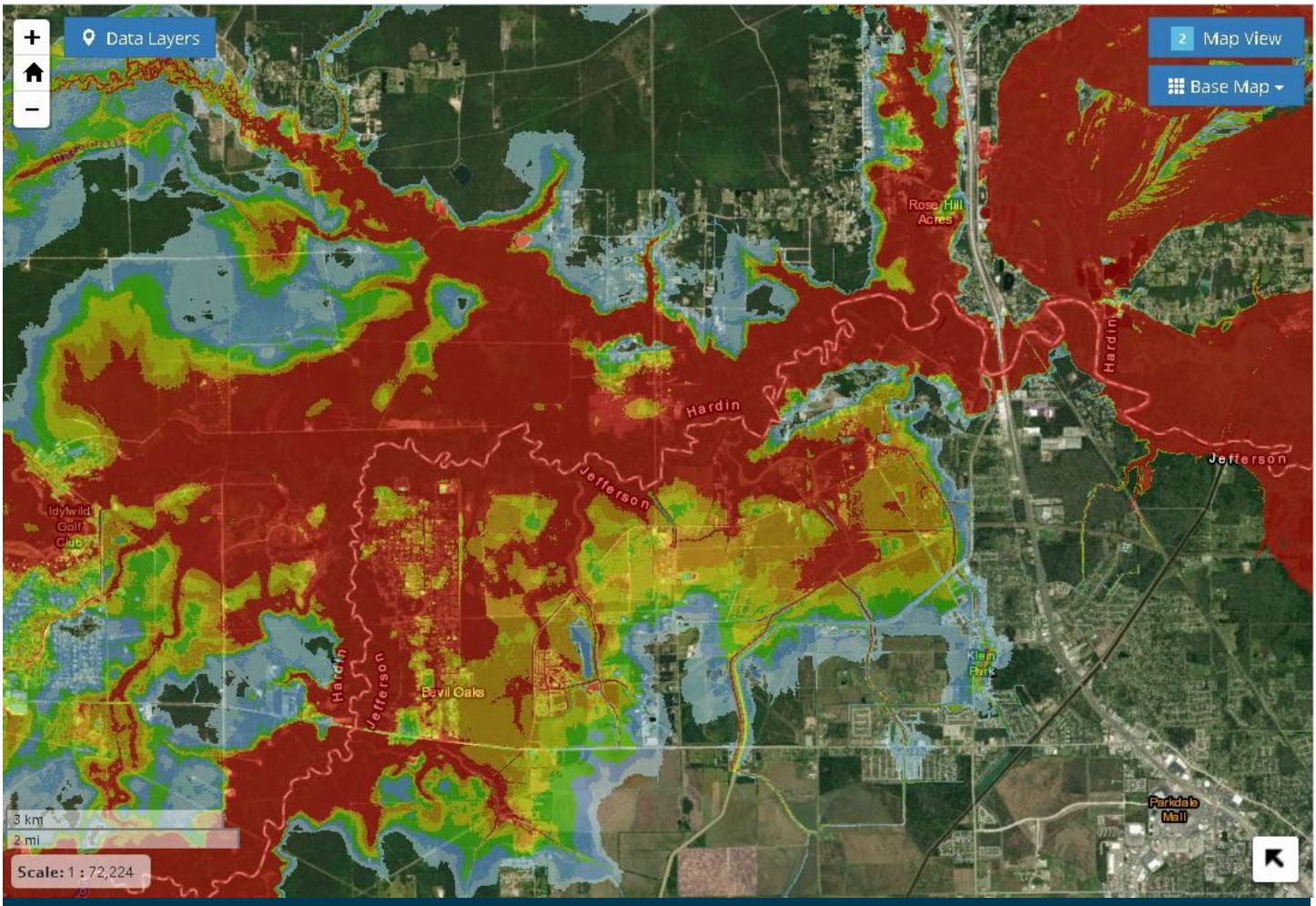

Flood Mapping for the Nation

A Cost Analysis for Completing and Maintaining the Nation's NFIP Flood Map Inventory

January 2020

ASFPM FOUNDATION

Cover Image: Estimated Base Flood Elevation (estBFE) Viewer

Screenshot of FEMA Region VI BFE viewer. Base Level Engineering (BLE) assessments are produced using high resolution ground data to create technically creditable flood hazard information that may be used to expand and modernize FEMA's current flood hazard inventory. https://webapps.usgs.gov/infrm/estBFE/ (accessed December 2019)

Flood Mapping for the Nation

A Cost Analysis for Completing and Maintaining the Nation's NFIP Flood Map Inventory

January 2020

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The Association of State Floodplain Managers Inc. (ASFPM) published this report as part of its mission to promote education, policies and activities that mitigate current and future losses, costs and human suffering caused by flooding. Founded in 1977, the organization had over 19,000 members in 2019, including members in 37 state chapters. ASFPM supports professionals involved in floodplain management, flood hazard mitigation, flood preparedness and flood warning and recovery. Members represent local, state and federal government agencies, citizen groups, private consulting firms, academia, the insurance industry and lenders.

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Flood Mapping for the Nation

Executive Summary

Since the inception of the National Flood Insurance Program (NFIP) in 1969, the nation has invested **$6.6 billion ($10.6 billion in 2019 dollars)** in flood hazard mapping to date, and realized multiple benefits from that investment. These benefits go beyond its uses for the NFIP to include community planning, design and construction of key infrastructure such as highways, bridges, water treatment facilities and much more. Commercial, private and public safety uses of flood hazard information reduce flood losses that would otherwise be paid for by taxpayers through federal and state disaster assistance. With a 2-to-1 benefit ratio, the $10.6 billion in investment equates to nearly $22 billion in savings from avoided flood damages.

Direct average annual flood losses have increased from approximately $4 billion per year in the 1980's to roughly $17 billion per year between 2010 and 2018. These direct losses are likely under-reported and do not include indirect losses related to business closures, lost tax revenue, and public and mental health costs that often disproportionality impact socially vulnerable communities more. With increases in frequency and amount of heavy rainfall and hurricanes due to climate change and increased development pressure in coastal areas and watersheds, flood losses are expected to continue their upward trend.

We are far from completing the initial job of mapping the nation. Complete and adequate flood hazard mapping for the nation would reduce current and future flood losses. Roughly 1.14 million miles of streams have been mapped out of the approximately 3.5 million miles of streams in the country, meaning only 33% of the rivers and streams in the country have flood hazard information available. Existing maps must be continually reviewed and updated to keep them accurate and the remaining 2.3 million miles of streams need flood hazard maps.

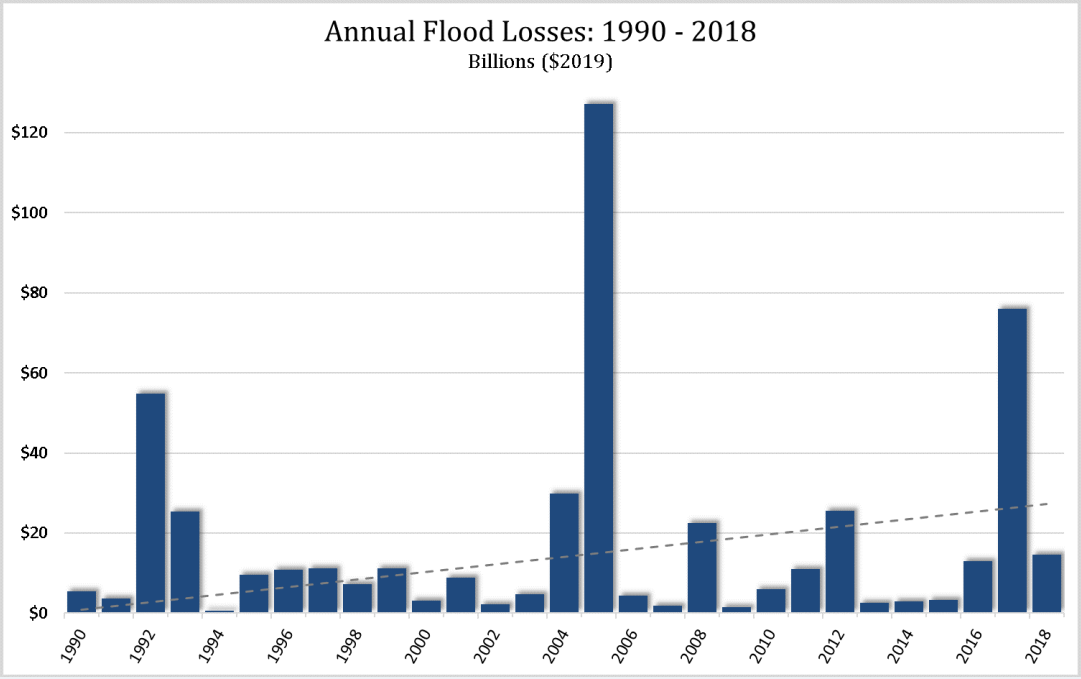
The Association of State Floodplain Managers (ASFPM) has developed an estimate of the total cost to adequately complete and maintain flood hazard mapping for all U.S. communities based on the parameters specified in the Biggert-Waters Flood Insurance Reform Act of 2012. This estimate shows the cost to complete flood mapping for the nation ranges from **$3.2 billion to $11.8 billion** (basis for cost difference explained on p. 14). The steady-state cost to then maintain accurate and up-to-date flood maps ranges from **$107 million to $480 million** annually. Congress will need to decide how quickly we need to have flood mapping available to every community, and then set a level of funding that will achieve that goal.

Costs and Impacts of Flooding

Since the beginning of 2017, the nation has experienced 11 U.S. billion-dollar weather disasters resulting from hurricanes and flood-related events. Sadly, three of the costliest hurricanes resulting in heavy flood losses occurred in 2017. Hurricane Harvey was the second costliest on record and 2017 set the record for the most disasters and costs in the US. The cost of the top five hurricanes since Katrina in 2005 reach almost $500 billion.

Floods are the leading cause of natural disaster losses in the United States, having cost approximately $155 billion in property damage since 2010 and accounting for a majority of federally declared natural disasters.

Direct average annual flood losses have jumped from approximately $4 billion per year in the 1980s, to nearly $17 billion per year between 2010 and 2018, with some years far beyond that.



Average annual flood losses have continually increased since 1990 based on analysis of the Spatial Hazard Events and Losses Database for the U.S. (SHELDUS) (CEMHS, 2019). www.sheldus.org

But the costs of flooding go far beyond these direct losses not included here. Unfortunately, the direct losses reported here are likely under-reported and do not include indirect losses related to business closures, lost tax revenue, and public and mental health costs that often more disproportionality impact socially vulnerable communities.

Individuals and businesses.

The effects of direct flood losses on individuals has been well documented. In addition to physical property losses, other indirect costs include lost wages, agricultural losses for crops and livestock, expenses for evacuating, risk for first responders and significant physical and mental health issues following the event, which for the most part have not been documented. For businesses, the effect of flooding is pronounced.

Across the nation, about 8.7 million properties are located within flood-prone areas.

Roughly 40 to 60 percent of small businesses never reopen their doors following a disaster.

Approximately 40 to 60 percent of small businesses do not reopen after a disaster (FEMA, 2015) and another 25 percent fail within one year according to FEMA. Similar statistics from the United States Small Business Administration indicate that over 90 percent of businesses fail within two years after being struck by a disaster. Businesses also experience indirect losses, such as lost revenues from being closed which, in turn, means lost taxes, jobs, and wages throughout the community. Businesses can additionally be impacted by employees being unable to get to work due to transportation system failures or their own homes being devastated. Supply lines can also be disrupted.

Communities. Communities suffer as well. Local funds earmarked for other uses must instead go to flood repair and recovery, physical and mental health, and the use of community resources (staff, equipment, and infrastructure) for response and rescue. Community infrastructure can be severely impacted, including the costliest elements such as water and wastewater treatment facilities. Debris collection and environmental cleanup can be significant. Local taxes (income, property, etc.) are reduced, both in the short and long term. While some of these costs will be reimbursed by the federal taxpayers in large disasters, smaller and more common disasters do not get federally declared and those costs are borne by states and communities as well as the property owners.

States. State infrastructure such as roads, bridges, and emergency facilities can be damaged or destroyed. State impacts of flooding include the diversion of state resources from necessary programs to response and recovery programs. State taxes (income, property, etc.) are reduced.

Federal Government. All taxpayers pay for the consequences of flooding. If property owners do not have flood insurance, taxpayers provide assistance through disaster relief. The casualty loss deduction allowance and lost wages due to business closure result in forgone tax revenue. Insurance subsidies, through either crop or flood insurance, result in costs to the U.S. Treasury.

What Does Flood Mapping for the Nation Mean?

FEMA is responsible for undertaking studies nationwide to identify areas having special flood, mudslide, and flood related erosion hazards; assess flood risk; and designate insurance zones. FEMA develops, in coordination with participating communities, Flood Insurance Rate Maps (FIRMs) that depict the community's flood hazards. With the passage of the Biggert-Waters Flood Insurance Reform Act of 2012, the **National Flood Mapping Program** (NFMP) was officially authorized and required FEMA to identify several new types of flood hazards including future conditions mapping described in the next section.

> "All flood hazard areas need to be mapped in order for the NFIP to fulfill its potential for reducing the rate of flood-related disaster costs." (Technical Mapping Advisory Council, 2000)

Section 100216 of the Biggert-Waters Flood Insurance Reform Act of 2012, Pub. L. No: 112-141, established the NFMP and describes the responsibility of FEMA to develop and maintain flood maps that are adequate to: 1) Make flood risk determinations and 2) Be used by state and local governments in managing development and reduce the risks associated with flooding. To accomplish this, the 2012 Act requires that FEMA shall review, update, and maintain NFIP maps with respect to:

1. All populated areas and areas of possible population growth located within the 100-year and 500-year floodplains[1];
2. Areas of residual risk, including areas that are protected by levees, dams, and other flood control structures and the level of protection provided by those structures;
3. Ensuring that current, accurate ground elevation data is used;
4. Inclusion of future conditions risk assessment and modeling incorporating the best available climate science; and
5. Including any other relevant data from NOAA, USACE, USGS and other agencies on coastal inundation, storm surge, land subsidence, coastal erosion hazards, changing lake levels and other related flood hazards.

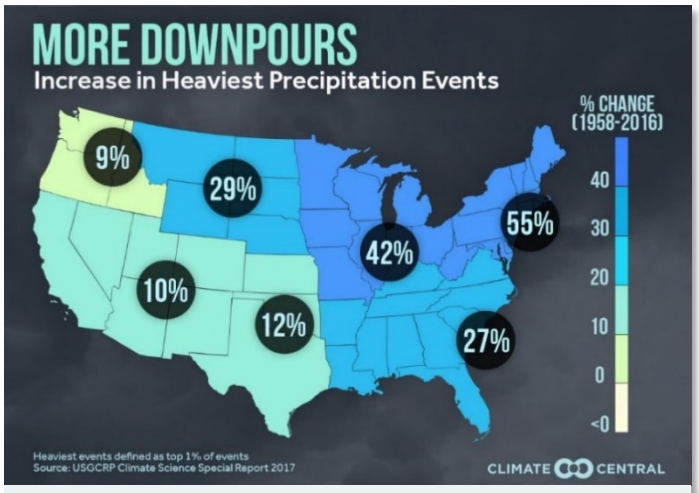
[1] ASFPM defines areas of possible population growth as any area that a property owner has the legal right to develop. Many rural floodplain managers will attest that rural subdivisions may be developed far away from existing population centers.

Future Conditions, Costs, and Impacts

The United States currently has a population of about 329 million, which is expected to be about 380 million by 2040 and 417 million by 2060. This population increase, combined with our desire to live near water, will lead to significantly increased pressure to develop in flood risk areas. Recent reports from the Government Accountability Office (GAO) and the National Climate Assessment and Development Advisory Committee indicate that there will be significant risk exposure to families, communities, infrastructure, and federal assets due to climate change and sea level rise.

What is the future condition?

Future costs and impacts of flooding will be driven primarily by two factors: **development** and **climate change**. Development occurs as a result of population changes, land use policies, and redevelopment of existing sites. Development anywhere in the watershed increases impervious surfaces, thus increasing runoff and flooding, Climate change is primarily realized through sea level rise, and more intense storms (including rainfall and hurricanes). One study on the impact of climate change and population growth on the NFIP indicated that by 2100, the 1% annual chance floodplain would increase in size by 45% in riverine areas (AECOM, 2013). Of that growth, 30% would be attributable to development and 70% to climate change. The same study predicted that coastal special flood hazard areas would increase by as much as 55% by 2100. Newer studies show that sea level rise is accelerating (R.S. Nerem, 2018), and that a majority of coastal communities will experience 30 days of high tide flooding annually by 2050 (NOAA Office for Coastal Management, 2020).



The number of days each year with extreme rainfall is, on average, increasing in every region of the U.S. (Climate Central, 2019)

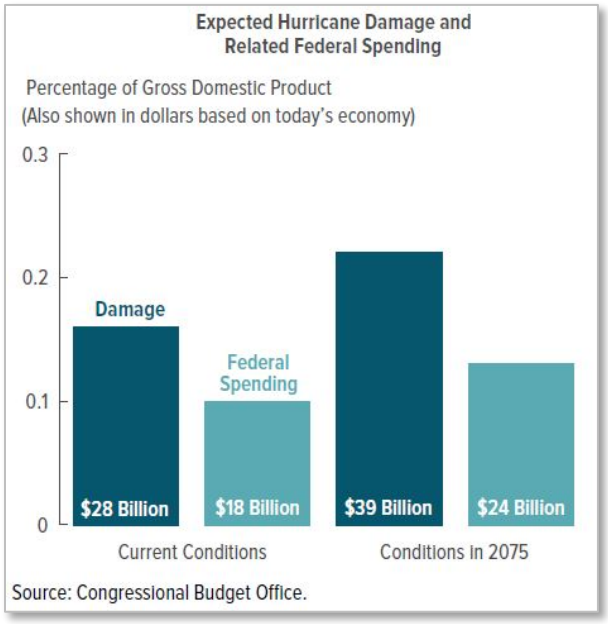
All areas of the country are experiencing more heavy rainfall events, which means more flooding. Trend data over the past 60 years – which is not even accounting for future conditions – shows this well. According to the Fourth National Climate Assessment (USGCRP, 2018) "Heavy precipitation is becoming more intense and more frequent across most of the United States, particularly in the Northeast and Midwest, and these trends are projected to continue in the future."

Today, stormwater systems that were designed to handle rainfalls of 1-2 inches per hour cannot handle 4 inches in a half hour without serious flooding.

In coastal areas, these conditions are exacerbated by sea level rise and more intense tropical storms. These, in turn, mean storm surges that push further inland and more frequent high tide flooding, sometimes referred to as "nuisance" flooding, estimated to be from 300% to 900% more frequent within US coastal communities than it was just 50 years ago (NOAA Office for Coastal Management, 2020).

What are the costs and impacts?

Financial impacts of flooding are high and will be higher in the future. Trends indicate that the federal taxpayer is paying a greater share of disaster costs than any time in history. A recent analysis shows that from 1989 to 2004, federal aid as a percentage of all economic costs from major hurricane events averaged 26% (J. David Cummings, 2010). Currently, the federal aid proportion has jumped dramatically to 64% and has been forecast to stay above 60% through the year 2075 (Congressional Budget Office, 2016).



Importance of Flood Mapping

It is nearly impossible to take action and reduce risk from flood hazards that haven't been identified. While it is estimated that 13 million Americans live in the FEMA identified 1% annual chance floodplain (or the 100-year floodplain or special flood hazard area), new models estimate that as many as 41 million Americans may live in the true 1% annual chance floodplain today (Wing, et al., 2018). That number increases to over 60 million for those that live in both the 1% and the 0.2% annual chance floodplain (or the 500-year floodplain).

Maps will not prevent floods from occurring, but they are an essential tool in avoiding or minimizing the damage to property and loss of life caused by floods, and for communicating flood risk. Without complete or accurate flood maps, local officials face serious difficulties in guiding development away from the most hazardous areas or to ensure that development is properly built to protect lives and property. The lack of maps showing which areas would flood in the mid-20th century was the reason the private insurance sector would not provide private flood insurance.

Complete and updated flood hazard mapping for the nation is the foundation to any subsequent actions to reduce flood risk.

Consider the following two scenarios:

- A developer proposes a new residential subdivisions of hundreds of new homes. The piece of land has a small stream on it which has never had a floodplain identified by FEMA because the land was previously farmed and had low flood risk. Because the minimum NFIP land use/development standards and community subdivision regulations do not require the developer to generate flood data or maps, the subdivision is developed, and homes encroach on the natural – but unidentified – floodplain. Roads serving the homes are too low and bridges in the subdivision are undersized. Later, because the area is now at risk (since there is now development on the former farm field), FEMA maps the area and the identified floodplain shows the newly built structures at risk from flooding. Homeowners are angry, local officials are angry, and everybody is fighting the new flood maps because they don't want flood insurance mandated for their home. But the worst part is that we are creating tomorrow's flood problems today because we have not identified floodplains on all of the rivers and streams that could potentially be developed. Flood maps must be done ahead of development.
- A homeowners' association owns a dam. Unfortunately, the residual risk areas of that dam (areas protected by the dam, areas impacted by a downstream release of the dam or failure of the dam) have never been identified and several new residential subdivisions have since been built below the dam. Then, one year, a storm strikes, weakening the dam. The next year a bigger storm hits and the dam fails. Because nobody ever knew the residual risk in the first place, several homes were flooded and lives were lost.

In both scenarios, complete, up-to-date flood maps would have averted disaster losses to life and property. Yet both of these scenarios happen all over the country – hundreds of subdivisions are being built right now on streams and rivers with no identified floodplains and thousands of unknowing homeowners live in residual risk zones below dams.

The reality is that flood maps are used for many purposes. FEMA's Flood Insurance Rate Maps (FIRMs) – the primary type of flood maps in the United States – are used not only for flood insurance, but also development regulations, and flood preparation, evacuation, and response planning for those at risk.

Government officials use flood maps to:

- establish zoning, land-use and building standards;
- to support land use, infrastructure, transportation, flood warning, evacuation, and emergency management planning;
- and to prepare for and respond to floods.

Insurance companies, lenders, realtors, and property owners depend on these maps to determine flood insurance needs. For citizens, businesses, and communities, the FEMA flood maps are the nation's default source of flood hazard information, even though they are primarily designed for flood insurance.

Flood hazard maps showing the depth and velocity of flooding along with buildings impacted by the flood water helps both emergency managers and developers understand flood risk.

Maps depicting flood hazard areas are not only the foundation of the NFIP, but also the basis of sound floodplain management policies at the local, state, and federal levels. Adequate, accurate and current maps are essential for the NFIP to function. 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. Local governments, with state assistance and authority, are the level of government with the tools to reduce future flood losses. Those tools are land use standards and building codes, which are used to guide development to lower flood risk areas, and to build resilience in flood risk areas so future damages and risk are reduced. Without flood mapping of the flood prone area there is no real tool to communicate flood risk to community officials, citizens or businesses. The sale of flood insurance is not mandated in areas outside special flood hazard areas mapped on FIRMs. Without adequate, accurate, and current maps, neither construction nor the insurance regulatory elements of the program can be effective (Technical Mapping Advisory Council, 2000).

Floodplain mapping is a cost-effective taxpayer investment. In 1997, FEMA conducted a benefit-cost analysis of its proposed flood mapping program (at that time it was called Map Modernization). Based on that analysis, floodplain mapping showed a benefit to the taxpayer of over $2 for every $1 invested in flood mapping.

In 2008, the State of North Carolina used the same methodology as FEMA, and calculated a benefit-cost ratio of 2.3 to 1. The North Carolina report further determined the following range of values of avoided losses per stream mile studied:

Flood Study Type	Range of losses avoided (per stream mile)
Detailed Study	$5,482 - $6,166
Limited Detailed Study	$1,713 - $2,539
Approximate Study	$721

The North Carolina report indicates that for the 29,733 stream miles studied throughout the state, the average benefit provided is $3,400 per year per mile and clearly shows significantly higher benefits of having more detailed flood studies (State of North Carolina, 2008).

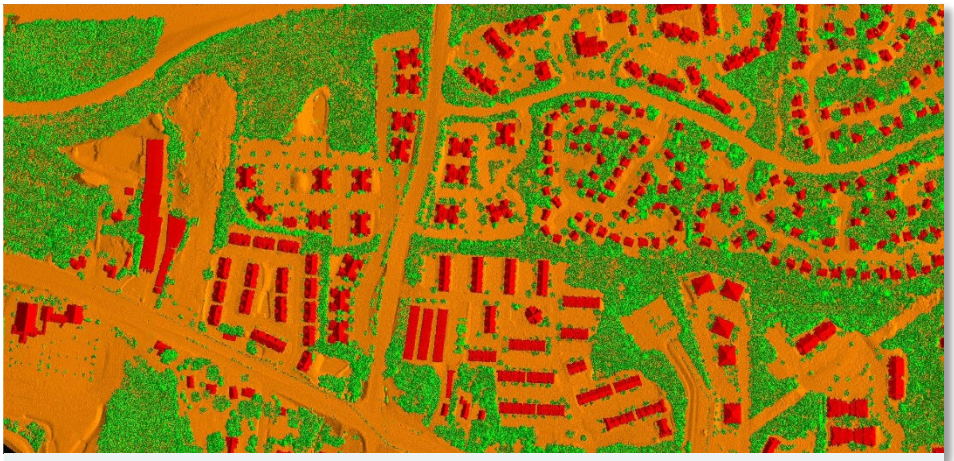
Also, the flood mapping program tries to maximize diverse funding sources. The program operates through fees and appropriated funds. It incentivizes cost-sharing and leverages state and locally collected data. In fact, for every dollar appropriated since 2012, $1.30 has been added by alternative state, local and other funding sources.

Flood mapping reduces disaster costs. Development that complies with the floodplain management requirements is better protected against major flood-related damage. Since flood mapping is the basis for community floodplain management regulations, then it stands to reason that new construction in mapped floodplains would have to comply with such codes and be constructed to be more resilient in future disasters. In fact, buildings constructed in compliance with NFIP building standards suffer approximately 80 percent less damage annually than those not built in compliance (Federal Emergency Management Agency, 2012). Lower damage amounts can be a proxy for lower impacts and demands on disaster assistance. In its final report the TMAC indicated that a small investment in mapping can result in huge savings in flood-related disaster assistance in the future (Technical Mapping Advisory Council, 2000).

Importance of Elevation Data

High-quality topographic or elevation data is essential in the creation of high quality flood maps and flood hazard data. The 3D Elevation Program (3DEP) managed by the U.S. Geological Survey (USGS) National Geospatial Program has responded to the growing needs for high-quality topographic data. The goal of 3DEP is to complete acquisition of nationwide Lidar by 2023 to provide the first-ever national baseline of consistent high-resolution elevation data. 3DEP is based on the National Enhanced Elevation Assessment (NEEA) that documented "… more than 600 business uses across 34 federal agencies, all 50 states, selected local government and tribal offices, and private and nonprofit organizations." (USGS, 2019).

The 3DEP program began in 2016 and provides more than $690 million annually in new benefits to government entities, the private sector, and citizens and realizes a 5:1 return on investment. Through Federal fiscal year 2018, $382 million has been spent with an estimated $629 million needed to complete high-quality topographic data for the country (USGS, 2019). Acknowledging how essential quality topographic data is to credible flood hazard information, FEMA has invested over $190 million since fiscal year 2014 in LiDAR through the 3DEP program.



Lidar data can be used to extract building footprints (in red) and identify the finished floor elevation in order to quantify potential damage based on flooding depths and to determine if buildings are above the base flood elevation. Image courtesy of John Dorman, North Carolina Flood Mapping Program.

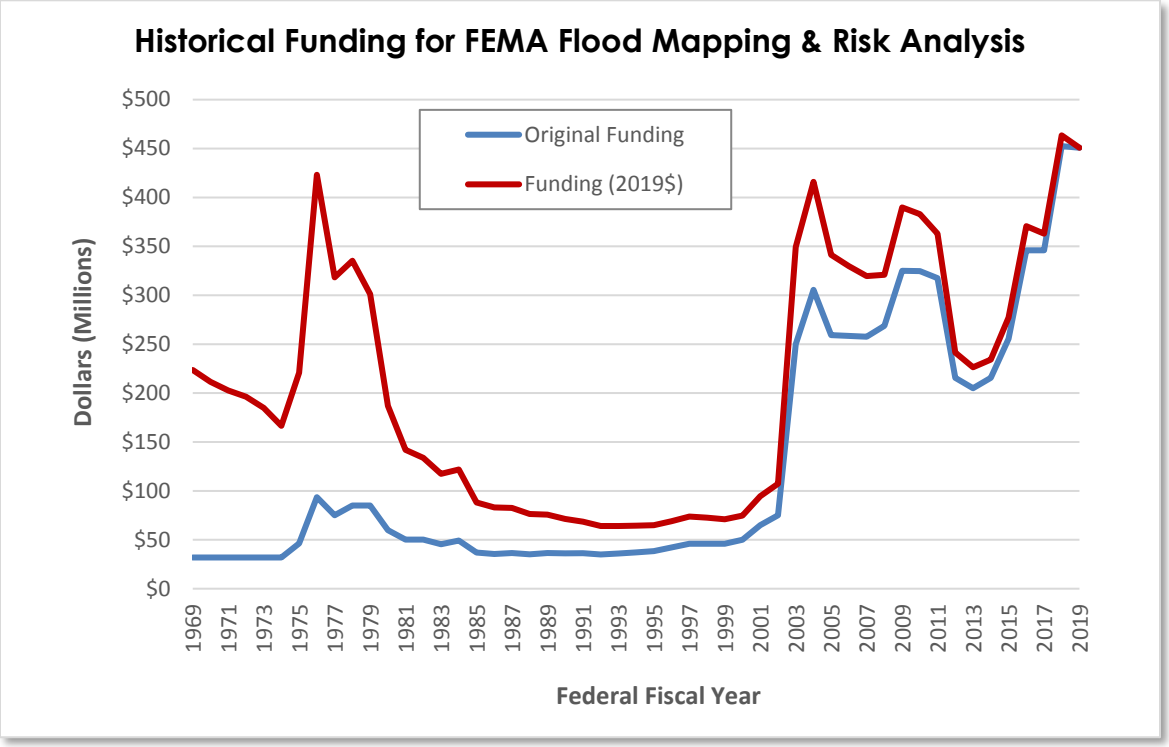
History and Current Status of Flood Hazard Mapping

Funding Sources – Appropriations and Fee Income

Flood hazard mapping and risk analysis is funded through the NFIP by two methods: direct annual appropriations from Congress, and since 1990, a Federal Policy Fee collected on receipts from premiums of flood insurance policies. Overall funding for the nation's flood hazard mapping and risk analysis program varies from year to year, with direct appropriations being as low as only $89 million as recent as FY2013, and reaching $262.5 million in direct appropriations in FY2019. Spending authority from fee collection for FY2019 includes $188.3 million for floodplain management and flood mapping. The combined total for FY2019 is $450.8 million (Congressional Research Service, 2019).

As identified in the original 2013 Flood Mapping for the Nation report, the majority of the floodplain mapping funding to produce new flood maps is derived from the direct annual appropriation for floodplain mapping. The majority of the Federal Policy Fee is used for operating the flood mapping program, including staffing, program management, IT infrastructure, maintaining a call center to support FEMA customers, acquisition services, and research and development. It also supports the cost for processing Letters of Map Change including Letters of Map Amendments (LOMA) and Letters of Map Revision (LOMR), all of which do not provide a significant contribution to the effort to develop new or updated maps.

Since the inception of the NFIP, an estimated **$6.6 billion ($10.6 billion in 2019 dollars)** has been invested in the nation's flood hazard mapping and risk analysis program. This amount includes both appropriated and fee generated funds.



Return on Existing Investment in the Nation's Flood Maps

What have been the results of investing in the nation's flood maps to date? The NFIP now claims there are $1.6 billion in avoided damages every year for buildings constructed in compliance with NFIP standards (FEMA, 2018). The Federal taxpayer would have largely paid for these losses through disaster relief and other programs. These losses avoided would have not been possible without the flood maps. So the investment in flood mapping since the inception of the program until now can be offset by losses avoided in just over six years.

- Over 22,000 communities participate in the NFIP. Those that have reasonably good flood data have been able to reduce flood damages to new development. Nearly, 5.1 million flood insurance policy holders have their financial investment in homes and businesses protected by flood insurance. These are all potential damages that are paid through an insurance mechanism rather than disaster assistance. Those who live at risk pay for at least part of the cost of those decisions. NONE of this would be possible without flood maps.
- Investment in floodplain mapping since 2003 has resulted in the creation of a digital platform for flood maps. This was a huge undertaking given that previous flood maps were developed using multiple, older cartographic methods. Now, the digital platform is

compatible with modern Geographic Information Systems, which means the maps can be integrated into federal, state, and local systems; positioning the nation to move quickly and more cost effectively to develop new and updated maps for every community in the nation. Furthermore, additional informational GIS datasets can be provided on the platform for use at the state and local level.

Cost of Flood Mapping for the Nation

Key Assumptions

To complete flood maps and flood risk data for the nation, it is necessary to make certain key assumptions about the mapping program. Below is the list of the key assumptions made in this report as it relates to what constitutes mapping the nation.

Assumption #1: The framework for mapping the nation going forward has been established in the 2012 Reform Act and dovetails well with FEMA's Risk MAP program and previous recommendations to improve floodplain mapping. In the past, and in the absence of clear Congressional direction, the mapping program was almost solely focused on supporting flood insurance rating as well as serving as a tool for the adoption and enforcement of local floodplain management regulations. However, the purpose of the National Flood Mapping Program is clearly meant to fulfill a broader mandate – to create the nation's flood risk data set so states, communities, and individuals can take action to reduce losses.

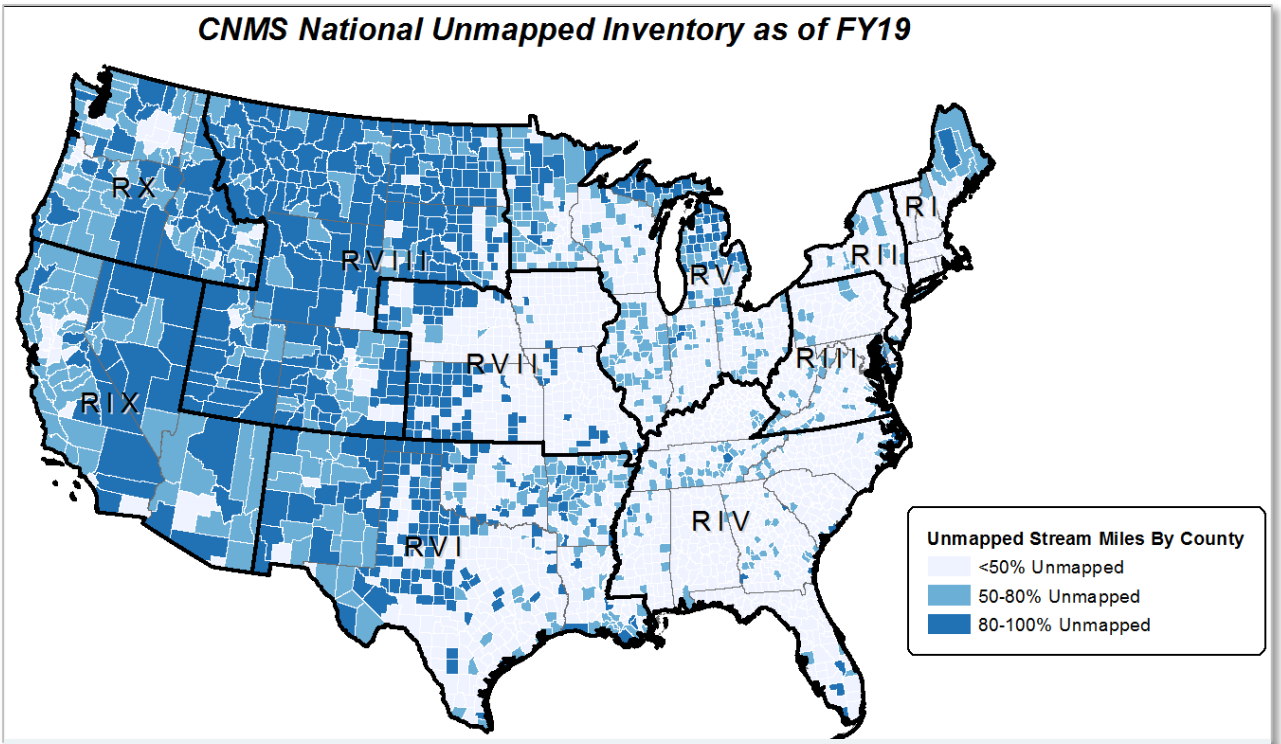
FEMA's Risk MAP program moved the discussion of flood hazard identification away from just the 1% annual chance flood and Flood Insurance Rate Maps to identifying multiple types of flood hazards and frequencies of flood risk. Further, the discussion has been shifted more to future and current risk, and what the property owner/community can do to reduce or mitigate risk, rather than whether a person is in or out of the Special Flood Hazard Area for purposes of determining mandatory flood insurance.

The Act makes a clear and unequivocal statement that flood maps produced by FEMA will be forward looking and inclusive of several types of flood risk data. Congress has, in effect, acknowledged what most state and local officials already know – that the FEMA flood map data should be the default and minimum national dataset for flood risk.

Assumption #2: Flood data and maps are developed for the entire nation. Based on the National Hydrography Dataset (NHD), there are approximately 3.5 million miles of streams in the nation. Currently, about 1.14 million stream miles have flood maps or just over 33% of the 3.5 million stream miles. For coastal or shoreline mapping, NOAA's official value for total length of U.S. shoreline is 95,471 miles (NOAA, 2018). Currently, about 44,158 miles of shoreline have flood maps or just over 46% of NOAA's total.

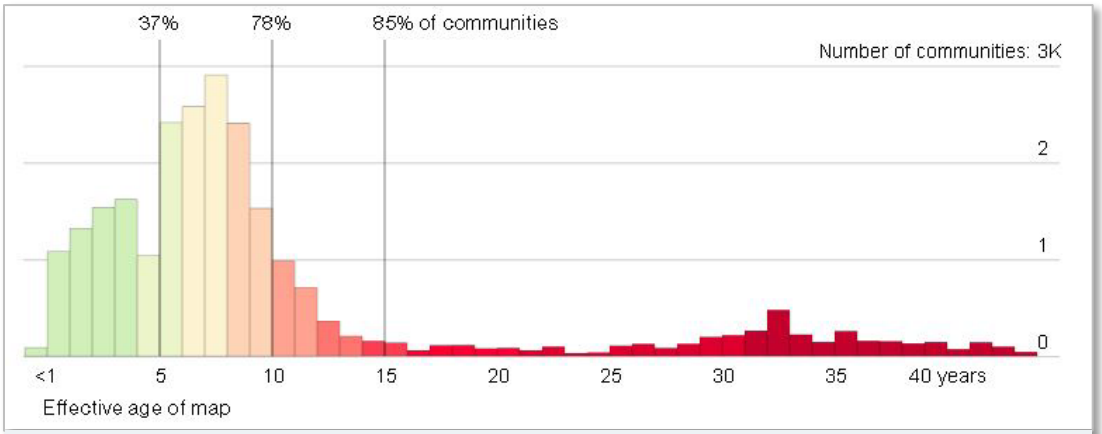
FEMA's floodplain mapping programs to this point have chosen to prioritize limited resources to those areas of greatest population and flood insurance policies on the assumption these are the highest risk areas. While this approach has produced accurate and detailed maps in counties

and communities with higher population levels (even in these communities there are flood prone areas that have not yet been mapped), there remains much more to be done. There are an estimated **2.3 million river and stream miles** and just over **50,000 coastal miles** that are *not mapped* as part of a Special Flood Hazard Area (SFHA).



FEMA Community Needs Management System (CNMS) Unmapped Stream Miles. Source: FEMA

There are over 6,500 counties and communities throughout the nation identified as *not having flood maps at all* and roughly 3,300 communities that have *maps over 15 years old*, with several of these *having paper maps over 30 years old* and based on using obsolete mapping methods.



Roughly 3,300 communities (or 15% of about 22,000 NFIP communities) around the nation have flood hazard maps that are over 15 years old, many of which are 30 years or older. Source: FEMA Data obtained by Bloomberg News (Bloomberg News, 2017)

The current approach ignores lesser populated areas that have considerable flood risk, especially in relation to the local economy, and may have rapidly developing areas with no flood data to guide development. These communities are found all over the nation and continue to find themselves less able to be resilient because the foundational flood data does not exist. Unmapped flood hazard areas present a serious threat to people who may choose to buy or build within them (Technical Mapping Advisory Council, 2000). Furthermore, much of that development may occur without regulation and pay less than full actuarial flood insurance rates, contributing to the NFIP deficit.

Nearly 1 million miles of streams exist on federal and state lands. While some development and infrastructure exists on these lands, the low future development potential coupled with other federal agencies primacy over such areas, this cost model only includes the cost to map federal and state lands in the high-cost range scenario. ASFPM believes that mapping these areas could have benefits; however, flood mapping could, and probably should be, developed by the owner agency as required by the federal Executive Order 11988.

Assumption #3: The minimal flood mapping level for the nation should be based on engineering models and include the ability to readily obtain flood elevation information. With advances over the past decade in automated technologies to map flood hazards and risk, and with high quality topographic data, the ability exists to map large geographic areas using methods such as Base Level Engineering (BLE) (FEMA, 2018). This mapping would be done at a cheaper cost and the quality would be much improved over maps produced 30+ years ago. Even if FEMA has correctly identified the general flood hazard area, communities and citizens need flood elevation data for important things like insurance rating, assessing actual flood risk and making development decisions, and to plan for resilient community growth in order to truly manage the flood risk at the local level.

Assumption #4: Up to date detailed elevation data (LIDAR or other topographic maps) are needed anywhere flood mapping and data are to be generated. The accuracy of elevation data has an enormous impact on the accuracy of flood maps. Having accurate topographic data for floodplain mapping is especially critical in regions with low relief, such as coastal areas –the very areas seeing the most significant population growth and development.

Assumption #5: Residual Risk is defined in this cost model as risk associated with levees and inundation/failure areas below dams; however, other residual risk areas should be identified. There is a new mandate in the law that all residual risk areas be identified, such as those areas repeatedly flooded by stormwater. The cost of mapping urban stormwater flooding is not included in the cost estimates for this report. It is important that TMAC work to help further define the term and criteria.

Assumption #6: The flood map inventory must be continuously updated. Flood map data is not static; it changes over time. Drivers of change include: 1) Change in hydrology, i.e.

updated rainfall records and changing storm patterns, 2) Changes in land use such as population growth or development causing changes in runoff, 3) Need for detailed flood studies as new areas develop, 4) Update of data based on new models, and 5) Technological advancements that allow for more dynamic analyses and presentation of flood risk. While the initial mapping effort for the nation must be completed, there too is an annual maintenance cost for the entire flood map and data inventory. The federal government's investment in the development of flood hazard data is considerable and must not be allowed to decay as happened in the mid-1980s and 1990s (see chart on Historical Funding for FEMA Flood Mapping).

The Cost

The national mapping program funding needs, shown in the table below, has been broken down into major program elements and provides a low and high cost associated with each. The basis for these costs are the assumptions explained in the preceding section and actual cost information obtained from FEMA, state flood mapping programs and other state and federal agencies involved in flood mapping efforts. Due to its complexity, the data behind these estimates is not included in this report, but is available from ASFPM upon request.

The most significant source of variability between the high and low range is due to assumptions made related to level of riverine flood studies for a given geographic area. While good cost data is currently available, it is important to note that changing technology as well as an assumption of nation-wide Lidar could result in reduced costs.

Program Element	Lower Range	Upper Range
Topographic Data Development – 3DEP Program	$ 630,000,000	$ 630,000,000
Discovery, Scoping, Risk Communication & Outreach	$ 39,000,000	$ 90,000,000
Riverine Flood Study	$ 1,819,000,000	$ 9,828,000,000
Coastal Flood Study	$ 13,300,000	$ 14,900,000
Levee	$ 373,000,000	$ 651,000,000
Dam Failure Inundation	$ 97,000,000	$ 199,000,000
DFIRM Production with QA/QC	$ 156,700,000	$ 206,000,000
Non-Regulatory Flood Risk Products	$ 50,000,000	$ 153,000,000
Total	**$ 3,178,000,000**	**$ 11,772,000,000**

The lower range does not include nearly 1 million miles of rivers and streams on federal and state lands, but does use the lower cost estimates associated with the latest mapping technology to generate minimal flood hazard data for rural areas. The upper range includes mapping flood hazard areas on all federal and state lands to ensure mapping of the 3.5 million

miles of rivers and streams in the nation. The upper range also considers the higher costs associated with urban areas and future development areas that as they become more developed (and thus more at-risk) there is an increased need for higher levels of detailed, engineered flood studies and thus higher costs. There is also significant variability for levee studies reflecting the relative uncertainty of the number of levee miles and the needed level of analysis.

Program Element	Lower Range	Upper Range
Steady-State Map Maintenance (Annual)	$ 106,900,000	$ 479,700,000
Total	**$ 106,900,000**	**$ 479,700,000**

In terms of map maintenance, the largest variable has to do with assumptions of map decay – or the accuracy of the map over time. Flood maps change over time due to several factors including changes in topography in the watershed, changes in development and growth, changes in precipitation, additional stream gage data, and changes in water levels in lakes and oceans. In areas where all of these are changing rapidly, maps need to be updated much more frequently than in some rural areas that have little growth and development. Also, accelerated sea level rise and climate change could result in higher decay rates than are presented in this cost estimate. All flood maps need to be periodically updated, but some more frequently than others. The more the flood maps reflect future conditions, the less the cost of updating those maps.

Cost Savings

The cost model developed by ASFPM for this report includes estimates based on available information from states and FEMA, and is also based on current technology and methods of providing flood map data, as well as the assumptions stated earlier. ASFPM believes there are ways to achieve cost savings by leveraging funding, advances in technology and other approaches. A few of these are presented below.

1. *Efficiencies in mapping using better technology.* Throughout the FEMA Map Modernization program and in Risk MAP, FEMA has been successful in driving program efficiencies. This is also a result of changing and improving technologies. One promising approach is called Base Level Engineering (BLE) which uses automated flood modeling of more rural riverine floodplain areas where high quality topographic information exists. Given that the single biggest cost variable is riverine flood studies, the use of BLE could be a significant cost savings to the program.
2. *Leveraging other federal, state and locally collected elevation data.* Some states routinely collect and maintain statewide, high-quality LIDAR data that can be used by FEMA for flood mapping. While contributing to the aforementioned 3DEP program, FEMA is still leveraging considerable benefits from 3DEP to the nation's flood mapping program.
3. *Maintaining/expanding the Cooperating Technical Partners Program.* The CTP Program is an innovative approach to creating partnerships between the FEMA and participating NFIP communities, regional agencies, state agencies, tribes and universities that have the interest

and capability to become more active participants in the FEMA flood hazard mapping program. The result can be the leveraging of partner contributions to flood mapping projects.

What remains to be done?

We are far from completing the initial job of mapping the nation. The framework for flood mapping as prescribed by the National Flood Mapping Program (NFMP) in the Biggert-Waters 2012 Reform Act, recognizes many of these existing needs and sets a robust course for moving forward. Unfortunately, as of January 2020, much remains to be done:

- Based on the National Hydrography Dataset (NHD) and NOAA shoreline data, there are approximately 3.5 million miles of streams and rivers, and 95,471 miles of coastlines in the nation. Currently, only 1.14 million stream miles and 45,128 shoreline miles have flood maps. By this metric, only about 1/3 of the nation has been mapped.
- Over 3,300, or roughly 15%, of NFIP communities have maps over 15 years old, with many of these over 30 years old and still having "unmodernized" paper maps. About 6,550 communities have never been mapped. Addressing both of these needs should be a priority for FEMA.
- Many of the added mapping requirements from 2012 are still not being addressed. This includes residual risk mapping around flood control structures and future conditions mapping. A 2016 TMAC report reviewing the National Flood Mapping Program stated "*To create technically credible flood hazard data, FEMA needs to address residual risk areas in the near term. Residual risk areas associated with levees and dams are of great concern.*" (Technical Mapping Advisory Council, 2016)

It should be noted that over the past several years, FEMA has stated that 90% plus of the population has been covered by a modernized map. However, this metric grossly overstates the population covered by a modernized map. This problem is discussed in the 2015 TMAC Future Conditions Assessment and Modeling Report:

> *However, this population metric has two challenges for moving forward. First, the metric over-predicts the population covered by a modernized map. FEMA generally studies streams that drain a drainage area of greater than one square mile. If a census block group has 10 miles of stream and only 1 mile is studied, the current metric will count 100 percent of the population within the census block group as being covered by a modernized map, as opposed to the 10 percent that may actually be covered. Therefore, the current metric can lead to a significant over-prediction of the population covered by a modernized map. This could lead policy makers to believe that flood hazards have been more widely identified than the reality. If the metric is changed to be more reflective of the streams studied within a census block group, then it may more realistically illustrate that the country has flood hazard areas defined for only somewhere between 16 percent and 22 percent of all streams."* (FEMA Technical Mapping Advisory Council, 2015).

Recognizing that much of the nation still needs to be mapped to adequate standards, FEMA is exploring ways to leverage new technologies to provide flood information more efficiently, accurately, and consistently across the nation through the Future of Flood Risk Data initiative. FEMA aims to provide a more comprehensive and dynamic picture of the nation's flood hazards, accounting for residual risks and multiple flood frequencies. This information could serve as a basis for a range of flood risk products. In moving towards this future, FEMA will need to develop strategic partnerships with other federal agencies, the private sector, and state, local, tribal, and territorial stakeholders. These partnerships will ensure that FEMA is leveraging the latest data and technologies, while serving the diverse needs of its customers.

Considerations for Congress and FEMA

The National Flood Mapping Program has yet to achieve its aim: to produce a reasonably complete set of flood data/maps for the country that identifies multiple types of flooding hazards and also future conditions. As Congress and FEMA consider the future and funding of the National Flood Mapping Program, the following factors should be included:

- We do what we measure. There must be an easily verifiable metric developed for the National Flood Mapping Program that more accurately reflects the extent of the flood mapping completed in the nation than what is currently being used. We suggest the NFIP measure the percent of miles mapped as a metric. Unmapped miles must be studied and added to FEMA's inventory so that flood risk information is available to communities ahead of development.

- Congress will need to decide how quickly we need to have flood mapping available to every community, and then set a level of funding that will achieve that goal. The current FY2019 authorization of about $450 million for the flood hazard mapping and risk analysis program is misleading because a much smaller amount of money is actually available (closer to $300 million) to create new flood maps. Using the median funding level of about $6-8 billion, one could divide by 10 if we agree the mapping should be available in 10 years. Congress should consider increasing the annual appropriation (ignoring the policy fee income since that is spent for operating costs like LOMA, LOMR, LOMC) for the national flood mapping program to accomplish that goal. Alternatively, some members of Congress have proposed a faster five-year effort in which a funding surge is appropriated to finish the job of initially mapping the nation.

- As directed by Congress in 2012, FEMA should begin providing residual risk and future conditions products as part of all flood mapping studies as soon as possible. The TMAC in its 2015 Future Conditions Report and in its 2016 National Flood Mapping Program Review support this view.

- The TMAC also identified the public policy hurdle related to the public availability of dam and related facility inundation maps. Congress may want to consider a specific provision as

part of a future NFIP reform bill or WRDA bill that would override the DHS Security Classification Guide for the Protection of Critical Infrastructure and Key Resources for dam failure inundation maps as "For Official Use Only."

- While not directly part of the National Flood Mapping Program, there is a critical need to ensure the intentional, funded update of the nation's rainfall frequency information which is a major data input into flood models. This past November, ASFPM testified that NOAA should be given the mandate and full budget to update our nation's rainfall frequency information at least every 10 years and this update must include future climate projections into precipitation frequency analysis.
- ASFPM also made a similar recommendation to fully fund the critical national stream gage and tidal gage networks. While more than 4,700 locations meet the criteria for inclusion in the Federal Priority Streamgage (FPS) Network, only 3,600 FPS are active due to funding limitations. These gages provide critical datasets over time so that trends can be identified.

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