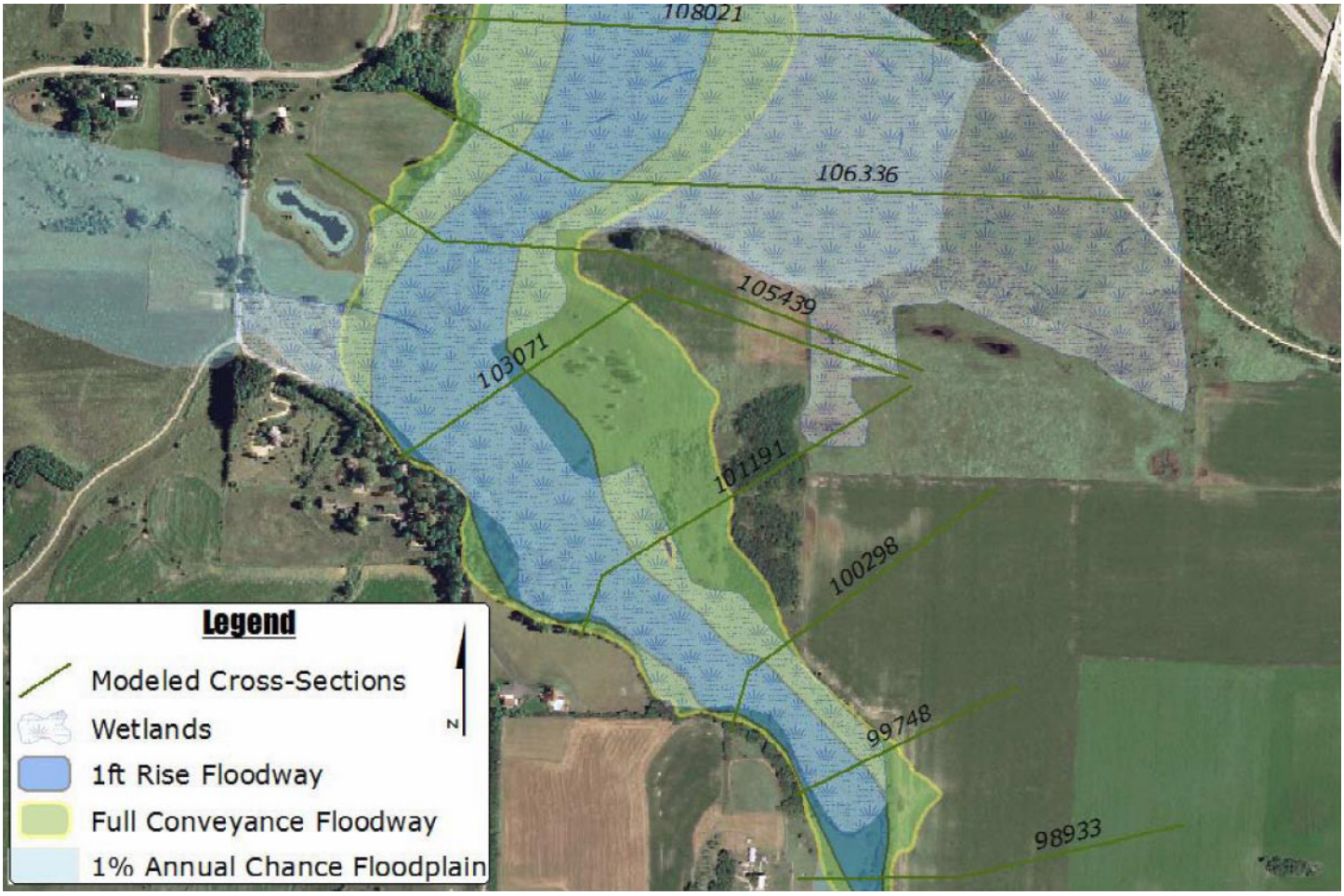
Respectively submitted,

_____ (chief executive officer)

cc: FEMA headquarters

*If your community opts for a floodway surcharge standard that is greater than zero, the letter should be modified to include the statement that the community recognizes the floodway standard adopted will increase flooding on existing development in the community by that amount.

Tool 3. Map a More Effective Floodway, cont.



This map shows how an effective flow path or full-conveyance floodway can differ from a floodway based on a typical flood insurance study's 1-foot rise standard. Map created by ASFPM.

4. MAP THE FULL CONVEYANCE FLOODWAY

This is the NAI approach. Instead of basing the floodway boundary on where flood heights are allowed to increase to a certain level, this approach bases the boundary on the floodplain's natural flow areas. Backwater areas are delineated as the fringe. The rest of the floodplain is treated as a regulatory floodway. This approach is the Wisconsin state standard (next page).

No matter which alternative is used to map the floodway, the regulatory requirements for permit applications in the floodway should be the same. These requirements and NAI-type improvements on floodway regulations are discussed under Tool 1 in NAI How-to Guide for Floodplain Regulations.

Tool 3. Map a More Effective Floodway, cont.

WISCONSIN'S ZERO-RISE FLOODWAY

Wisconsin Administrative Code NR 116 establishes standards for use by local government floodplain management regulations. The state Legislature passed the state's floodplain management law in 1967, one year prior to Congress' passage of the NFIP. The law directed the Department of Natural Resources to establish standards by which local governments should regulate land-use within designated floodplains.

NR 116 sets criteria for a standard that is, for all practical purposes, a "zero rise" floodway. The Wisconsin Legislative Reference Bureau, the agency that publishes administrative rules, insisted that NR 116 include a number. DNR inserted 0.01 foot to represent "zero" as near as practical. Therefore, all floodways mapped in Wisconsin are zero-rise (full-conveyance) floodways.

In addition to this floodway mapping standard and the prohibition of "any development which will cause an obstruction to flood flows or an increase in regional flood discharge," NR 116 included some land use restrictions. Habitable buildings, storage of dangerous materials, public or private sewage systems, and most water wells are prohibited in the floodway.

In order to encroach into the floodway, the applicant must conduct an analysis to calculate the increase in flood height or flood discharge of a proposed project. Any increase greater than 0.01 foot will require the community to amend its floodplain development ordinance to adopt a new profile, if not a new map. In addition, flood easements must be obtained from all property owners impacted by increased flood heights.

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
BARABOO RIVER								
A	103.64	1,347	2,443	2.3	962.7	962.7	962.7	0.0
B	104.02	1,789	4,869	1.2	969.3	969.3	969.3	0.0
C	104.40	816	2,139	2.6	972.6	972.6	972.6	0.0
D	105.01	1,274	2,850	2.0	976.5	976.5	976.5	0.0
E	105.18	461	1,682	3.3	981.3	981.3	981.3	0.0
F	105.29	808	4,081	1.4	982.2	982.2	982.2	0.0

Compare the "Increase" column numbers for a Wisconsin river with the Floodway Data Table on p. 57.

Tool 3. Map a More Effective Floodway, cont.

STEP 7. BUILD THE CASE

As with future conditions mapping, you will probably need to lay some groundwork before you can expect support for a change. Keep in mind floodways are viewed by most lay people as areas where no development is allowed. Floodway property owners will not be excited about a new map or rules that makes the floodway larger or harder to build in.

Prepare your talking points for areas without floodway maps. Explain the benefits of having a floodway map:

- They are simpler to administer.
- They save money for developers in the flood fringe.
- They protect properties well away from a development site that might not be addressed in a site-specific analysis.

Prepare your talking points for areas with floodway maps. Explain the benefits of better mapping criteria:

- Explain how the community is better protected from liability if it protects its residents and property owners by not permitting new development to adversely impact others.
- Review problems with the current floodway mapping standards highlighted in the previous section
- Better standards mean better protection of existing developments.
- Relate the concept of preventing encroachments to the No Adverse Impact approach discussed in Section One.

Communicate with your audience.

- Be able to explain the technical aspects to engineers. This will probably need support from an engineer knowledgeable in the study methods used in your area. Communicating choices and associated impacts with clear and accurate information was one of the keys for Mecklenburg County, North Carolina staff to gain widespread support for their new maps (see the Mecklenburg County case study on page 79 in the NAI How-to Guide for Planning):
  Staff knew that extending floodplain regulations to a larger area would not be well-received by affected property owners or developers. If enough people opposed the idea, it would not pass the respective councils. Accordingly, a stakeholder involvement process was initiated. After meetings with different groups and organizations, staff showed and explained the model's findings. Several engineers representing the stakeholders reviewed the models and convinced their clients they were accurate.
  Eventually several key organizations, including the real estate board and chamber of commerce, agreed that the maps were based on "good science."
- Be able to explain the legal concepts to attorneys. ASFPM has a webpage dedicated to NAI legal issues with reports on recent court rulings related to the NAI approach.
- Be able to explain all the concepts to your citizens, council members and developers. ASFPM has materials on NAI, including a PowerPoint, poster and publications that include the graphic on page 50 of this *Guide*.
- 3-D displays can be very effective to show impacts of encroachments on flood heights (see box, next page). These are described in more detail under Tool 4 in the NAI How-to Guide for Education & Outreach.
- Relate to local conditions. Have buildings been constructed in the past without freeboard that would be especially susceptible to damage if new development causes flood levels to rise 1 foot higher than the base flood? Has there been a recent flood that damaged new construction or affected properties outside the mapped SFHA?
- See also Step 2, Tool 5 in this *Guide*; Tool 5 in the NAI How-to Guide for Planning, and ASFPM's Building Public Support for Floodplain Management for other suggestions on educating the public.

Tool 3. Map a More Effective Floodway, cont.

Pick the right venue(s) to make your case. You want an audience interested in flooding and receptive to new ideas. Here are some situations where you may find such an audience:

- When there is a staff meeting or public meeting on a flood-related topic;
- If there has recently been a damaging flood in or near your community;
- When budgeting for a bridge or flood protection project that will have its protection level lowered by increased flood heights;
- When there is a staff or public meeting on a major development that will likely impact flood heights, velocities or storage;
- When flood-related plans or ordinances are up for review; or
- When your FIRM is being revised.

3-D displays can explain problems with encroachments to any audience.—WARD'S Natural Science, West Henrietta, NY.

continued on page 66

Tool 3. Map a More Effective Floodway, cont.

Photo via floodsmart.gov.

STEP 8. PREPARE NEW FLOODWAY MAPS

Once the alternative has been chosen, new maps should be prepared. Sometimes, this work may have to be phased in as funds are available or when streams are restudied for other purposes.

If your community is a Cooperating Technical Partner with FEMA, talk to the FEMA Regional Office about cost sharing a new study under that program. The timing may coincide with a revised flood insurance study, in which case the community can request the study to include its higher mapping standard. An example request letter is on page 61.

If it appears mapping will take several years or more, the community should start requiring site-specific analyses to include the new standards.

STEP 9. IMPLEMENT

Preparing the maps is only half the job. They need to be incorporated into your regulatory program, by ordinance amendment if your regulations do not authorize staff to use better mapping when it becomes available.

Submit the new maps to FEMA. However, because the floodway is a locally-adopted tool and does not affect flood insurance rating, FEMA may not fund a map revision. As long as your floodway is more restrictive than the FIRM's and its use is required in your regulations, you do not have to request a map revision.

Implementation of the floodway rules is dependent on your regulatory requirements and administration. These topics are covered under Tool 1 in NAI How-to Guide for Floodplain Regulations.

Tool 4.
Map Residual Risk

The 1976 Teton Dam failure in Idaho shows the high velocities in the resulting flood. This occurred on a sunny day, catching many downstream occupants by surprise. Photo by Eunice Olson, courtesy of A. G. Sylvester.

Floodplain maps are prepared for different purposes, so they will show different features. The purpose of the National Flood Insurance Program's Flood Insurance Rate Maps is to provide information for flood insurance rating, development regulations and the mandatory purchase of insurance requirement. As such, it focuses on the base flood, shown as the Special Flood Hazard Area. FIRMs may depict floods greater than the base flood. Often the shaded X Zone is used to show the area between the base and the 500-year flood. However, because there are no regulatory or insurance requirements in the X Zone, many FIRM users focus only on the SFHA. There is also a tendency to view the X Zone as safe from flooding and many communities do not consider X Zones as warranting attention in their regulatory programs.

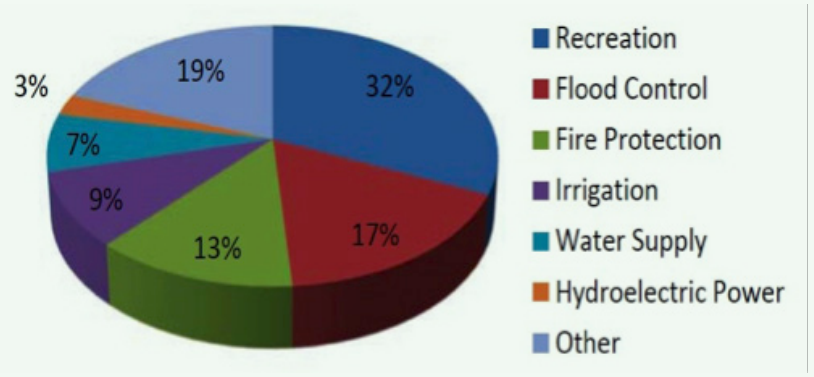
Many X Zone areas are higher than the base flood. However, areas protected to the base flood level by a flood control structure, such as a levee or dam, are also mapped as X Zone. These areas are not higher than the base flood and,

Tool 4. Map Residual Risk, cont.

in fact, can flood if the structure fails or is overtopped. These areas are subject to what is called "residual risk," i.e., the additional risk of flooding an area ostensibly protected from the base flood.

Although the probability of flooding may be lower because of the flood control structure, the consequences in terms of danger to people and damage to property are much higher if there is a failure. Floods that result from levee or dam failure can be especially dangerous because it can occur on short notice and can come in the form of a wall of water and high velocities, as in the photo on previous page.

Another concern is residents of the flood¬prone area may not even realize they are at risk. They may assume the flood control structure protects them from all floods, an attitude that may be reinforced by the designation on older FIRMs of the X Zone as an area of "minimal flood hazard." Most concerns about residual risk relate to levees and dams.



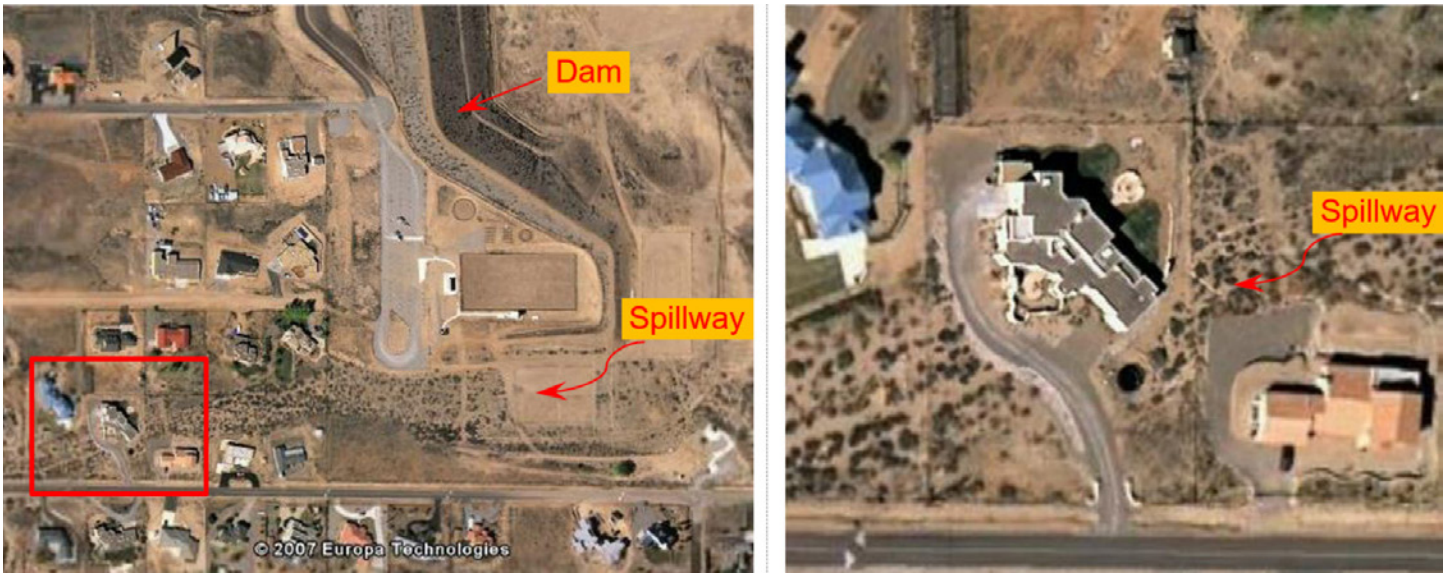
Only 17 percent of the dams in the U.S. were designed for flood control. (ASFPM's "A Strategy to Reduce the Risks and Impacts of Dams on Floodplains," 2013, p. 16)

While there are similarities in the resulting flood, they have been treated differently by federal programs. FEMA recently issued new "Analysis and Mapping Procedures for Non-Accredited Levee Systems," and the Corps started its Levee Safety Action Classification program to classify levee systems based on the consequences of overtopping or failure. Because both programs are relatively new and will provide communities with new information about their levees' conditions, Tool 4 in this *Guide* focuses on residual risk associated with dams.

Dams are designed to hold back water for different purposes, such as water supply, recreation and hydro power. While they all retain water, fewer than one out of five dams were built for flood control. However, many downstream residents assume they are safer from flooding because of a dam.

Dams also vary in size, ownership and construction. Generally, the larger, publicly-owned dams are subject to higher standards of design and maintenance. But, any dam can fail or be overtopped by a flood larger than it was designed for.

Tool 4. Map Residual Risk, cont.



This flood control dam in Albuquerque, New Mexico has an emergency spillway on its south side. The spillway is not mapped as a flood hazard area. Note the area in red, which is enlarged to the right. It shows houses have been built in the path of the spillway's flow. Images from an unpublished paper by Les Bond, 2007.

While providing some flood reduction for millions of people under most scenarios, dam failure risk remains for communities downstream of dams. Federal and state agencies generally identify three categories of dams based on the downstream risk. Usually the most dangerous is a "high hazard" or "potentially high hazard" category. If these dams fail, there is a threat to life. According to the 2016 National Inventory of Dams, there are more than 90,000 dams in the United States. More than 15,000 of them are potentially high hazard and nearly 12,000 are listed as having significant hazard potential. Of these two categories, more than half either do not have an emergency action plan or are not required to have one.

The high hazard dams are not the only ones to address. There are more dams in the next lower category, which usually means there will be property damage from a dam failure.

There are two other impacts not related to a dam failure or overtopping:

1. Reservoirs can be drawn down, either to increase storage capacity before an expected flood or to prevent a failure caused by leakage. The result can be higher than normal flows downstream that can cause threats to safety and property.
2. FEMA maps the base flood hazard. If a dam is rated as retaining the base flood, the area downstream may be shown as a very narrow flood hazard, often not much wider than the channel. In some cases the downstream area may not have any flood hazard area mapped. Similarly, the spillway overflow path may not be mapped as a flood hazard area. See the example above.

Tool 4. Map Residual Risk, cont.

The end result is development can occur without accounting for the residual flood hazard and that downstream residents may be unaware of the hazard of a failure or an operational release.

While some flood control dams were constructed with an awareness of the risk to downstream properties, many were constructed in rural areas as low hazard dams because there was little potential for damage downstream. Low hazard dams are seldom designed to the same standards as high hazard dams and are much more likely to fail or be overtopped by a major flood event. As the downstream areas became developed and even urbanized, these dams have had to be reclassified as high hazard potential. This phenomenon is commonly referred to as hazard creep, meaning that while the dam did not change, the adverse impacts of a failure have increased.

Even where there is a mapped floodplain downstream, the SFHA is often much smaller than the area that would be flooded by a dam breach (see map, p. 69).

A dam failure emergency ***action plan*** is prepared by the dam owner. It focuses on steps to be taken to minimize the likelihood of a failure during an emergency. For example, emergency spillways may be opened to draw water down.

A dam failure emergency ***response plan*** is prepared by the community's emergency manager. It focuses on steps to take in the downstream affected area to minimize loss of life and property. For example, it would specify when to call for an evacuation.

HOW TO MAP RESIDUAL RISK STEP 1.

COLLECT INFORMATION ON THE RISK

Many local officials are not aware their community is downstream of a dam. Therefore, rather than rely on local knowledge, talk to the county emergency manager and state dam safety office. The Association of State Dam Safety Officials maintains a website with state program and contact information.

You can select which dams warrant your attention based on the impact of their failure to your community.

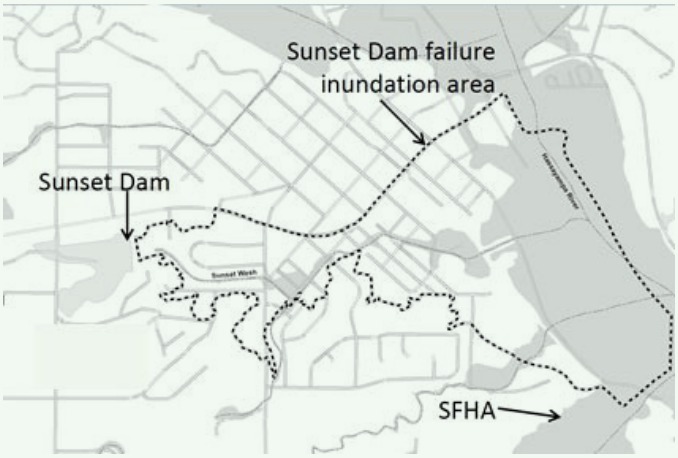
For each dam, collect the following information:

- Whether the dam has been cited by the state program or is considered in good condition;
- Whether the dam owner has an emergency action plan;
- Whether your local emergency manager has a coordinated emergency response plan; and
- A dam breach inundation map.

The first three will help you prioritize which dams and residual risk areas should be addressed first.

Dam breach inundation map:
A basic tenet of residual risk is to plan for a flood, even if the odds of one appear remote. Conditions can change and a dam failure flood impact can be catastrophic. Therefore, regardless of how well prepared the dam owner and your emergency management office are, a dam breach inundation map should be obtained.

DAM BREACH INUNDATION MAPS



The FIRM for this area in Maricopa County, Arizona shows only a small part of the dam breach inundation area as SFHA. Most of the area is X Zone, where there are no federal requirements for development regulations or for the purchase of flood insurance.

This mitigation planning map highlighted the inaccuracy of the AE Zone boundary.

Above are dam breach inundation map examples. They may show just the area affected, as in the example on the left, or they may show the timing of the downstream flood, as in the example to the right.

The 2012 NFIP Reform Act included a requirement to map residual risk areas—not only areas protected by levees and dams, but also failure inundation zones. However, dam failure zones are not yet being systemically identified or published in any FEMA mapping product.

Your community's emergency manager is the best person to go to for available dam failure inundation mapping. If a dam breach inundation map is not available, your community should consider preparing one. There are two approaches to preparing a dam breach inundation map:

1. A simplified inundation map has conservative floodplain boundaries and is less expensive than a detailed study. It's considered adequate for warning and emergency response.
2. A more detailed study is called for when there is a large dam, a large population at risk,

Tool 4. Map Residual Risk, cont.

and/or complex downstream conditions, such as split flows or more dams that could fail if an upstream dam fails.

FEMA developed a simplified mapping tool, Geospatial Dam Break, Rapid EAP, Consequences and Hazards (GeoDam-BREACH). This was done to make dam breach inundation studies and emergency plans more affordable. The result can link with FEMA's Risk MAP products to assist communities with emergency and hazard mitigation planning. A dam breach map should be prepared in cooperation with the dam owner. In some cases the map may be required by a regulating agency. If the owner is reluctant, he or she should be reminded damage resulting from a dam failure has historically been the legal responsibility of the dam owner under the tenet, "If you capture and store water you are responsible for its safe release." Owners should be made aware your objective is to prevent or minimize danger and damage of a breach and you should be working together. If an unmapped area is developed, the classification of the dam may change to a higher hazard, which may place additional requirements on the owner (see example right).

MAPPING THE HAZARD IN VIRGINIA

In 2008 the Virginia Dam Safety Act was amended to require mapping of dam break inundation zones for all regulated dams. Dam engineers are required to provide hazard classification analyses, inundation maps, inspections and emergency action plans. The largest barrier to developing inundation mapping for all dams was the high cost to dam owners.

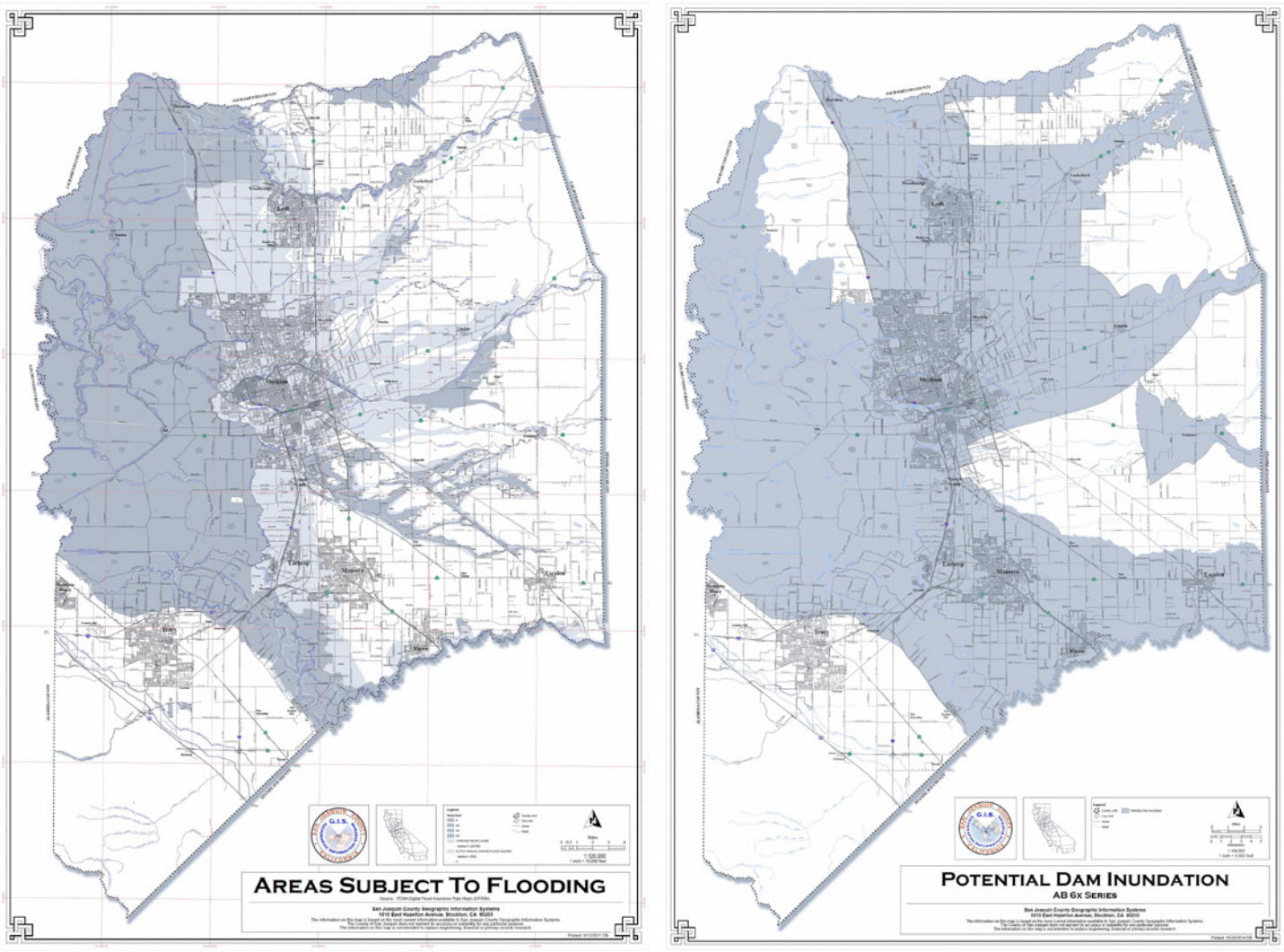
In 2011 the Virginia General Assembly authorized a low cost, simplified inundation mapping solution for dam owners. This was intended to help communities prevent downstream development and keep low-hazard-potential dams as low-hazard. If a map indicates a dam is low-hazard-potential, the owner is eligible for a general permit with minimal requirements—as long as the dam maintains that classification.

If a map shows a dam as significant- or high-hazard-potential, the owner must provide the full inundation analysis and mapping. As a result of these amendments, Virginia has inundation maps for all regulated dams.

Excerpt from page 38 in "A Strategy to Reduce the Risks and Impacts of Dams on Floodplains."

continued on page 73

Tool 4. Map Residual Risk, cont.



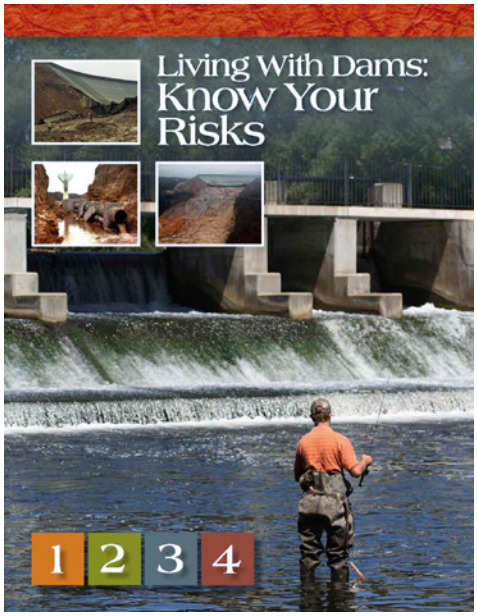
San Joaquin County, California posts these two maps on its Natural Hazards Disclosure website. The names and locations of the dams are not shown, which may reduce concern about terrorists using the information.

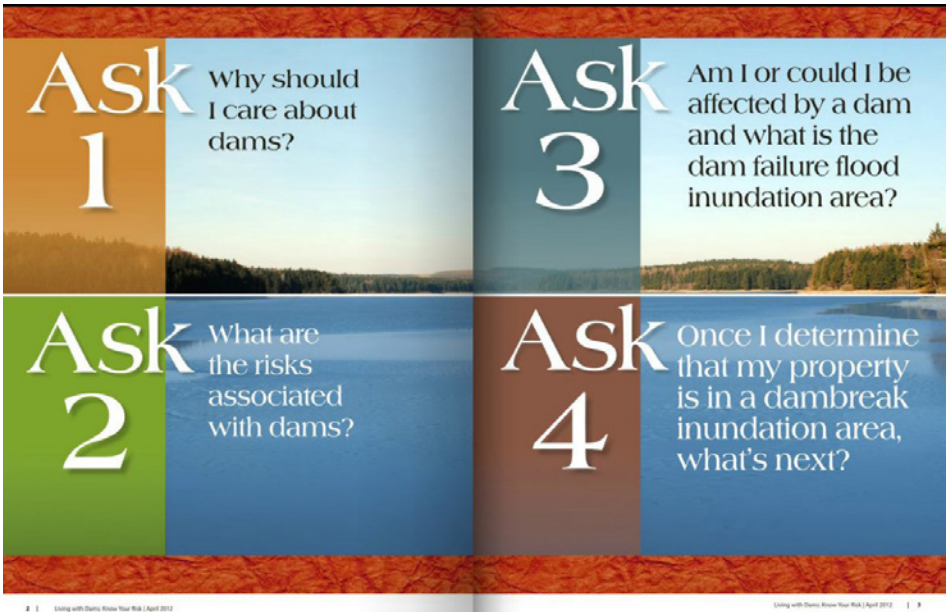
STEP 2. PREPARE A MAP FOR THE PUBLIC

A dam failure inundation map is needed to advise the public of the hazard and to guide land use management programs. One problem with using a dam breach inundation map is that some agencies limit access to emergency managers. Therefore, even if you or your emergency manager can obtain a dam breach inundation map, you may not be able to make it available on a website or other public format. Needless to say, you will need to show a map to other staff, the public and your elected officials if you want to do anything to reduce the risk.

If your map is available to the public, use it. You may want to simplify it or add explanatory information, but if it's already on a website, it should be open to reproduction and distribution. Below is an example that only shows the area affected, which is sufficient for floodplain management purposes.

Tool 4. Map Residual Risk, cont.





This guide is available at http://www.livingneardams.org/brochure/#/1/.

If the responsible agency will not allow its map to be made public, talk to its staff. In some cases the agency is concerned about liability and the potential for the information to be misunderstood. There have been cases where an agency allowed a community map to go public, provided it had a different name, such as a "dam failure evacuation map." Such a name does not convey accuracy, as the map is an emergency management tool to facilitate evacuations, and the community accepts responsibility for informing the public how to use it.

STEP 3. EXPLAIN THE HAZARD

While a map may identify areas at risk, it does not convey consequences of a dam breach or overtopping. Residents, businesses and critical facilities in affected areas need to be told of the hazard and threat to life and property. This must be done carefully to avoid underestimating the threat or denial that there is a risk.

The Association of State Dam Safety Officials developed two guides for the public. Also, outreach and education efforts are explained in more detail in NAI How-to Guide for Education & Outreach.

STEP 4. MANAGE EXPOSURE TO THE HAZARD

Knowing about the residual risk downstream of a dam is good, but not the end product. Local governments need to do something to reduce that risk.

State agencies generally have jurisdiction over the construction and maintenance of a dam, so the community's effort should focus on properties affected by a breach. There are three main approaches a community can take to manage its exposure to the hazard:

Tool 4. Map Residual Risk, cont.

1. Manage the development in the hazard area using one or all of the following types of development regulations:
   a. Set standards for new construction, similar to floodplain management regulations. For example, buildings could be prohibited in areas mapped as very deep or fast moving during a dam failure.
   b. Zone the hazardous area for land uses appropriate for the hazard, such as agriculture.
   c. Require the developer to conduct or fund an analysis of the upstream dam and/or its spillway to identify potential problems if the development were approved (see box right).

2. Prepare and maintain a dam breach emergency response plan. The Community Rating System identifies four main components of a local dam failure emergency response plan:

VIRGINIA'S RULES FOR DEVELOPMENTS IN DAM BREAK INUNDATION ZONES

§ 10.1-606.3. Requirement for development in dam break inundation zones.

A. For any development proposed within the boundaries of a dam break inundation zone that has been mapped in accordance with § 10.1-606.2, the locality shall…

(i) review the dam break inundation zone map on file with the locality for the affected impounding structure,

(ii) notify the dam owner, and

(iii) within 10 days forward a request to the Department of Conservation and Recreation to make a determination of the potential impacts of the proposed development on the spillway design flood standards required of the dam. The department shall notify the dam owner and the locality of its determination within 45 days of the receipt of the request….

If the department determines that the plan of development would change the spillway design flood standards of the impounding structure, the locality shall not permit development as defined in § 15.2-2201 or redevelopment in the dam break inundation zone unless the developer or subdivider agrees to alter the plan of development so that it does not alter the spillway design flood standard required of the impounding structure or he contributes payment to the necessary upgrades to the affected impounding structure pursuant to § 15.2-2243.1. Excerpted from page 44 of "A Strategy to Reduce the Risks and Impacts of Dams on Floodplains."

Tool 4. Map Residual Risk, cont.

a. A threat recognition system that gives emergency managers early notice of a potential problem;
b. An emergency warning dissemination system to advise those at risk of the impending flood;
c. Specified response operations keyed to the threat, such as when to order an evacuation; and
d. Coordination with the critical facilities that will be affected.

More guidance on this dam failure emergency response planning can be found in Activity 630 (Dams) of the *CRS Coordinator's Manual*.

3. Inform people about the hazard and precautions they should take. Three approaches should be pursued:

a. Annual (or more frequent) notices to properties at risk about the hazard, how warnings will be issued and appropriate safety measures people should take;
b. Pre-scripted notices issued when the threat occurs; and
c. Disclosure of the potential hazard in plats, deeds and other media so people are advised before they purchase a property or move into the area.

NFIP/CRS Activity 630 (Dams) provides credit for local dam failure emergency response plans. As a condition of credit, communities must conduct one or more annual outreach projects to the properties that would be affected by a dam breach. Activity 330 (Outreach Projects) provides additional credit for public information activities before, during, and after an emergency.

All three regulatory approaches discussed above are credited under Activities 420 (Open Space Preservation) and 430 (Higher Regulatory Standards). Activity 340 (Hazard Disclosure) has credits for advising house hunters about the hazard and placing notices on plats and deeds.

WISCONSIN'S ZONING REQUIREMENT

Wisconsin has addressed the issue of hazard creep in its floodplain management regulations. Wisconsin NR 116 states, "Areas downstream of dams shall be zoned and regulated by municipalities with floodplain zoning ordinances in compliance with the standards in [this] section, to reduce potential loss of life and property located downstream of the dam."

Dams without downstream zoning in place are designated high-hazard-potential dams. This designation can result in additional costs for the dam owner since high-hazard-potential dams are required to have increased spillway capacity, according to page 32 from "A Strategy to Reduce the Risks and Impacts of Dams on Floodplains."

Tool 5.
Map for Future Risk

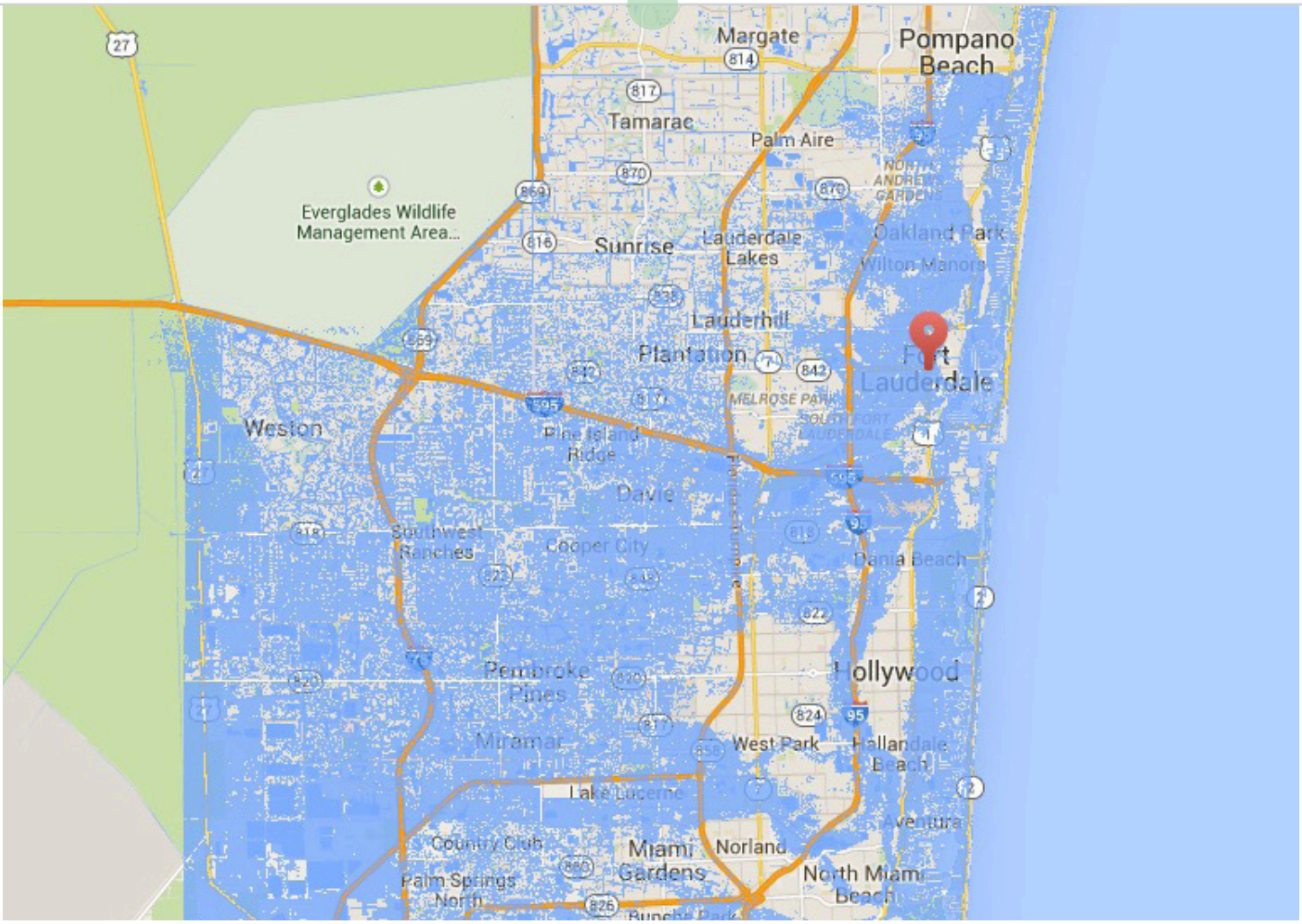


Image from Miami.curbed.com story (http://bit.ly/2naFrBS).

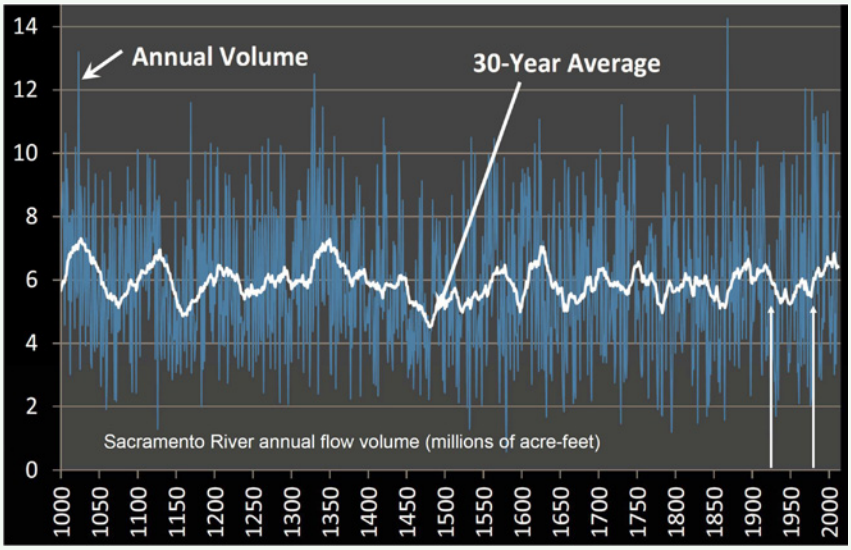
Future conditions are important to today's floodplain manager. A house built today should be protected from the flood hazard that may be expected over the next 100 years. We need maps and data that show what can be expected over that time.

There are five reasons why many current maps do not accurately show today's flood hazards, much less the future risk of increased flood heights and larger floodplains.

1. Most riverine floodplain maps are based on studies that use information on historic flooding. Streamgage records of past floods are extrapolated to determine the statistical likelihood of floods reaching certain levels in the future. A lot of engineering judgment is required to account for changes in the floodplain that may have occurred since the beginning of the gage records.

Tool 5. Map for Future Risk, cont.

2. There are few gages in the U.S. with records that go back to before the 1920s. In many areas, the period with records has been found to be a relatively dry time. An example of this is shown to the right. The data collected over the last 50-100 years used to extrapolate the likelihood of future flooding do not represent flooding conditions since a study was done or the conditions expected in the near future.



The white line in this graph shows the estimated 30-year-average annual flows on the Sacramento River since the year 1000. The variation over the years is due to historical climate change—each century has seen wet and dry cycles. The two arrows at the lower right show the period of record used for a flood insurance study, 1925-1980. It can be seen that the flood study was based on river flows during a dryer period. Many flood insurance studies are based on such data. New digital FIRMs often just transfer the floodplain delineation from older studies or are based on older studies' hydrology.

The hydrologic study on smaller streams assesses the amount of rainfall and snowmelt that will stay in the watershed and the rate at which the runoff will reach the stream. The NFIP mapping standard is to assess the conditions in the watershed at the time of the study. It doesn't take long for unregulated development to change those conditions, especially in a smaller watershed.

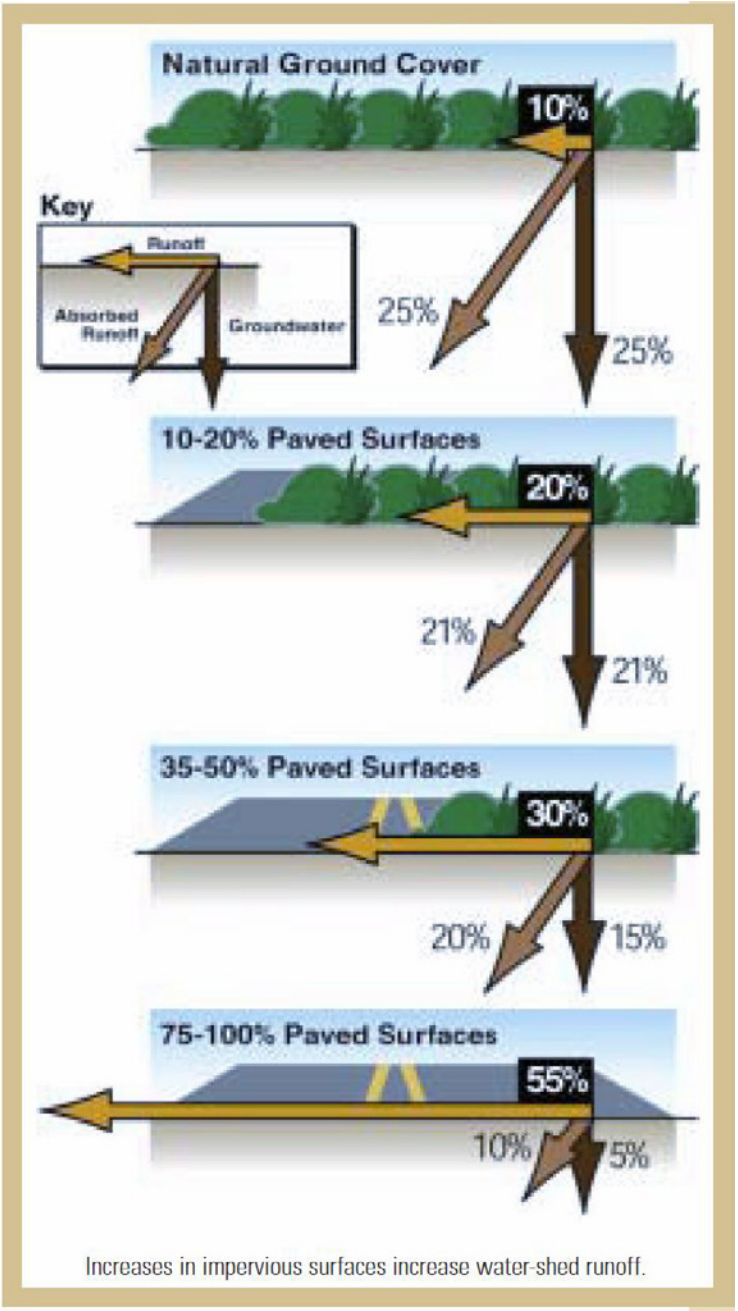
It may not take more than a few years for a rural watershed to become urbanized. When that happens, the water absorbing surfaces of farmland or pastures is replaced by the water repelling surfaces of roof tops, streets and parking lots. Urban development also brings storm drains and improved drainage that speeds the runoff to the receiving stream. The graphic on the next page illustrates what happens to the runoff when there is no stormwater management program that regulates watershed development.

3. Increased runoff means more frequent and higher floods. A flood study based on last year's watershed may be out of date today and will very likely understate the flood hazard 10 or 20 years from now. The increased flows also aggravate other flood-related hazards such as streambank erosion.
4. Floodplain contours are being changed by streambank and shoreline erosion. Properties on the outside edge of a river bend may be getting undercut by the stream channel. A building in the X Zone may fall into the river if the channel bank is eroded away. Properties along a coast not in a Coastal A Zone or V Zone may be subject to wave action after the beach or protective dunes wash away.

Tool 5. Map for Future Risk, cont.

5. One climate change impact is sea level rise. Warmer waters expand, resulting in higher ocean levels and larger coastal floodplains. Melting glaciers and polar ice have added to the ocean's volume. It is clear that a flood study based on past experience will not reflect expected future ocean levels. Similarly, with climate change comes more extreme rainfall events. Riverine studies based on rainfall history won't reflect the true hazard from more severe storms that will occur in the future.

One reason FIRMs and flood insurance studies do not account for future conditions is that FEMA's attorneys have advised the agency that insurance rates cannot be based on presumptions of what may happen. FIRMs must reflect what is known today. This legal interpretation does not prevent communities from mapping for future risk for its regulatory program.



Increases in impervious surfaces increase water-shed runoff.

Tool 5. Map for Future Risk, cont.

HOW TO MAP FOR FUTURE RISK

STEP 1.
REVIEW ALTERNATIVES

There are several ways to incorporate future risk into your mapping program. They are listed under this step, ranging from the less-effective to most-effective NAI approaches.

> Freeboard should be considered an interim step. It does not produce a better map. It simply provides a factor of safety to help account for shortcomings in your map.

1. Add Freeboard

Freeboard is a factor of safety required of new construction. It is usually 1, 2 or 3 feet added to the base flood elevation. It is explained in more detail in Section 6.C in the FEMA 480 Desk Reference.

Adding freeboard is a simple and straightforward amendment to your regulations. It's easy to understand that it provides extra protection from future increases in flood heights and there are no mapping revisions or expenses. A 1 foot freeboard is now a part of the International Building and Residential Codes, with more than 1 foot for many critical and essential facilities.

An added advantage is that buildings built 1 or more feet above the BFE on the FIRM receive significantly lower flood insurance premium rates. The reason for this discount is that such buildings are better protected from flood damage.

Freeboard has two shortcomings when used as a hedge to future flood risk:

- As a protection measure, freeboard is traditionally limited to the mapped floodplain. That means future buildings in the regulatory floodplain will be higher than the BFE. However, unless the community regulates areas outside the SFHA, no extra protection is provided to existing buildings or new construction outside the SFHA that will be affected by higher flood heights. One way to address this is to regulate all areas lower than the freeboard elevation, including those in adjacent X Zones.
- A small freeboard of 1 foot may not do much if future flood heights are expected to increase by 3 or 4 feet (as predicted in various sea level rise scenarios and as some communities have found when using a fully urbanized watershed mapping standard). See also the federal government's new approach to set protection levels in the box on the next page.

NFIP/CRS Freeboard is credited under Activity 430 (Higher Regulatory Standards). The higher the amount of freeboard, the greater the credit. 75 percent of all CRS communities are getting freeboard credit.

Tool 5. Map for Future Risk, cont.

2. Map the Regulatory Floodplain using a Higher Flood Elevation
This approach works like the freeboard approach and it addresses one of the shortcomings of freeboard. The GIS office can use the best available topographic base map to delineate the regulatory floodplain as 1, 2 or more feet higher than the BFE. The result will be a regulatory floodplain larger than the SFHA.

Like freeboard, this is easy to understand and administer. No new flood study or modeling is necessary. Like freeboard, buildings in the SFHA built to the new flood protection elevation will get significantly lower flood insurance premium rates as long as the BFE on the current FIRM does not increase.

Again like freeboard, this approach does not produce a more accurate map. It produces a larger regulatory floodplain to account for expected, but unstudied, future risk. It should be considered an interim measure until more accurate maps can be prepared.

THE FEDERAL FLOOD RISK MANAGEMENT STANDARD

As part of the implementation of the federal government's Climate Action Plan, President Barack Obama released Executive Order 13690, "Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input."

The EO establishes

> "The Federal Flood Risk Management Standard (Standard), a flexible framework to increase resilience against flooding and help preserve the natural values of floodplains. Incorporating this Standard will ensure that agencies expand management from the current base flood level to a higher vertical elevation and corresponding horizontal floodplain to address current and future flood risk and ensure that projects funded with taxpayer dollars last as long as intended."

Communities should have the same concern that development built to the standards of their regulations "last as long as intended."

In implementing the standard, federal agencies are given the flexibility to select one of three approaches for establishing the flood elevation and hazard area they use in siting, design and construction:

1. Using best-available, actionable hydrologic and hydraulic data and methods that integrate current and future changes in flooding based on climate science and that consider the criticality of the action (preferred option where data are available);
2. 2 or 3 feet of elevation, depending on the criticality of the action, above the 100-year, or 1 percent-annual-chance, flood elevation; or
3. 500-year, or 0.2 percent-annual-chance, flood elevation.

In effect, freeboard of 2 or 3 feet is one option for federal agencies to address future risk. It is not the only option, but it should be included in an overall program.

The standard is no longer mandatory, but is wise to protect people, property and taxpayer investments. Communities and states are urged to consider adopting these principles, which they can still do, even without the EO in place.

Tool 5. Map for Future Risk, cont.

Unlike freeboard, this approach will add protection to those properties outside the SFHA. However, their X Zone insurance premium rates will not be affected as they are not based on the elevation of the structure.

To prepare such a new map, the community must select how high to go. Here are some options:

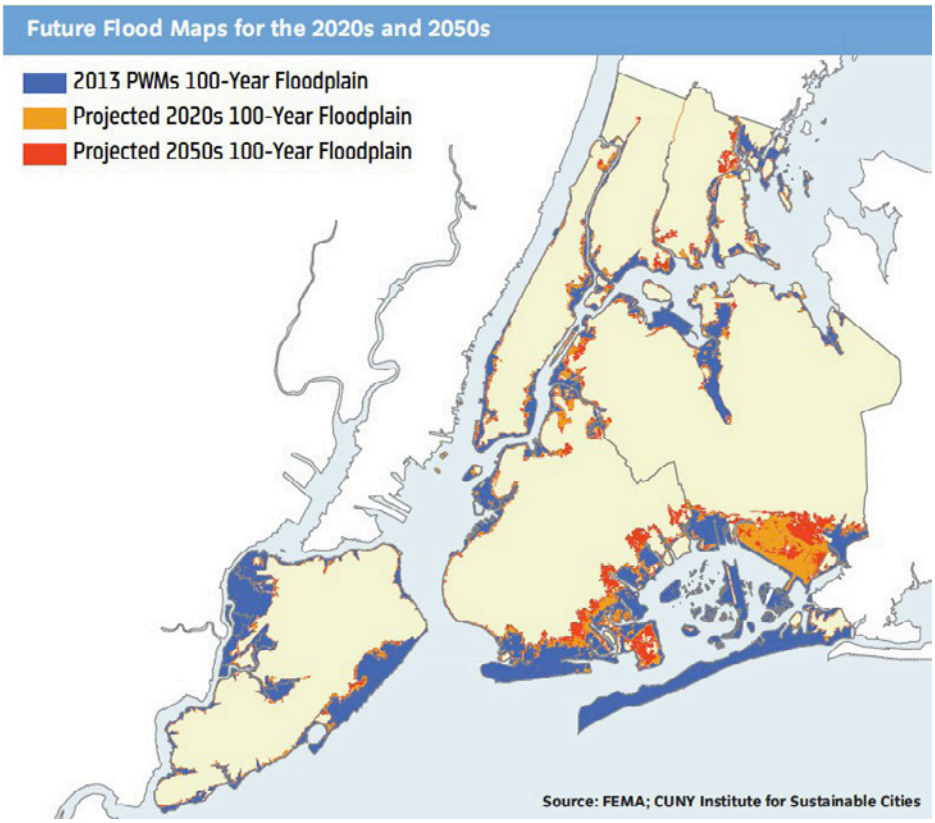
- Add 1, 2 or 3 feet to the BFE. This can be arbitrary and won't do much if future flood heights are expected to increase by a higher level. In addition to adopting a higher flood protection level, the area regulated should be expanded to include all land outside the SFHA that is below that higher level.
- Adopt the 500-year floodplain as the regulatory floodplain. This floodplain is already shown on FIRMs where there is an AE Zone, so no new mapping is needed.

  However, in some areas the 500-year floodplain may not be much higher than the BFE, so it may not provide much additional protection. Further, in coastal areas the published 500-year flood elevation is usually a stillwater elevation and may not reflect wave heights. As such, it may actually be lower than the 100-year BFEs shown on the FIRM. Use the flood of record where it was higher than the BFE. If you have good records, this can be quite manageable. It has the added advantage of being easier to convince people that the community should protect people and property from a real hazard that already happened.

- Identify key features and draw new regulatory floodplain boundaries to include them. Key features could include larger undeveloped areas adjacent to the SFHA, dunes that are sensitive or unstable, unstable bluffs, wetlands, endangered species habitats and areas subject to flood-related special hazards (see page 49).
- Coastal communities can use a tool like the Corps of Engineers' Sea Level Change Curve Calculator to determine local increases in sea level and extrapolate them to flood heights.

There are computer mapping programs and 3-D displays that can show the floodplain boundary using different scenarios so mappers and decision makers can see the impacts of proposed changes. Most of the U.S. coast is covered by sea level rise models. These aids are discussed on pages 64 and 65 and in Tool 4 of the NAI How-To Guide for Education & Outreach.

Tool 5. Map for Future Risk, cont.



3. Regulate Watershed Development

Development in the upstream watershed contributes to increased runoff and flooding. Such development can be managed to prevent or minimize the increases. Stormwater management or watershed protection regulations do this by requiring on-site detention or retention of the increased runoff caused by the development.

Some regulations set higher standards and require low impact development and other techniques that have other benefits, such as protecting natural areas and recharging aquifers.

The more effective regulations require mapping based on planned future watershed conditions.

This is better than the freeboard alternative discussed earlier in that it protects new and existing development from potential increases in flood hazards while freeboard only benefits new buildings. Note that while vital to preventing increased flooding from watershed development, this approach may not be relevant for areas subject to coastal flooding and it does not address increased flood risks due to climate change.

Activity 450 (Stormwater Management) credits basic stormwater management regulations (SMR). More than 50 percent of CRS communities are getting SMR credit. Activity 450 provides more credit for using low impact development techniques (LID) and basing the regulations on a watershed master plan (WMP).

4. Use a Floodplain Model that Reflects Future Risk

This is the best NAI approach: incorporate what is known about future risk and add a factor of safety to the engineering model used in your current flood study or do a whole new study with such a model. The future risk data should account for watershed development and climate change that will result in increased rainfall and sea level rise.

Tool 5. Map for Future Risk, cont.

Here are some ways to do this:

- Update the hydrology. If your FIRM is based on a study conducted 20 or more years ago, just updating the hydrologic model with more gage records will result in a more accurate BFE and regulatory floodplain. It may not reflect future conditions, but it will provide an improved level of protection and it avoids debates over climate change and predicting the future.
- Run a watershed runoff model based on local land use plans for future development in the watershed. This approach is used by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) (see p. 86) and the Denver, Colorado Urban Drainage and Flood Control District (see p. 99).
- Run a watershed runoff model assuming a fully-built out watershed. This is what Mecklenburg County's Storm Water Services did (right).
- Use a higher base flood discharge. For example, regulatory studies in New Jersey use 125 percent of the base flood discharge to account for unknowns such as debris that obstructs flow. This approach is like using a standard freeboard in that it may

MECKLENBURG COUNTY, NORTH CAROLINA MAPS FOR FUTURE CONDITIONS

Beginning in 1999 Mecklenburg County, North Carolina began conducting flood studies based on "fully developed watersheds" using adopted land use plans of communities within the county as a guide. ASFPM's 2004 report on NAI Floodplain Management Case Studies noted:

> "Charlotte-Mecklenburg Storm Water Services researched and quantified the effects that future development in the floodplain and watershed would have on flood heights, the impacts that would result from different allowable rises in the floodway, and the benefits of water quality buffers along streams. The agency concluded that the expense of mapping and regulating hazard areas based on ultimate development conditions in the watershed, and requiring water quality buffers along streams, would be offset by the future damage and disaster costs that would be prevented by such an approach. This research made it possible for the future-conditions and accompanying regulatory data to be incorporated up front, as all the floodplains of the county were being remapped."

The county developed two floodways to minimize the negative impacts of future floodplain development. The community accepted a 0.5 foot FEMA floodway and its own 0.1 foot community floodway. Floodways are developed through an iterative modeling process that accounts for lost storage from potential filling of the floodplain fringe.

Since 2004 Storm Water Services has updated and revised the floodplain maps for all eight communities. The results have been gratifying. Even though the communities adopted much more detailed land use plans for future development, the updated flood studies resulted in flood elevations and floodplain limits very similar to the studies completed 15 years earlier.

The result is that all development in or near the mapped floodplain over the course of the last 15 years is still at or above the BFE.

There have been a handful of cases where new flood profiles are slightly higher than the earlier studies, and the regulatory floodplain limits slightly wider. However, the higher flood levels are due to improved topographic data or better analytical tools, not because of watershed development. The entire county has been remapped and areas where revised maps have shown a higher flood level comprise less than 15 percent of the total stream miles.

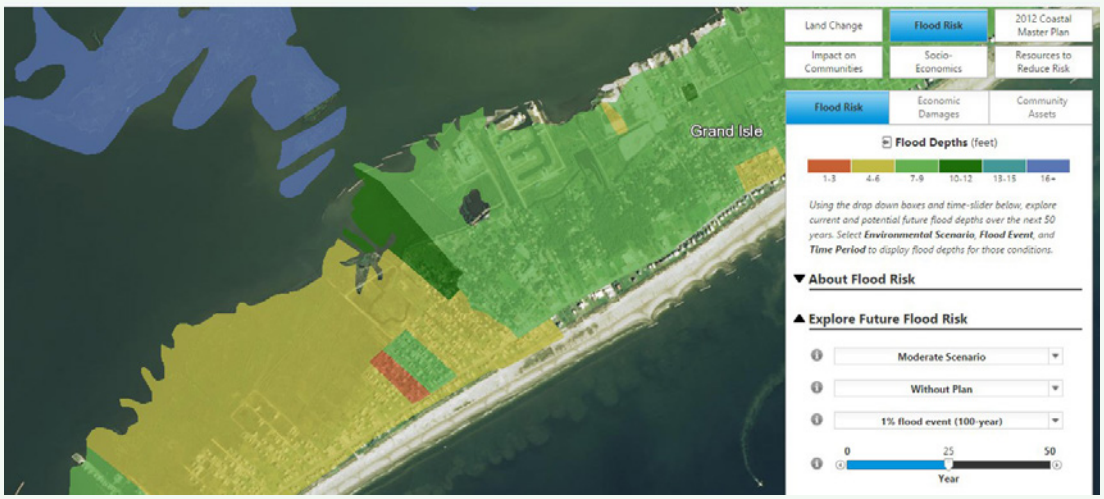
Tool 5. Map for Future Risk, cont.

not be high enough to address expected future flood increases.

- Use a higher flood discharge based on a study of climate change impacts in the area, if there is one.
- For coastal areas, use one of the sea level rise models, preferably the one with the greatest increase in flood levels, just to be safer.
- Use a greater confidence level in the hydrologic analysis. A standard flood insurance study uses a confidence level of 50 percent, meaning half the time the base flood discharge is higher than the model's product. A standard study to set flood elevations for a flood control project uses a confidence level higher than 50 percent because lives are at stake. Your model could use 90 percent, 95 percent, or a higher level. The result will be a higher discharge, higher BFE and higher level of confidence that the regulatory elevation reflects the true 1 percent-chance flood.
- Base the flood elevation and mapping on the energy grade line. The water surface of a riverine floodplain is higher at the edge of the floodplain than at the center of the channel or thalweg (the deepest part of river). This is because water moves faster at the deeper channel and slower at the shallow edge. For a river flowing at 10 feet per second, the water surface at the edge of the floodplain can be 1.5 feet higher than the BFE at the thalweg. The faster the velocity, the greater the difference in water surface elevation.
- Most hydraulic models calculate the water surface at the thalweg, where the velocity is the greatest. This understates the BFE at the edge of the floodplain. The energy grade line is the elevation of the water surface where the velocity is zero, i.e., at the outermost edge of the floodplain. Using the energy grade line for the BFE is more accurate and results in a higher protection level.

In all cases, it should be remembered that no model is a perfect predictor of a future flood and there are many unknowns seldom taken into account, such as the potential for ice or debris to obstruct flood flows at bridges or a coastal storm occurring during a "king tide." Therefore, the community's program should recognize the need for a safety factor and include freeboard on top of the new regulatory flood elevation.

continued on page 87



This is the Louisiana Flood Risk and Resilience Viewer, prepared by the Louisiana Coastal Protection and Restoration Authority. It displays information on coastal land change, flood risk and impacts to communities for today, 25 years from now and 50 years from today.

Tool 5. Map for Future Risk, cont.

SEWRPC DES PLAINES RIVER BASIN STUDY

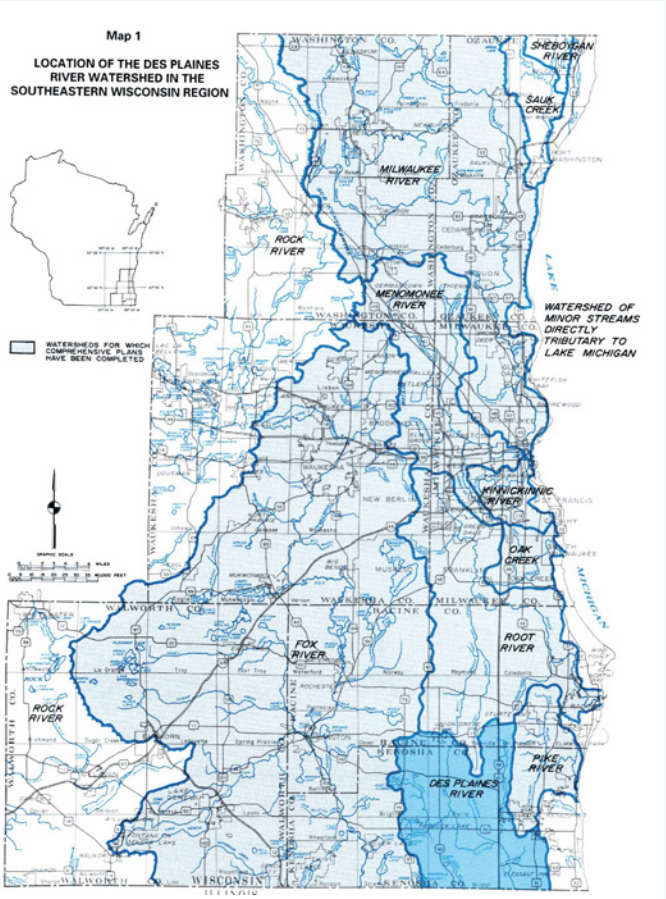
The Southeastern Wisconsin Regional Planning Commission serves seven counties and 148 cities, villages and towns in the metropolitan Milwaukee area. Since the early 1960s, it has been conducting watershed planning studies that look at water quality, flooding, natural floodplain functions, erosion, land use and stormwater management.

In addition to producing detailed plans for mitigating flooding of existing "at risk" development, the planning studies produce new flood data and maps. The data are based on the "planned development" within the region. "Planned development" means the hydrologic analysis calculates the potential change in runoff associated with land use changes under planned conditions. The floodplain maps are provided to FEMA for use in updating FIRMs.

The studies generally address existing and future hydrologic conditions. Any reductions in discharge or regulatory flood elevation that would result from recommended flood mitigation or storm water management techniques are not reflected in the regulatory maps until those techniques have been fully implemented.

The Des Plaines River Study is typical of watershed planning studies conducted by SEWRPC. It includes in-depth descriptions and analyses of the entire watershed.

The recommended plan, if fully implemented, would result in improved water quality and reduction in flooding. The Des Plaines River flows from Wisconsin into Illinois. In addition to generally reducing flows under recommended plan conditions along the river and its tributaries in Wisconsin, an NAI plan objective was achieved: causing no increase in flood flows at the Wisconsin-Illinois state line. The 100-year discharge would be reduced 3-14 percent on the main stem of the Des Plaines River and nearly 80 percent on some tributaries. These significant reductions in discharge would reduce flood losses not only for major events, but for more frequent minor events too.



Map of SEWRPC's seven-county region showing completed watershed plans (as of 2003).

Tool 5. Map for Future Risk, cont.

STEP 2.
BUILD THE CASE

You may find less than full support to pay for the cost of remapping your community's floodplains to reflect future conditions. Some decision makers will not like the idea of increased construction costs that result. Some may not agree with the concept of climate change. You will likely need to do some convincing. The discussion above provides a general rationale for mapping future risk, but here are some local approaches to try:

- Tally recent flood damage in your community. FEMA may be able to help with data on disaster assistance and flood insurance claim payments. Include local government expenses for flood fighting, rescue, clean up and recovery. Add cost of repairs to local streets and bridges. Include economic cost to local businesses and count how many small businesses closed because of flooding. Section One of this *Guide* shows how the flood costs can be summarized for the nation and it may give you some more ideas.
- Summarize safety and health risks from recent floods. Were there any deaths or near misses? Did people have safe drinking water? Did mold and mildew problems develop? What about the stress put on those who were flooded and then had to wait for a year or more for mitigation funds?
- Work with other offices that have similar concerns about the cost of future flooding on their operations or are concerned about climate change for other reasons. Review Tool 1 in the NAI How-to Guide for Planning on working with others, lining up allies and taking advantage of opportunities as techniques to bring about change in your community.
- In some areas, such as low lying coastal areas, people are already experiencing sea level rise effects. They may have noticed streets are closed more often during high tides, for example. You might start with those who have been impacted as they may be more willing to agree and act.
- Use models that show alternative watershed development scenarios. The NAI How-to Guide for Planning describes how Mecklenburg County's Storm Water Services used a flood model to convince builders that flood protection standards should be based on "build-out land use conditions." The model showed an increase of up to 4 feet at some locations, but by building the case using technical information, the development community agreed.
- Be visual. Maps that show floodprone areas under different scenarios can help. Tool 4 in the NAI How-to Guide for Education & Outreach describes some online map programs that show the areas affected by different riverine and sea level flood heights.
- Use 3-D displays and computer mapping programs to show what happens when human development changes watershed and floodplain conditions (see pp. 64-65).
- Sometimes, public support is needed in addition to agreement by your department heads and elected officials. Tool 5 in the NAI How-to Guide for Planning and ASFPM's Building *Public Support for Floodplain Management* have suggestions for educating the public.

The end result is consensus that your community's floodplain maps should be revised or that a new standard is needed for the next round of mapping.

Tool 5. Map for Future Risk, cont.

STEP 3.
USE INEXPENSIVE MAPPING OR REGULATORY MEASURES, WHERE APPROPRIATE

Your ultimate goal should be to prepare a new flood model or use an existing model that accounts for future flood risk. If that will take some time, you can still do some things in the interim that don't cost your community's treasury a lot of money. If you are in the CRS, you can promote these measures as a way toward a class improvement.

- Adopt a freeboard of 3 feet or more (credited under Activity 430 (Higher Regulatory Standards), freeboard (FRB)).
- Adopt stormwater management regulations that require peak runoff and volume from new development to be no greater than runoff from the site in its pre-development condition (credited under Activity 450 (Stormwater Management), stormwater management regulations (SMR)).
- Adopt the 500-year floodplain, adopt an area flooded in the past, and/or add 1 or more feet to the BFE to map a larger regulatory floodplain (credited under Activity 410 (Floodplain Mapping), new study (NS)).
- Conduct a watershed study on one sub watershed at a time over several years (credited under Activity 450 (Stormwater Management), watershed master plan (WMP)). Mecklenburg County, North Carolina did this (see p. 84).

STEP 4.
USE THE NEW MAPS

By themselves new maps do not protect your community from future flood risk. They are not the end product. There are many sea level rise reports and plans, but there are very few local land use regulations based on sea level rise.

You need to adopt the maps and data in your floodplain management regulations, stormwater management regulations, capital improvements design and planning programs. Don't forget you still need freeboard, setbacks and other safety factors.

SECTION FOUR

Case Studies

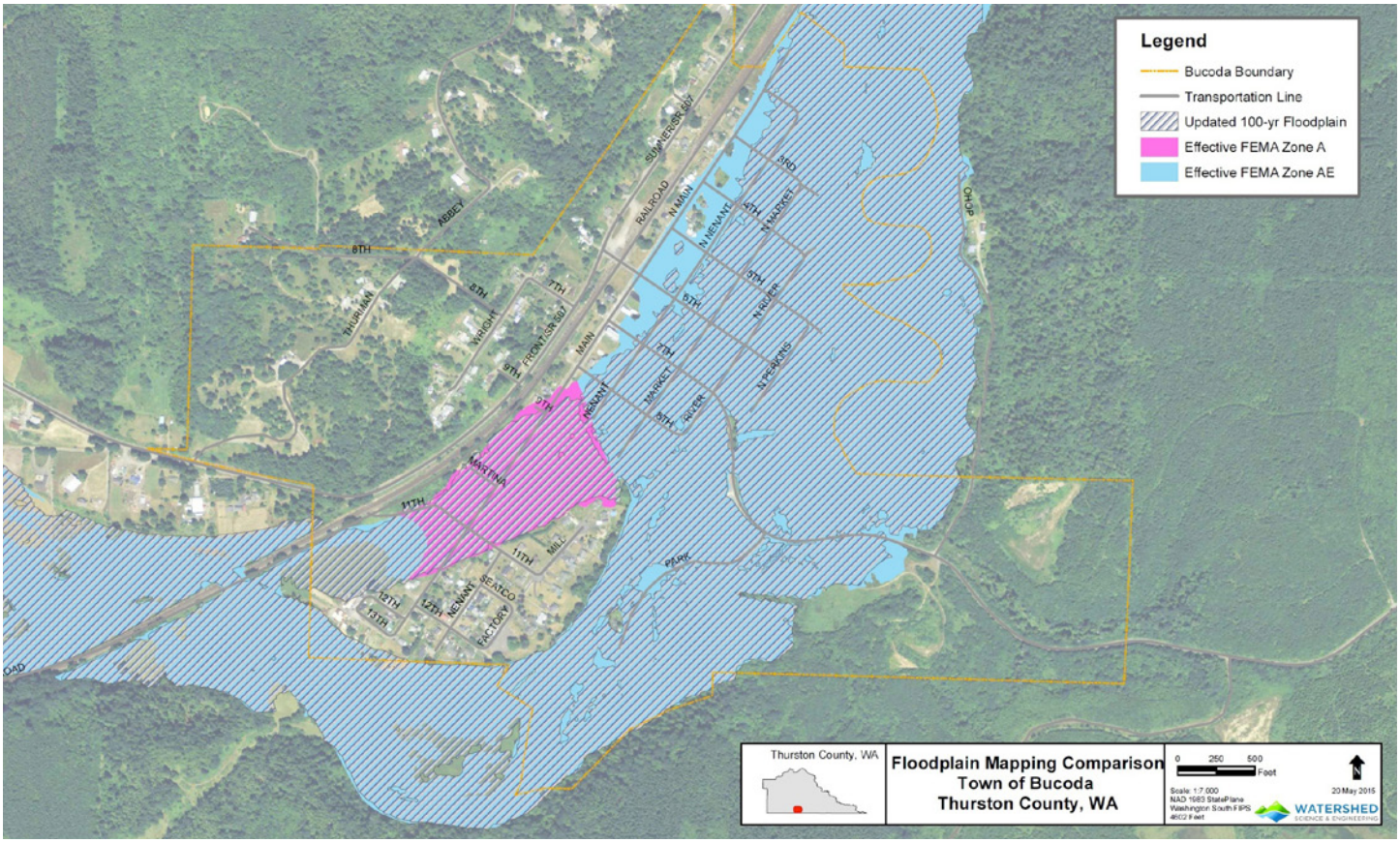
Bucoda, Washington

A Small Town Completes its Map

Bucoda (population 565) is located in Thurston County south of Olympia. More than 50 percent of the town's land area and 76 percent of its population are in the Special Flood Hazard Area.

It received its first Flood Insurance Study and Flood Insurance Rate Map in 1981. They were based on a 1979 study of the Skookumchuck River by the USGS. Most of the river was mapped in detail as an AE Zone with a floodway. However, in one area the SFHA is separated from the main channel by an "island" of high ground. Flood studies done in the 1970s seldom, if ever, identified multiple flow paths, primarily because the early version of the most frequently used model—HEC 2—was not able to handle complex flow patterns. As a result, some of the Skookumchuck's SFHA was designated approximate A Zone, with no floodway or BFEs.

Bucoda, Washington, cont.



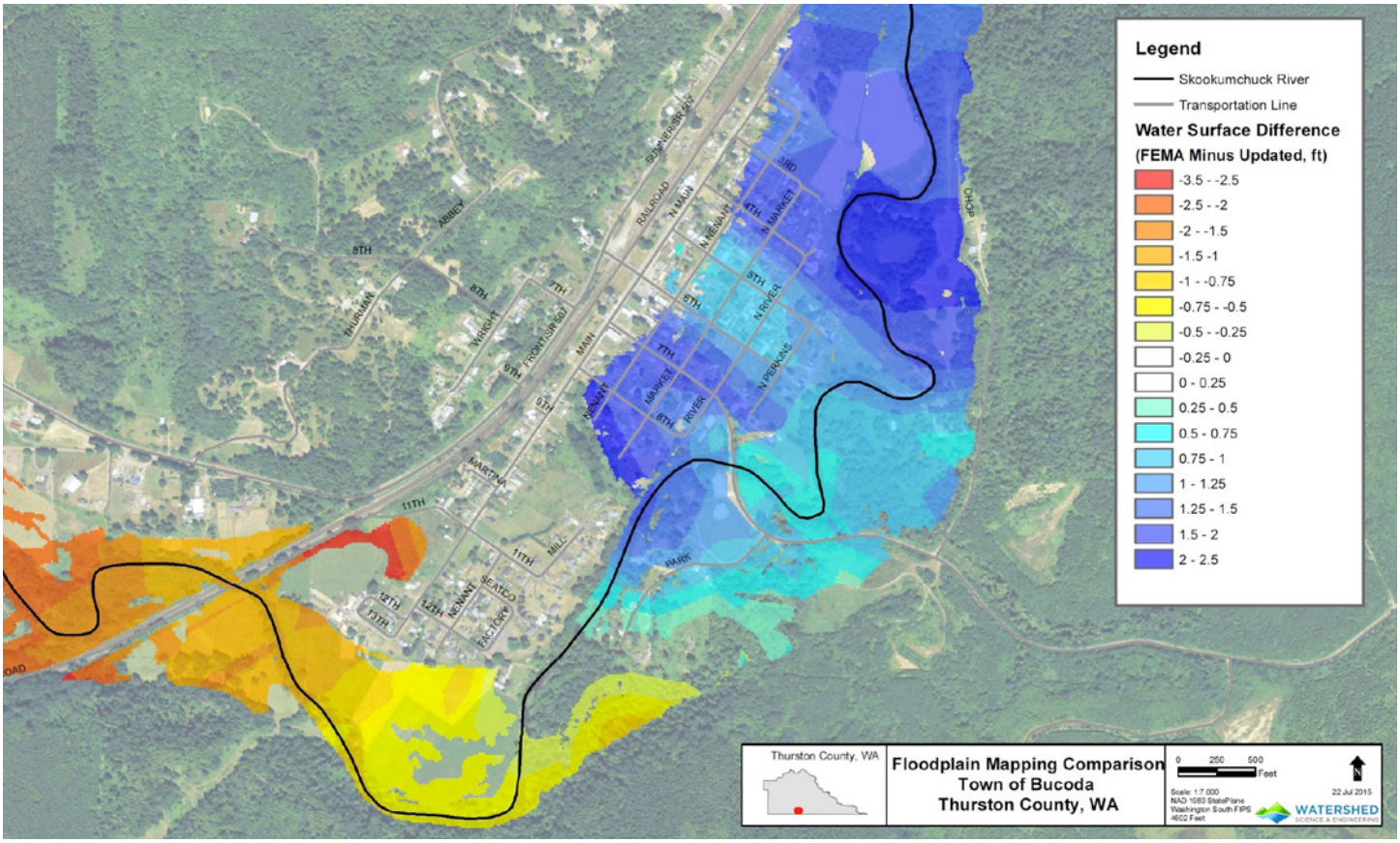
Bucoda's new study provided a BFE for the by-pass (in red). By incorporating all the flows around the island, the new model lowered the BFE and shrank the floodplain upstream of the by-pass. The FIRM's higher BFEs and larger SFHA boundary stay in effect though.

In 2012 FEMA replaced the 1981 map with a countywide Digital Flood Insurance Rate Map that did not include any new hydrologic or hydraulic analysis of the Skookumchuck. Bucoda realized that its FIRM had a gap. What was called the Bucoda By-pass Channel did not have adequate data for an effective floodplain management program. However, there were no readily available solutions other than asking FEMA for a new map.

Bucoda flooded in 1990, 1996, 2007 and 2009. After the 1996 flood, several homes were elevated above the 1996 flood of record. After the 2007 flood, the state, three counties and nine municipalities formed the Chehalis River Basin Flood Authority, responsible for developing flood hazard mitigation measures throughout the basin (see map).

As part of its effort to explore alternative flood reduction measures, the flood authority contracted with an engineering company to develop a flood model of the Chehalis River and its major tributaries. The primary purpose of the model was to review the impacts of different flood control projects.

Bucoda, Washington, cont.



By incorporating more effective flow areas in the model, the new study showed lower BFEs upstream of the island (in blue) and higher BFEs downstream (in yellow and orange). However, higher regulatory flood elevation impacts relatively few people because most of the downstream area is undeveloped.

As Biggert-Waters 2012 brought increases in flood insurance rates, residents of this area asked for help. Town officials were advised the lack of a BFE prevented A Zone buildings, including those elevated after the 1996 flood, from getting lower actuarial rates that would reflect their level of protection. The flood authority was asked if it could help and hired Watershed Science and Engineering to develop and apply a flood model for the flood authority. WSE incorporated new cross-sections that enabled modeling of the split flow through the Bucoda by-pass channel. WSE also used records of the 2009 flood high water marks and used them to calibrate the hydraulic model.

While the 1979 study ignored the by-pass, the new model was able to incorporate its flow area into the study. With a model that showed more capacity to carry flood flows, the 100-year flood elevation dropped by as much as 2.5 feet upstream of the by-pass and increased more than 3 feet downstream. These changes are shown in the map above. The upstream 100-year

Bucoda, Washington, cont.

flood elevation is lower, even though the revised discharge used for the 100-year flood was 40 percent higher than the Q100 in the city's FIS (see table).

Event	Peak Flow ("Q")
1981 FIS 100-year event	9,060 CFS
1996 Flood*	11,300 CFS
2009 Flood*	10,500 CFS
Updated 100-year event	12,600 CFS

* Observed flow at USGS gage just downstream of Bucoda, WA.

Everyone was a winner:

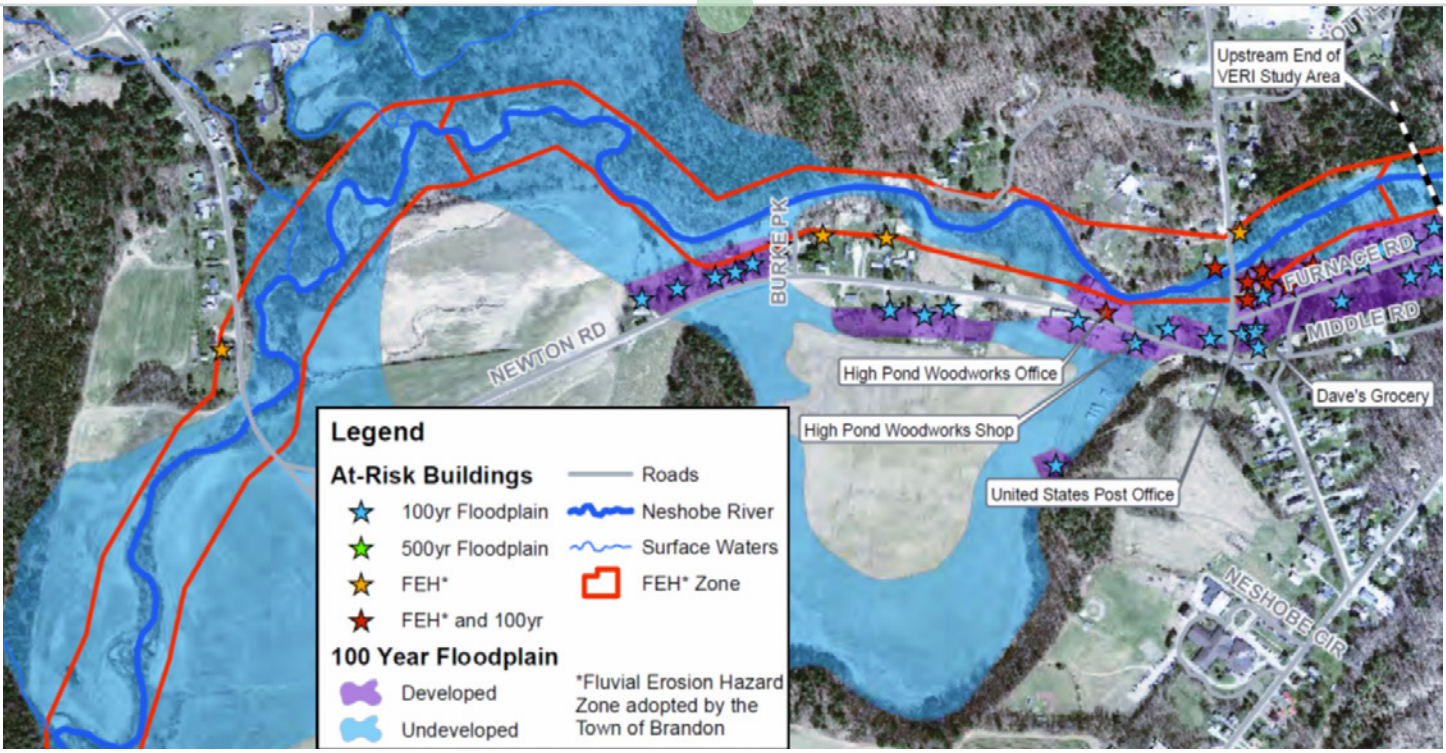
- The town has the data needed to manage development.
- Residents in the by-pass area have the data needed to show their homes to be above the "community determined" BFE in an approximate A Zone.
- By building on an existing newer study for the area, the cost was minimized. The engineer was very familiar with the study and area.
- Upstream of the by-pass, the FIRM's BFEs are higher than the study's, so they stay in effect until the map is revised. If the FIRM is not revised, new construction will be required to be protected higher in relation to the FIRM's BFE, and flood insurance rates for new construction will be lower.
- While properties downstream of the by-pass have a higher BFE, the area is mostly undeveloped.
- There were no objections at a public meeting held to discuss adoption of the new map.

NFIP/CRS

Bucoda is considering applying to join the CRS. If it joins, it will receive credit under Activity 410 (Floodplain Mapping), even though the flood authority paid for the study and map.

Brandon, Vermont

River Corridor Mapping



The fluvial erosion hazard (FEH) area and the FIRM's SFHA are treated together on the town's maps.

River channels naturally erode and move over time. However, they move "in such a manner that they generally maintain their dimension (width and depth), pattern (meander length), and profile (slope) without aggrading (building up) or degrading (scouring down)…" ["Defining River Corridors Fact Sheet," p. 1.] Vermont has a program that recognizes this and works to "manage the meander," which is especially important where the channel changes are due to human development.

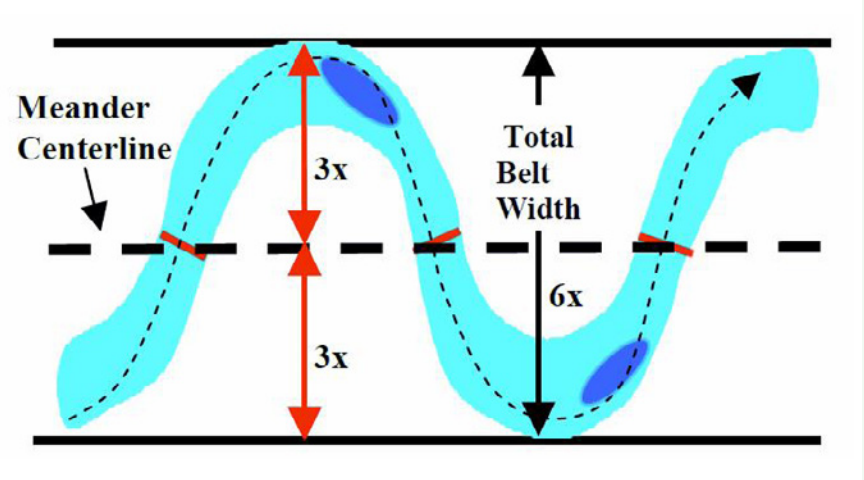
The maps: The state's Department of Environmental Conservation maps "river corridors" that are intended to include the expected limits of channel migration. In order to efficiently map the entire state's hazard, a formula was developed based on research findings. The mapping technique is relatively simple and has additional criteria to better fit local conditions.

DEC prepares river corridor maps and makes then available to municipalities. While FEMA has mapped only 20 percent of the total stream miles in Vermont, DEC has prepared river corridor maps for every stream in the state with a drainage area of 2 square miles or greater.

River corridor maps start with a formula that sets the outside parameters. The mapper then reviews local topography and adjusts the line based on additional criteria listed on the next page.

Brandon, Vermont, cont.

Mapping technique: The width of the river corridor is based on research that concluded the natural sinuosity, or width of the meander belt, can be calculated by the following formula: B=3.7W1.12 where B=meander belt width and W=channel width. A simpler graphic explanation is to the right.



Idealized representation of how a river corridor is mapped: A meander centerline is drawn down the valley and corridor limits are measured out as parallel lines "3 x channel width." Image from pg. 3 in "Defining River Corridors Fact Sheet."

Additional criteria: The following additional guidelines make the formula map more appropriate locally:

- The formula assumes the stream is not confined by roads, levees or other impediments to erosion.
- One exception to the above: a public highway funded by state or federal funds and is certain to be protected or replaced. The river corridor stops there, but can be extended to the opposite side of the river to the full meander belt width.
- The river corridor boundary is limited by known natural impediments to river erosion such as a rock outcropping that is resistant to erosion. This is illusrated in the graphic on the next page.
- For rivers with slopes of 2 percent or less, the formula results in the meander belt being approximately equal to six times the channel width.
- For rivers with slopes greater than 2 percent, the river corridor is four times the channel width plus 50 feet on each side.
- For drainage areas of 2 square miles or less, the river corridor is the width of the channel plus 50 feet on each side

The regulations: Communities are encouraged to use maps for planning and regulatory programs. The regulatory standards encouraged by DEC are straight forward:

Within a river corridor:

- Where there is no development currently, no new development is allowed.
- Where there already is development, no new development is allowed closer to the river.

The state administers these rules for state projects because the municipalities do not have legal authority to enforce land use regulations on state agencies.

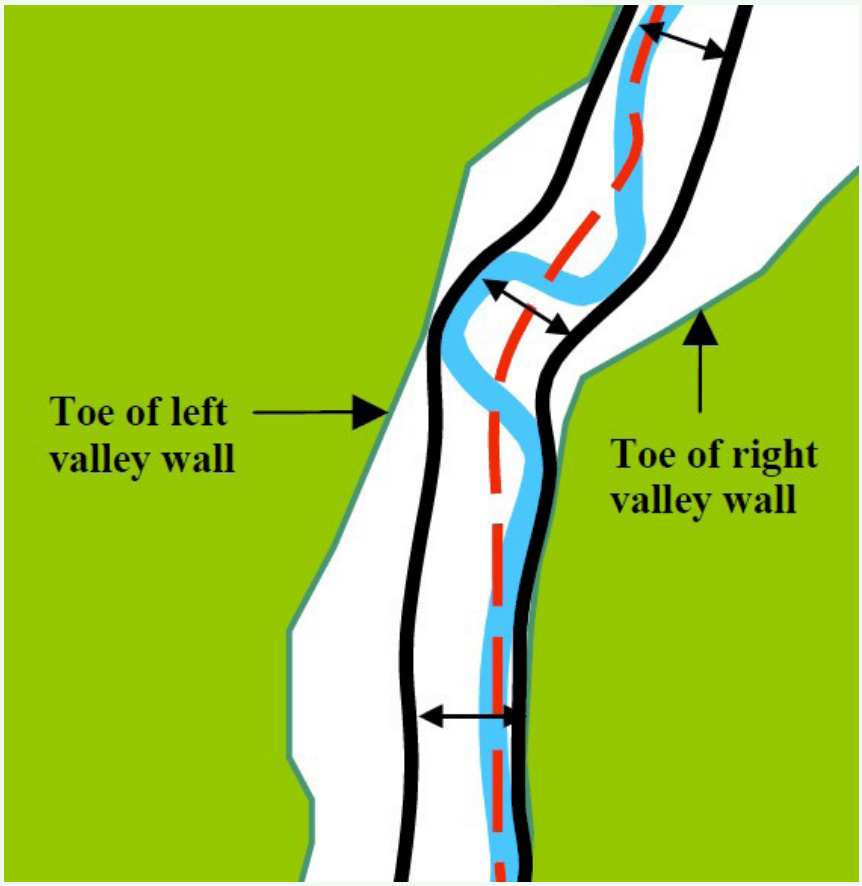
Municipalities are not required to use the maps, but if they do (and then join CRS), they will be eligible for a lower cost-share toward FEMA disaster assistance. Normally, the 25 percent non-FEMA cost-share for public assistance is split 50-50 between the state and benefitting

Brandon, Vermont, cont.

community (12.5 percent paid by each). Communities that adopt river corridor maps for land use regulation will only have to pay 7.5 percent and the state will pay 17.5 percent toward FEMA public assistance grants after a disaster.

Brandon's regulations: Brandon took a look at all of its river related policies after extensive damage from Tropical Storm Irene in 2011. It prepared a comprehensive program that included construction of high flow bypasses, relocation of damaged houses, conversion of a farm field to a river corridor easement, wet floodproofing town offices and adopting the river corridor map. Watch this video about Brandon's story.

The town's flood hazard regulations adopted the river corridor map, which shows the fluvial erosion hazard (FEH) area. Ordinance excerpts are on pages 97-98. The FEH and SFHA are treated together. The ordinance pretty clearly states that both areas are not for development, certainly not for new buildings.



The corridor limits set by the formula are adjusted for physical conditions in the valley. Image from pg. 3 in "Defining River Corridors Fact Sheet."

NFIP/CRS

Brandon is not in the CRS. If it did join, it would receive credit for the river corridor map under Activity 410 (Floodplain Mapping), even though the state paid for the mapping. It would also receive significant credit for the regulations that it enforces throughout its SFHA under Activities 420 (Open Space Preservation) and 430 (Higher Regulatory Standards).

EXCERPTS FROM BRANDON'S FLOOD HAZARD REGULATIONS

The following language is from Article VIII (Flood Hazard Regulations in the Brandon, VT Land Use Ordinance). Key requirements are italicized.

Section 803. Lands to Which These Flood Hazard Regulations Apply

A. Regulated Flood Hazard Areas

The flood hazard regulations shall apply to the Fluvial Erosion Hazard Areas and Special Flood Hazard Areas (hereafter called "hazard areas") in the Town of Brandon, Vermont as described below. These hazard areas overlay any other existing zoning districts and the flood hazard regulations herein are the minimum standards that must be met before meeting the additional standards applicable in the underlying district. These hazard areas include:

1. The Fluvial Erosion Hazard Zone as determined on the most current Fluvial Erosion Hazard Zone Map published by the Vermont Agency of Natural Resources which are hereby adopted by reference and declared to be part of the flood hazard regulations, and
2. The Special Flood Hazard Area in and on the most current flood insurance studies and maps published by the Department of Homeland Security, Federal Emergency Management Agency…

Section 804. Summary Table: Development Review in Hazard Areas

The hazard areas are not appropriate sites for new structures or for development that increases the elevation of the base flood or obstructs the ability of streams to establish and maintain geomorphic equilibrium.

…

#	Activity	Hazard Zone		
	P Permitted **C** Conditional Use Review **X** Prohibited **A** Exempted	**Special Flood Hazard Area**	**Floodway**	**FEH Zone**
1	New Structures	X	X	X
2	Storage	X	X	X
3	Improvements to Existing Structures	P, C	C	C
4	Small Accessory Structures	P	X	C
5	At Grade Parking	P	C	C
6	Replacement water supply or septic systems	C	C	C
8	Fill as needed to elevate existing structures	C	C	C
9	Fill	X	X	X
12	Grading	C	C	C
13	Road maintenance	A	A	A
14	Road improvements	C	C	C
15	Bridges and culverts	C	C	C
16	Channel management	C	C	C
17	Recreational vehicles	P	P	P
18	Open space, recreation	A	A	A
19	Forestry	A	A	A
20	Agriculture	A	A	A

EXCERPTS FROM BRANDON'S FLOOD HAZARD REGULATIONS, CONTINUED

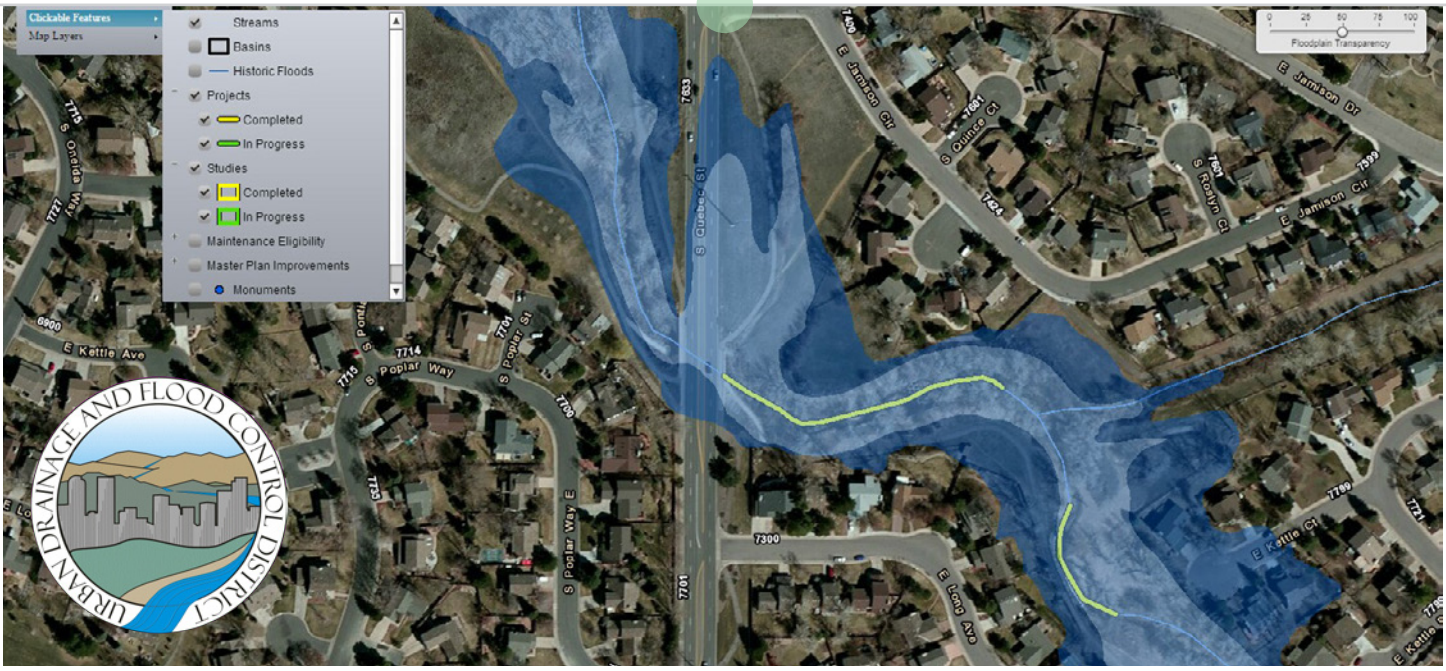
Section 806. Development Standards

The criteria below are the minimum standards for development in the hazard areas. Where more than one zone or area is involved, the most restrictive standard shall take precedence…

C. Fluvial Erosion Hazard Zone;

1. Improvements to existing structures, and any associated fill as needed to comply with elevation requirements in the Special Flood Hazard Area shall not decrease the distance between the existing primary building and the top of bank;
2. Accessory structures may be located within 50 feet of the existing primary building provided that the location does not decrease the distance between the existing primary structure and the top of bank;
3. Development shall not increase the susceptibility of that or other properties to fluvial erosion damage;
4. Development shall not increase the potential of materials being swept onto other lands or into the stream and causing damage to other properties from fluvial erosion;
5. Development shall not cause an undue burden on public services and facilities including roads, bridges, culverts and emergency service providers during and after fluvial erosion events;
6. Bridge and culvert projects must have a Stream Alteration Permit; and
7. Channel management activities must be authorized by the Agency of Natural Resources.

Denver (Colorado) Urban Drainage and Flood Control District



The Denver Urban Drainage and Flood Control District was created in 1969. It serves 2.8 million people in seven counties and 32 municipalities. The district covers more than 1,600 square miles and includes 3,500 miles of streams. A key part of the district's early work was concluding that its programs had to be remedial and preventive.

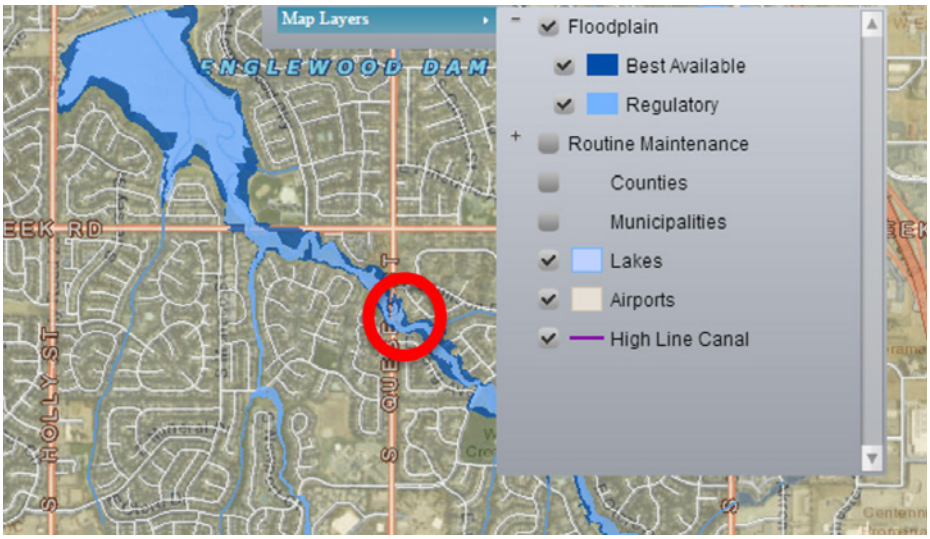
To determine what projects should be initiated, the district conducts watershed plans, known as Major Drainageway Plans and Outfall Systems Plans. The local governments request the plans for their problem areas, pay part of the cost and have a say in selecting the consultant. In short, they are part of the planning process and have reasons to see the plans completed.

The watershed plans look at current and likely future conditions and evaluate different approaches to reduce and prevent flood losses. One by-product of the plans is more detailed floodplain mapping data for current and future conditions. The district uses these data for Flood Hazard Area Delineation (FHAD) studies. These are funded fully by the district, which publishes them independently from the plans.

FHADs are more than just new studies in approximate A Zones. They fill gaps where there are inadequate data (in A and X Zones), and provide higher standards data in three ways:

1. FHADs are based on 2-foot contour equivalent LiDAR or even finer mapping, where available, for the topographic base map, which is more accurate topography than used for many older FIRMs.
2. Where there are local land use plans, the FHAD hydrology is based on runoff conditions based on planned future land use. These are generally 20-30 years in the future from the date of the plan.

Denver, Colorado, cont.



Where the future conditions base flood discharge (Q_{100}) is less than 30 percent of the current conditions Q_{100}, FEMA agreed to incorporate the FHAD into a FIRM revision. Where the future conditions Q_{100} is greater than 30 percent of the current conditions Q_{100}, the district prepares two maps, one for the FIRM revision based on current conditions, and one based on future conditions for the community to use for floodplain management.

3. Some FHADs used a 0.5-foot-rise floodway mapping standard criterion before it became a state requirement in 2012. Since 2012 all of them use this lower encroachment threshold.

All three of these higher standards can receive credit under Activity 410 (Floodplain Mapping), including having future conditions mapping incorporated into the FIRM.

Even if the plans do not recommend a project, there will still be a FHAD. However, the utility of FHADs is dependent on adoption of them by the local governments. In Colorado, local regulatory maps must be so designated by the Colorado Water Conservation Board. The district's approach to involve local governments in watershed planning is very helpful in getting them to adopt the floodplain maps that come from that planning. Many communities automatically adopt new FHADs in their regulations once they have been designated by water conservation board.

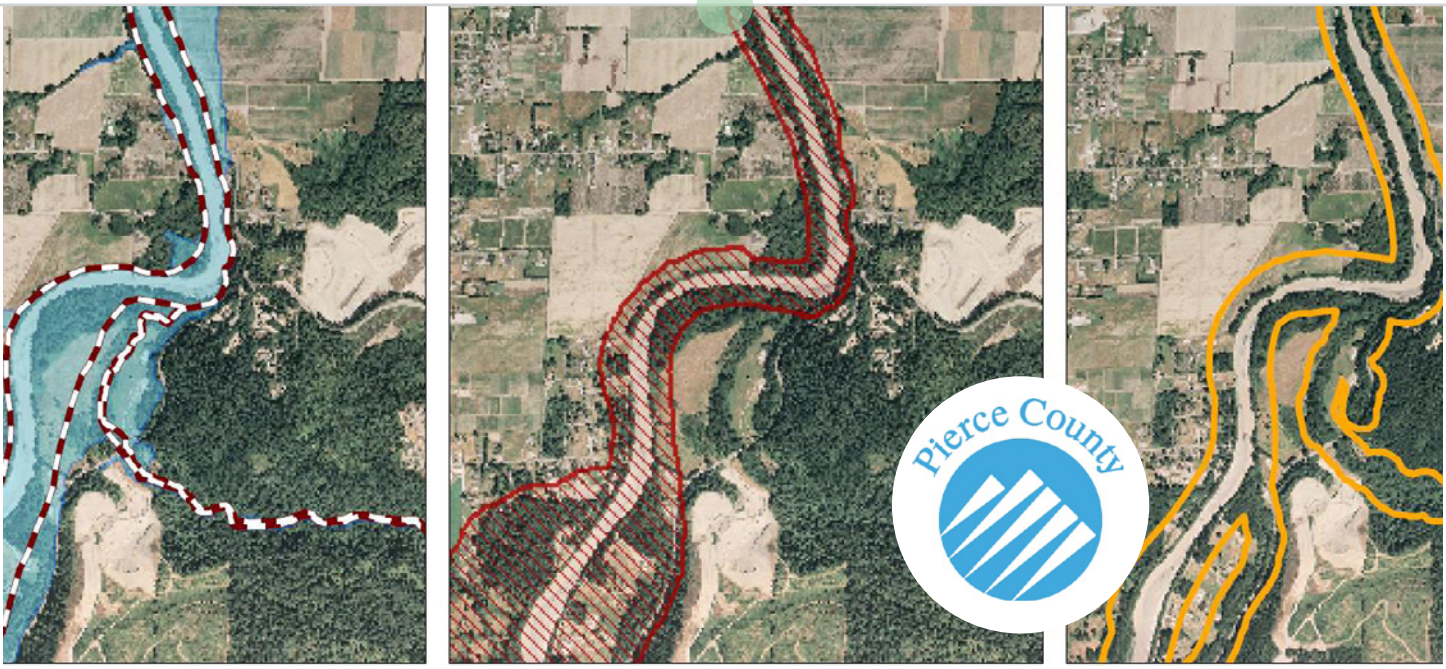
One very helpful public information feature of the FHAD program is that all the maps can be seen on the district's website GIS portal. This system shows the area's floodplain. As seen in the graphics on pages 99 and 100, the lighter areas are floodplains shown on the FIRMs. The darker areas are the FHADs, but are called "best available" maps. FHADs that have been incorporated into FIRMs are shown as light blue, so there are more of the district's maps in use than may appear on the mapping portal. In the future, the district will have a GIS layer with source data that will identify which portions of a FIRM are district-developed FHADs.

Any website visitor can zoom in and see flood data for a property. The example on page 99 is for the area in the red circle on the map to the left. The transparency of the floodplain layer can be adjusted to see buildings and other features in the base aerial photograph. The yellow line shows there was a completed project along this reach.

The district recently has become more involved in helping its cities and counties receive CRS credit for its activities. In 2014, 20 of the 42 cities and counties were in the CRS. Twelve of them were receiving credit for four different elements in Activity 410 (Floodplain Mapping): new studies, cost-sharing on studies with FEMA, higher study standards, and having floodways mapped using the 0.5 foot rise.

Pierce County, Washington

A Comprehensive Approach



The rivers in Pierce County, Washington flow from Mount Rainier and the Cascade Mountains west to the Puget Sound. Most of the urban areas and municipalities are in the western, downstream part of the county. Floodplain management is managed by the Pierce County Department of Public Works Surface Water Management office.

Large river flooding occurs mostly from November through February, when rains and snow melt overload the channels. With larger rivers and generally undeveloped upper watersheds, the county knew it needed to concentrate its program in the floodplains. The first step was to get good floodplain maps.

Ever since it received its first preliminary Flood Insurance Rate Map in 1986, Pierce County has been augmenting the regulatory maps provided by FEMA. Eight approaches have been followed to provide regulatory data that will better protect people and property.

1. **More flood hazard areas mapped and regulated.** Pierce County knew there were more areas subject to flooding than shown on the 1986 draft FIRM. It requested FEMA add 8,854 acres of approximate A Zone to the SFHA. The county's maps were based on staff reviews of NRCS hydric soils maps, topographic maps and records of known flood events. FEMA was hesitant to add so much SFHA, but was won over when the county agreed to adjudicate any Letter of Map Change. In effect, Pierce County agreed to defend any technical and legal challenges to its map.

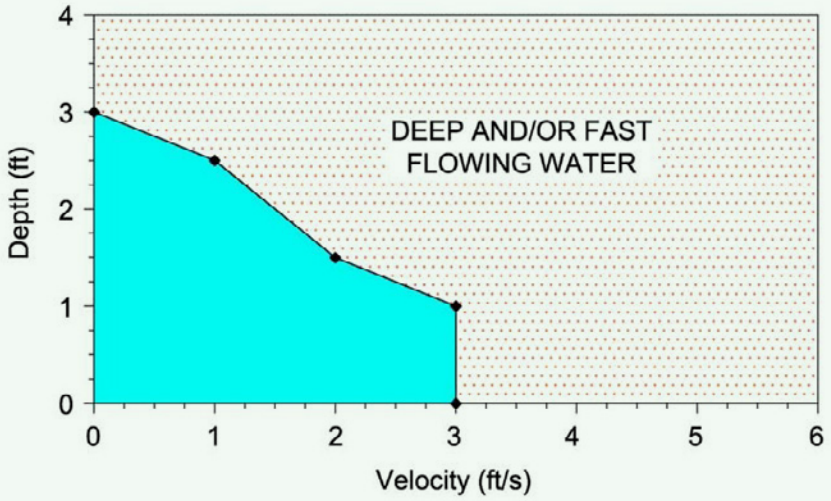
Pierce County's Flood Hazard Areas

Pierce County's Flood Hazard Areas ordinance (Section 18E.70.020) identifies all of

Pierce County, Washington, cont.

the following as flood hazard areas subject to floodplain management regulations:

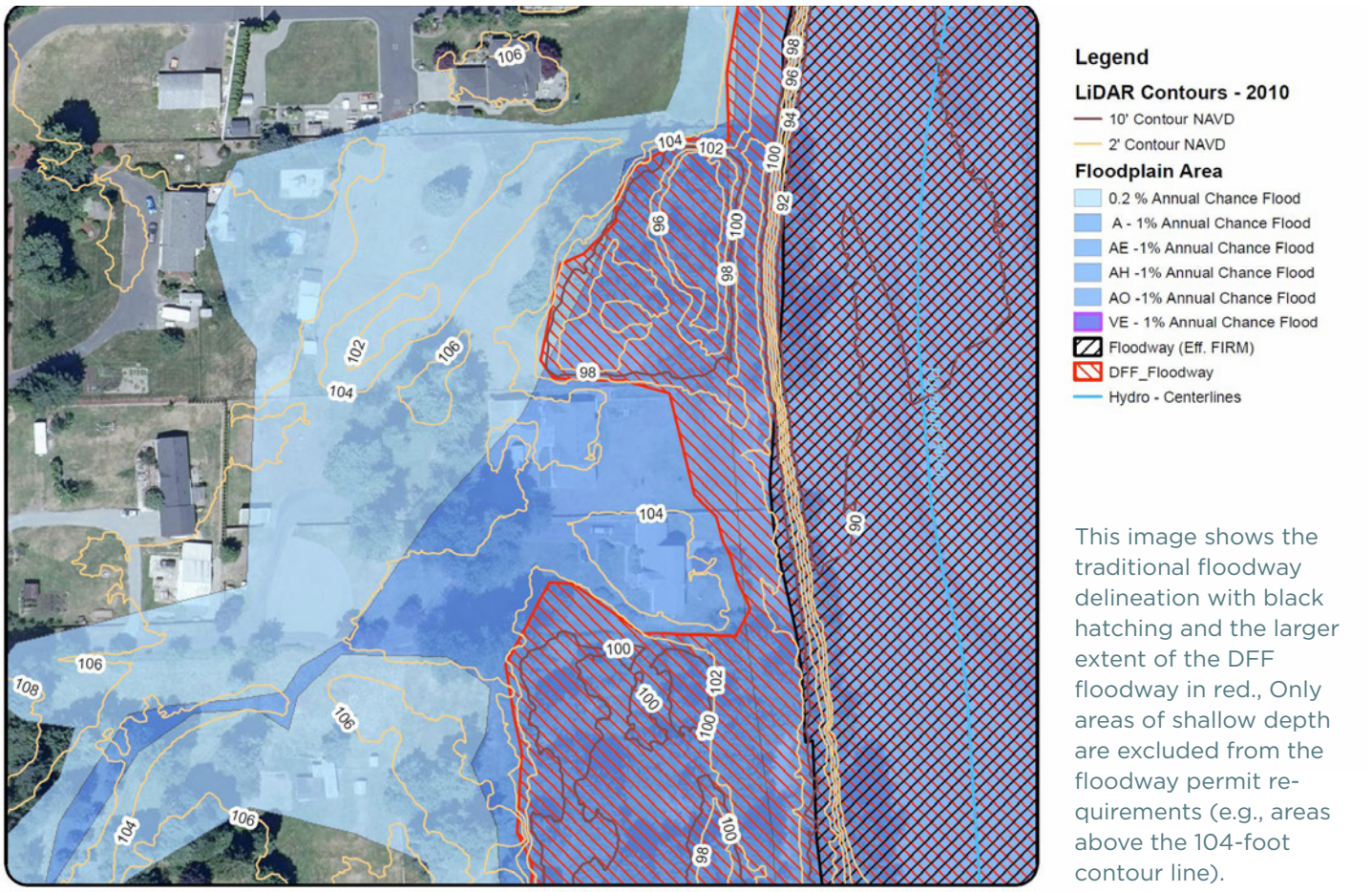
- *FEMA FIRM and Floodway Map numbered A and V Zones.*
- *Areas within 300 feet horizontal distance from the BFE shown on the FIRM.*
- *Areas within 5 feet of vertical height from the BFE shown on the FIRM.*
- *FEMA Flood Insurance Rate Map approximate A and B Zones (shaded X Zones) and areas within 300 feet horizontal distance from the mapped A and B Zones.*
- *Areas within 65 feet horizontal distance from the ordinary high water mark of an identified natural watercourse. Areas within 300 feet horizontal distance from a mapped groundwater flooding area.*
- *Areas not identified as a mapped flood hazard area, but within 10 feet of vertical relief from the bottom of an identified pothole or within 2 feet of vertical relief of a potential surface water spillway or other type of outlet.*
- *Channel Migration Zones for identified watercourses.*



Graphic used to explain Pierce County's Deep and/or Fast Flowing floodway mapping criteria. This graphic illustrates No. 5 on the next page.

2. **Mapping small streams.** The county's Flood Hazard Areas ordinance (Section 18E.70.030) requires any development proposal "within 65 feet horizontal distance from the ordinary high water mark of an identified natural watercourse" must include a floodplain and floodway study. This includes channels that have not had a floodplain delineation.
3. **More detailed data.** Many areas of approximate A Zone have been converted to AE Zones since 1986. The county paid for studies and used its role as a FEMA CTP to coordinate new studies. These studies have been done to higher standards than FEMA's study standards. While detailed studies can be very expensive, the county looks for other approaches that produce defensible regulatory standards. For example, in pothole areas in the X Zone, where standard riverine mapping programs are not relevant, recorded high water marks or maximum overtopping elevations are used to set building protection elevations.
4. **Coastal mapping.** Pierce County's FIRM shows the coast as an approximate A Zone that does not conform to topography, account for the highest tides or wave impacts. The county approximated the coastal hazard by adding a couple of feet to account for inland waves, incorporating the highest probable tide, and using county-

Pierce County, Washington, cont.



This image shows the traditional floodway delineation with black hatching and the larger extent of the DFF floodway in red., Only areas of shallow depth are excluded from the floodway permit requirements (e.g., areas above the 104-foot contour line).

funded LiDAR data to better map the coastal hazard area.

New construction is required to be set back to ground that is 2 feet above this regulatory elevation. Where a new structure cannot be built on high ground it must be constructed to V Zone building standards. This coastal flood hazard elevation will be superseded by a detailed Risk MAP coastal study that has 112 transects and uses new LiDAR.

5. **Floodway mapping standard.** Since 1987, Pierce County has delineated floodways using "Deep and/or Fast Flowing" (DFF) criteria for places too dangerous to be built on. DFF is where water is more than 3 feet deep, flowing faster than 3 feet per second, or a combination of the two. The depth was calculated using a LiDAR digital elevation model. Velocity was calculated at the cross section and then interpolated through the floodplain by hydraulic engineers.

   All areas that meet these criteria are added to the floodway delineated on the county's GIS floodway layer. When a DFF floodway has not been mapped, the permit applicant is required to do the calculations. This standard is now the basis for floodway delineations on nearly 100 miles of 19 rivers. An example is above.

6. **Inclusion of channel migration hazard.** Most of Pierce County's floodplains are composed of quaternary alluvium, i.e., loose sediment that can be highly erodible. The county witnessed many floods where a new channel alignment appeared after water receded.

Pierce County, Washington, cont.

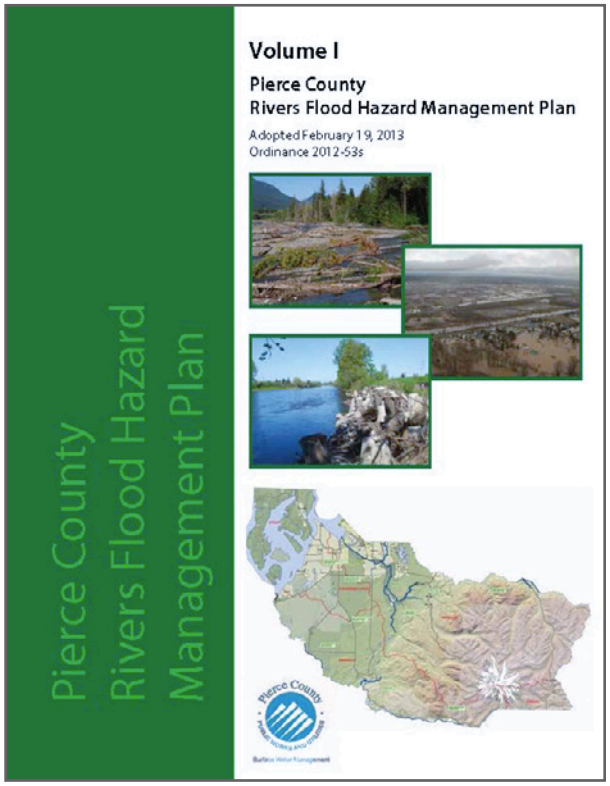
With state support, 30 miles of three rivers now have CMZ mapped. The width of the severe migration potential area was based on the distance the channel edge could travel in 5-10 years of steady lateral migration (with exceptions where the channel was in bedrock or susceptible to avulsion). The reaches where the CMZ was identified as "severe" were mapped as floodway. In some areas the CMZ extends more than 500 feet beyond the SFHA. This means no new structures are allowed. An example of how the CMZ can overlap the SFHA is shown on page 105.

7. **Endangered species protection.** Following a lawsuit based on the Endangered Species Act, FEMA issued new guidance to ensure local floodplain management regulations within the Puget Sound watershed did not encourage destruction of salmon habitat. The guidance is discussed in the Puget Sound model ordinance case study in NAI How-to Guide for Regulations.

The recommended approach involved overlaying the floodway, CMZ and Riparian Habitat Zone (generally a 200-foot setback from the channel). The outer boundary of these three areas was called the "protected area." The map on page 105 shows this approach.

Communities were encouraged to prohibit development in the protected area or "demonstrate that any proposed development in the area does not adversely affect water quality, water quantity, flood volumes, flood velocities, spawning substrate, and/or floodplain refugia for listed salmonids." Buildings were also prohibited. Pierce County met most of the new criteria but still reviews projects on a case-by-case basis until a few ordinance amendments are adopted that will qualify the county at the programmatic level.

8. **Public input.** None of these approaches would have worked without active involvement of affected parties and members of the public. The Surface Water Management office has dedicated public information staff and many opportunities for input.



One example of this effort is the 2012 Pierce County Rivers Flood Hazard Management Plan, an overview of the flood hazard, current policies and projects for each watershed. It devotes 15 pages to mapping policies and has sections and recommendations on floodplain mapping, CMZ mapping and regulation, and technical assistance on floodplain information.

The plan was developed under the guidance of an advi¬sory committee that included local officials, citizens and representatives of organizations as varied as the Audubon Society, Master Builders Association,

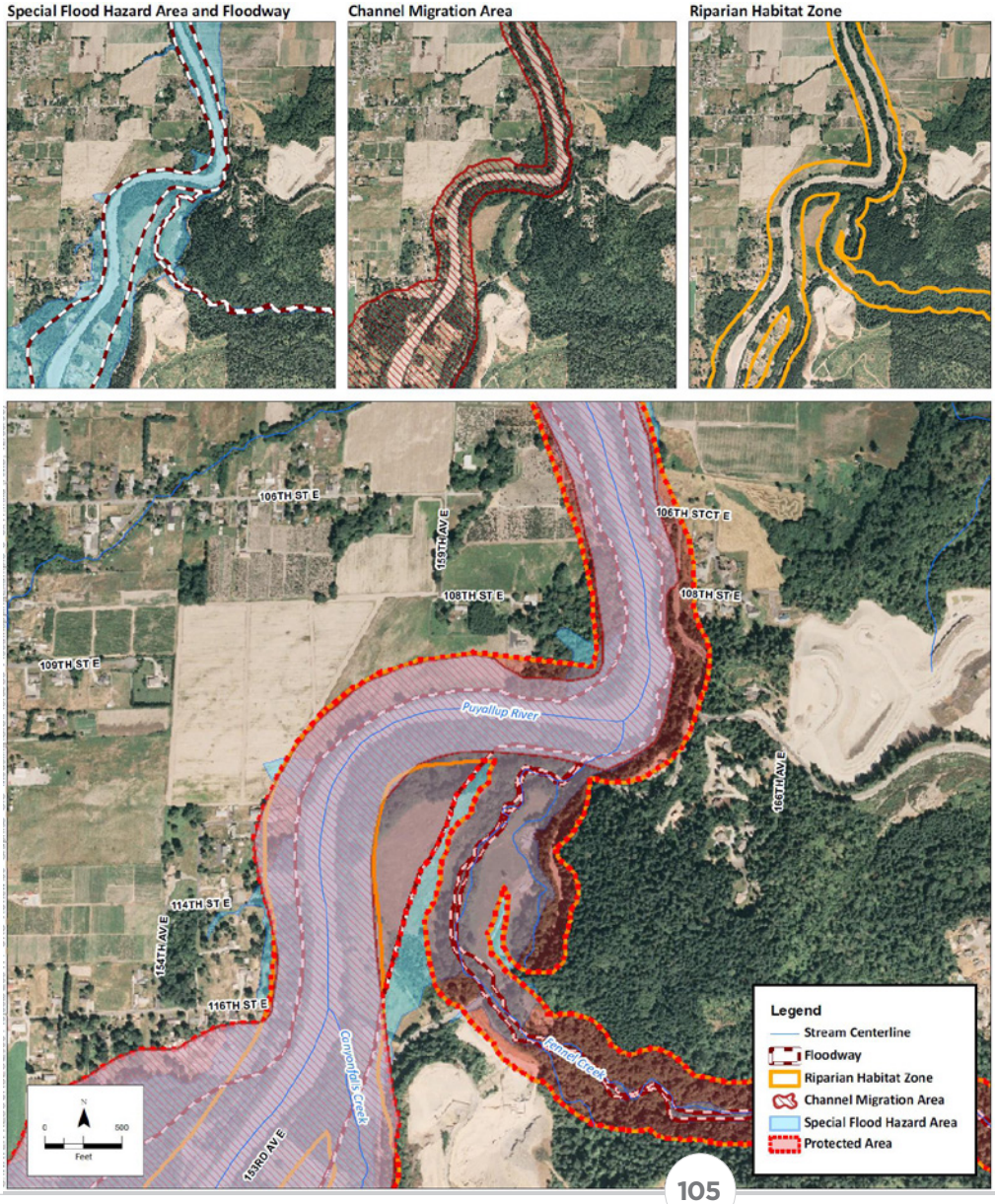
Pierce County, Washington, cont.

Washington Department of Fish and Wildlife, local tribes and Pierce County Association of Realtors. Development of the plan took two years and several public hearings on the draft.

Pierce County is currently receiving credit under Activity 410 (Floodplain Mapping) for its new studies, higher mapping standards, floodway mapping criteria, special hazard mapping and being a CTP.

In 2014 Pierce County was receiving the maximum credit for several new studies, but being a large county, the impact adjustment reduced the total points for each. On the other hand, the impact adjustment for requiring flood studies for development within 65 feet of any stream has an impact adjustment of 1.44 because the regulation affects many areas outside the mapped SFHA. The county's credit for Activity 410 came in at 306 points, more than half a CRS class.

Pierce County is one of only six Class 2 or better communities in the CRS in the country.



This graphic shows the relative locations of the floodway, riparian habitat zone, and the channel migration area, the determinants of the protected area. The regulatory floodplain includes all of the SFHA and protected area. Enforcing this ordinance throughout the regulatory floodplain is needed to comply with the Endangered Species Act. A community can receive CRS credit if the regulatory floodplain extends beyond the SFHA.
Source: Pierce County, WA, 2007, GeoEngineers, 2005; USDA, 2006 (Air Photo)

SECTION FIVE

Resources & Fact Sheet

Resources

RESOURCES AND REFERENCES

General Mapping Guidance

Floodplain Management Requirements, a Study Guide and Desk Reference for Local Officials, FEMA 480, 2005. http://bit.ly/2eL1Vsm

Mapping Coastal Inundation Primer, National Oceanic and Atmospheric Administration Coastal Services Center, 2012. http://bit.ly/2g0hWXN

- CRS Coordinator's Manual, FEMA, 2017. http://bit.ly/2rnRahc

National Flood Insurance Program mapping website. http://bit.ly/2g0uNdM

National Flood Insurance Program regulations. http://bit.ly/2f92R8J

See also Tool 2, Step 1 for links to different kinds of maps.

NAI Mapping

No Adverse Impact Toolkit, ASFPM, 2003. http://bit.ly/23VSf1n

No Adverse Impact Legal Issues website, which includes Professional Liability for Construction in Flood Hazard Areas, Jon Kusler, Esq. http://bit.ly/2gnmWuB

Strategies to Establish Flood Frequencies Associated with Flood Event High Water Marks, ASFPM, 2014. http://bit.ly/2f92sDm

Floodways and Encroachments

The Floodway Encroachment Standard: Minimizing Cumulative Adverse Impacts, ASFPM, 2013. http://bit.ly/2gnkJ26

Residual Risk

"A Strategy to Reduce the Risks and Impacts of Dams on Floodplains," ASFPM, 2013. http://bit.ly/2fAWbk6

Association of State Dam Safety Officials, http://www.damsafety.org/

Geospatial Dam Break, Rapid EAP, Consequences, and Hazards (GeoDam-BREACH). http://bit.ly/2eL2v9O

Future Risk

TMAC Future Conditions Risk Assessment and Modeling, Technical Mapping Advisory Council, December 2015. http://bit.ly/2fJY7Vq

U.S. Climate Resilience Toolkit. http://toolkit.climate.gov/

US Army Corps of Engineers' Sea Level Change Curve Calculator. http://bit.ly/1TLaOPw

Incorporating Sea Level Change Scenarios at the Local Level, NOAA, 2012. http://bit.ly/2flM4gd

Coastal Flood Exposure Mapper, NOAA. http://bit.ly/20bLRMl

Sea Level Rise Viewer, NOAA. http://bit.ly/1Ss01cU

Coastal Change Hazards Portal, U.S. Geological Survey. http://on.doi.gov/1mQUEE3

Fact sheet:

NAI How-to Guide for Mapping

"If we continue to encourage at-risk development and ignore the impact to others, can we accept the consequences, and are you willing to pay for it?"

-Larry Larson, ASFPM

"No adverse impact is an approach that ensures the action of any community or property owner, public or private, does not adversely impact the property and rights of others."

-NAI Toolkit, 2003

For case studies and specific examples of NAI success, visit http://bit.ly/1H5SeXL.

To speak to a No Adverse Impact expert, contact ASFPM at ASFPM@Floods.org or (608) 828-3000.

THE CONCEPT

Communities that effectively reduce flood losses and promote and protect public safety make sure the actions of one person do not adversely affect others. That is the essence of No Adverse Impact floodplain management.

One of the most important parts of the NAI approach is accurate maps and related flood hazard data that can provide information needed to determine if others are adversely impacted by a proposed development project.

Most communities use Flood Insurance Rate Maps prepared for the National Flood Insurance Program as the basis for its floodplain management programs. FIRMs can be helpful but have shortcomings. They should be viewed as a start to an NAI program.

The *NAI How-to Guide for Mapping* describes what is needed for accurate and useful maps that can support an NAI program. Seven factors are advanced for communities to follow to improve their mapping programs and products:

1. Take responsibility for mapping your hazards
2. Know your map's shortcomings
3. Think beyond the 100-year flood
4. Map your known flood hazards
5. Account for the unknown
6. Coordinate with other community programs
7. Educate the public

Fact Sheet, cont.

While there are many ways to ensure an accurate and useful map, this *Guide* describes five basic tools that illustrate what your community can do:

Build a complete map:
Floodplain maps can be missing two types of information. They may not show all the areas subject to a flood hazard, or there may be information missing that's needed to manage development and design flood protection measures, such as flood-prone areas subject to wave action. Tool 1 provides checklists to identify gaps in your community's maps. It covers ways to fill those gaps and keep the maps updated to reflect changed conditions and new data.

Integrate your maps:
There are important features often not mapped as part of the usual flood study. Examples of these features include bank and beach erosion, ice jams, habitat for riparian species and shorelines subject to special regulations. One of the best way to coordinate these concerns and programs is to have them reflected on the floodplain map. Tool 2 has checklists to help identify these floodplain-related concerns in your community and steps to take to obtain and integrate the needed information.

Map a more effective floodway:
The basic tenet of the NAI approach is that new development should not be allowed to increase flooding on other properties. The regulatory floodway approach is the primary way to ensure this tenet in riverine floodplains. The standard used to map floodways on FIRMs allows increased flooding. Tool 3 provides regulatory and mapping methods to make up for the FIRM's shortcomings and to prepare new and more effective floodway maps.

Map residual risk:
For various reasons, FIRMs do not show what would be flooded should a levee or dam fail or be overtopped. As a result, large populated areas may be subject to fast and deep flooding with little or no advance warning after a structure breaches. Using dams as an example, Tool 4 reviews steps to map the hazard-prone areas, advise the public of the hazard and manage new development in those areas.

Map future risk:
Today's development could last for many years, but flood hazards can become worse over time. Structures protected from today's flood hazard will be subject to more damage as time goes on unless steps are taken to manage for the future risk. Tool 5 describes mapping techniques and regulatory measures that can be used to identify risk and account for it in a floodplain management program.

In Summary
Relying solely on NFIP FIRMs leaves a community open to increased flood losses. By themselves, most FIRMs do not cover all of a community's flood and flood-related hazards. FIRM mapping standards allow development to cause increased flooding on others, do not reflect hazard downstream of many dams and don't account for flood risk changes over time.

If communities view their FIRMs as the base to build from and take the initiative to improve their maps, they can overcome these shortcomings and better protect their residents and businesses from flood damage. This *Guide* shows how the NAI approach can mean better floodplain maps and a more effective floodplain management program.

Resources
For more information refer to ASFPM's NAI Resource Center: http://bit.ly/1Ei2r19