

**COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENVIRONMENT
SUBCOMMITTEE ON INVESTIGATIONS & OVERSIGHT
U.S. HOUSE OF REPRESENTATIVES**

HEARING CHARTER

An Examination of Federal Flood Maps in a Changing Climate

Thursday, February 27, 2020
2:00 p.m.
2318 Rayburn House Office Building

PURPOSE

The purpose of this hearing is to discuss how flooding and sea level rise affect American property owners, how the Federal Emergency Management Agency (FEMA) uses science to inform its flood products, how the National Oceanic and Atmospheric Administration (NOAA) researches and communicates flooding and sea level rise, and whether additional federal resources are needed to research and communicate present and future flood risk to the public. In addition, we will discuss what tools exist to help property owners, coastal managers, community planners and other stakeholders understand and evaluate their flood risk, including FEMA and NOAA flood map products.

WITNESSES

- **Mr. Michael Grimm**, Assistant Administrator for Risk Management, Federal Insurance and Mitigation Administration, Federal Emergency Management Agency, U.S. Department of Homeland Security
- **Mr. Mark Osler (OSS-ler)**, Senior Advisor for Coastal Inundation and Resilience, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
- **Mr. Ryan R. Branfort, PLS, GISP**, Senior Vice President, Wilson & Company, Inc., Engineers & Architects
- **Mr. Chad Berginnis (Ber-GHIN-is)**, CFM, Executive Director, Association of State Floodplain Managers

OVERARCHING QUESTIONS

- What is the intended purpose of FEMA flood maps, and how are they being used today?
- What science and modeling techniques does FEMA use to develop flood maps, and are there any data gaps?
- Are there any new modeling or analysis tools that could help FEMA update flood maps with greater frequency/at less cost without sacrificing quality?

- What products exist to help homebuyers, coastal managers, and community planners evaluate future flooding risks?
- How does NOAA science inform FEMA flood products, including FEMA flood maps?
- When will FEMA show future conditions on flood maps?
- What flood information, tools, and services does the National Oceanic and Atmospheric Administration (NOAA) provide to help property owners, managers, community planners and other stakeholders understand and evaluate coastal and inland flood risk?
- What is NOAA's role in researching and communicating the role of climate change in accelerating sea level rise, changing precipitation patterns, and other resulting impacts that affect flooding and flood risk?
- What would the ideal collaboration be between FEMA and science agencies like NOAA to develop the highest-quality and most useful flood hazard and risk products?

BACKGROUND

Flood Risk and Climate Change

Flooding is the most prevalent and most expensive type of natural disaster in the United States.¹ Flood events have occurred in all 50 states and U.S territories since May 2018.² Flooding has cost the U.S. over \$1 trillion in inflation-adjusted dollars since 1980.³ It also costs lives, causing approximately 80 deaths on average per year for the last 30 years.⁴

There are four main types of flooding: fluvial floods (river, lake, or stream floods), pluvial floods (flash floods and surface water), coastal floods (storm surge), and urban flooding. Fluvial flooding can be due to excessive rain or snowmelt, while pluvial flooding occurs during extreme rainfall and is independent of overflowing water bodies. Coastal flooding can be from intense windstorms during high tides, and tsunamis.⁵ Urban flooding, or flooding in densely populated areas, occurs when a source of inundation – rainfall, hurricane, groundwater seepage, river overflow, infrastructure failure – overwhelms stormwater systems and causes water accumulation.⁶

Flood risk is an expression of the likelihood that a flood hazard will incur damages to humans, buildings, and infrastructure.⁷ While flooding is a natural and recurring event, flood risk is increasing due to sea level rise, climate change, land use change, and increased development in

¹ U.S. FEMA, "TMAC: Future Conditions Report Interim," October 2015, Accessed here: https://www.fema.gov/media-library-data/1448469075684-d54e851ba84ab6b998ae9cbeb6d42eac/TMAC_2015_Future_Conditions_Report-INTERIM_508_11252015.pdf

² Congressional Research Service, "A Brief Introduction to the National Flood Insurance Program," December 30, 2019, Accessed here: <https://fas.org/sgp/crs/homesec/IF10988.pdf>

³ Ibid.

⁴ National Oceanic and Atmospheric Administration, National Weather Service, "Weather Related Facility and Injury Statistics," 2018, Accessed Here: <https://www.weather.gov/hazstat/>

⁵ Zurich Insurance Company, "Three Common Types of Flood Explained," 2020 Accessed Here: <https://www.zurich.com/en/knowledge/topics/flood-and-water-damage/three-common-types-of-flood>

⁶ U.S. Global Change Research Program, "National Climate Assessment: Floods," 2020, Accessed Here: <https://nca2014.globalchange.gov/highlights/report-findings/extreme-weather/content/floods>

⁷ U.S. FEMA, "Hazard Identification and Risk Assessment," February 5, 2020, Accessed Here: <https://www.fema.gov/hazard-identification-and-risk-assessment>

floodplains.⁸ Climate change is expected to increase the frequency and intensity of flooding events in the U.S. by changing the factors that contribute to floods.⁹ These factors include: heavy precipitation events that are projected to increase;¹⁰ warmer temperatures that are leading to earlier and faster snowmelt in the western U.S.;¹¹ strong hurricanes that are becoming more frequent causing more storm surge;¹² and rising sea levels.¹³

By the end of the century, our nation's floodplains – land areas adjacent to rivers and streams that are subject to recurring inundation – are expected to grow by approximately 45 percent.¹⁴

National Flood Insurance Program

The primary federal policy used to manage flood risk in the United States is the National Flood Insurance Program (NFIP) administered by the Federal Emergency Management Agency (FEMA), through the Federal Insurance and Mitigation Administration (FIMA).¹⁵ The NFIP was created under the National Flood Insurance Act of 1968,¹⁶ and was most recently reauthorized by Congress on December 20, 2019.¹⁷

Communities that choose to participate in NFIP must adopt in their state or local governments' minimum land management standards with enforcement mechanisms and must regulate development in the floodplain. Communities may choose to adopt more stringent standards than required by NFIP if they wish.¹⁸ Currently, over 22,000 communities in 56 states and jurisdictions participate in the NFIP.¹⁹

In addition to the NFIP providing access to federally-backed flood insurance, it also has a mandate to mitigate the nation's flood risk through floodplain management.²⁰ The NFIP maps flood hazards, releases flood maps to the public, requires local land-use and building code standards, offers funding mechanisms to rebuild after floods, and provides grants and incentives for property owners and localities to invest in risk reduction measures.²¹

⁸ Ibid. at 1

⁹ Intergovernmental Panel on Climate Change, "Special Report: Global Warming of 1.5 °C, Summary For Policymakers," 2018 Accessed Here: <https://www.ipcc.ch/sr15/chapter/spm/>

¹⁰ U.S. Global Change Research Program, "Climate Science Special Report, Chapter 8: Droughts, Floods, and Wildfire," 2017 Accessed Here: "<https://science2017.globalchange.gov/chapter/8/>

¹¹ U.S. Global Change Research Program, "Fourth National Climate Assessment, Chapter 24: Northwest," 2017, Accessed Here: <https://nca2018.globalchange.gov/chapter/24/>

¹² Intergovernmental Panel on Climate Change, "Chapter 3: Changes in Climate Extremes and their Impacts on the Natural Physical Environment," 2017, Accessed Here: https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap3_FINAL-1.pdf

¹³ U.S. Global Change Research Program, "Climate Science Special Report, Chapter 12: Sea Level Rise," 2017, Accessed Here: <https://science2017.globalchange.gov/chapter/12/>

¹⁴ AECOM, "The Impact of Climate Change and Population Growth on the National Flood Insurance Program Through 2100," June 2013, Accessed here: <https://www.aecom.com/fema-climate-change-report/>

¹⁵ Congressional Research Services, "A Brief Introduction to the National Flood Insurance Program," Accessed: 2019

¹⁶ 42 U.S.C. 4001 et se

¹⁷ U.S. FEMA, "National Flood Insurance Program: Reauthorization," December 23, 2019, Accessed Here: <https://www.fema.gov/national-flood-insurance-program/national-flood-insurance-program-reauthorization-guidance>

¹⁸ FEMA operates a program called the Community Rating System, which provides discounts for some flood insurance policies in communities that adopt stricter standards and risk reduction measures.

¹⁹ U.S. FEMA, "Policies in Force By Month," December 19, 2019, Accessed Here: <https://www.fema.gov/policies-force-month>

²⁰ Ibid. at 1

²¹ FEMA administers three hazard mitigation programs, the Hazard Mitigation Grant Program (HMGP), the Pre-Disaster Mitigation (PDM) Grant Program, and the Flood Mitigation Assistance Grant Program (FMA). See CRS Report IN11187, "Federal Emergency Management Agency (FEMA) Hazard Mitigation Assistance" for information on each.

NFIP is funded primarily through the premiums, fees, and surcharges paid by policyholders, but it also receives direct annual appropriations for the mapping and risk analysis program only – primarily, the development of Flood Insurance Rate Maps (FIRMs). To date, NFIP has invested \$6.6 billion (\$10.6 billion in 2019 dollars) in flood hazard mapping.²²

FEMA Flood Insurance Rate Maps (FIRMs)

Communities that have opted into the NFIP must work with FEMA to create Flood Insurance Rate Maps (FIRMs). The FIRMs serve as a regulatory tool, showing a picture of risk that is used to determine which properties are required to purchase flood insurance, as well as the areas required to adopt flood management standards. This creates incentives for communities to minimize the depiction of risk on the FIRMs, in order to lessen their constituents' flood insurance rates and mitigation costs.

The NFIP is required to identify on the FIRMs the Special Flood Hazard Area (SFHA), the area with 1% or greater risk of flooding each year, also known as the 100-year flood zone. In a community that has opted into the NFIP, property owners within the SFHA are required to purchase flood insurance as a condition of receiving a federally backed mortgage. These property owners within the SFHA may purchase the Standard Flood Insurance Policy of the NFIP or private flood insurance, if the coverage of the private flood policy is at least as broad as the NFIP.²³ Communities within the SFHA that have opted into the NFIP must enact minimum standards for development on the floodplain.²⁴

Since its inception, the mapping practice for NFIP has been to apply historical climate information to existing topography and development conditions; therefore, current FIRMs do not reflect future flood hazards based on future climate and sea level. The Technical Mapping Advisory Council (TMAC) is a federal advisory committee created in the *Biggert-Waters Flood Insurance Reform Act of 2012* to provide recommendations to FEMA on NFIP. In 2015, the TMAC submitted a report to FEMA on “Future Conditions Risk Assessment and Modeling,” which recommends that all future conditions flood risk (i.e. long term erosion and sea level rise) information and maps be advisory (non-regulatory) at the NFIP administration level but that communities should be allowed to adopt future conditions for local regulatory and decision-making purposes.²⁵ In spite of TMAC's recommendations, FEMA FIRMs only look at current risk.

In addition to FIRMs, other regulatory flood products FEMA provides include Flood Insurance Studies (FIS), Flood Boundary and Floodway Maps, Letters of Map Change, and GIS databases.

²² Association of State Floodplain Managers, Inc. (ASFPM), “Flood Mapping for the Nation: A Cost Analysis for Completing and Maintaining the Nation's NFIP Flood Map Inventory,” January 2020, Accessed Here: https://asfpm-library.s3-us-west-2.amazonaws.com/FSC/MapNation/ASFPM_MaptheNation_Report_2020.pdf

²³ Requirements for private insurers are defined further at 42 U.S.C. §4012a(b)(7). See Congressional Research Service, “Private Flood Insurance and the National Flood Insurance Program (NFIP),” December 30, 2019, Accessed Here: <https://crsreports.congress.gov/product/pdf/IN/IN10450>.

²⁴ U.S. FEMA, “FEMA Flood Map Service Center: Welcome!,” Accessed Here: <https://msc.fema.gov/portal/home>

²⁵ Ibid. at 1

FEMA also provides non-regulatory flood products, including Flood Risk Products (FRP), and Hazus.²⁶

FEMA Flood Mapping Process

FIRMs are developed under FEMA's Risk Mapping, Assessment and Planning (Risk MAP) process. The regulatory, as well as scientific, nature of the Risk MAP process means that the FIRMs do not always represent the best-available science of risk for an area. There is no standard, reliable schedule for when a community can update its map through the Risk MAP process.

The official FIRMs in place across the United States, and even in close-by communities, are not uniform in when they were last mapped and in scientific accuracy. In general, FEMA issues and revises flood maps in clusters of municipalities within a single county. FEMA prioritizes "remapping" according to population growth, development factors, better science, and changing environmental conditions.²⁷ Users can see the status of a property under NFIP, as well as all FIRMs, at a FEMA website called the Flood Map Service Center, where it is possible to search the address of any commercial or residential property.

The Risk MAP process is determined by requirements in statute. FEMA does not itself conduct the mapping exercise. Rather, it relies on private sector engineering companies ("mapping partners") to conduct the data collection and technical flood studies that inform the maps.^{28,29} FEMA is required to communicate closely with the community, incorporate waiting periods between steps, and collect data from communities. The map process can become a negotiation process between FEMA and local entities over the data; communities with the resources to hire their own firms collect their own data. There is an appeals process for the maps for community members who present conflicting scientific information, and an option to appeal to an independent panel of experts known as a Scientific Resolution Panel.³⁰ The current FIRM process follows practices that were in place when the NFIP was established and have not changed substantially since the 1970s.³¹ As of October 2019, it takes FEMA 3-5 years on average to update a community's flood map.³²

In general, the current FIRM process, and subsequent rating system, combines two sources of flood risk: fluvial (river) flooding and coastal flooding – to establish a base flood elevation, or

²⁶ U.S. FEMA, "FEMA Flood Map Service Center: Products and Tools Overview," February 2020, Accessed Here: <https://msc.fema.gov/portal/resources/productsandtools>

²⁷ FEMA uses a process called the Coordinated Needs Management Strategy to prioritize and track the need to update FIRMs through RiskMAP. (FEMA, <https://www.fema.gov/coordinated-needs-management-strategy>)

²⁸ Office of Inspector General, "FEMA Needs to Improve Management of Its Flood Mapping Programs," September 27, 2017, Accessed Here: <https://www.oig.dhs.gov/sites/default/files/assets/2017/OIG-17-110-Sep17.pdf>

²⁹ U.S. FEMA, "Cooperating Technical Partners Programs," September 24, 2019, Accessed Here: <https://www.fema.gov/cooperating-technical-partners-program>

³⁰ The SRP was authorized in the Biggert-Waters Reauthorization Act of 2012. <https://www.floodsrp.org/>

³¹ Congressional Research Service, "National Flood Insurance Program: The Current Rating Structure and Risk Rating 2.0," November 7, 2019, Accessed Here: <https://fas.org/sgp/crs/homesec/R45999.pdf>

³² U.S. FEMA, "Technical Mapping Advisory Council Annual Report," December 2015, Accessed Here: https://www.fema.gov/media-library-data/1454954097105-a94df962a0cce0eef5f84c0e2c814a1f/TMAC_2015_Annual_Report.pdf

BFE.³³ The BFE is the elevation (in feet) to which flood waters are anticipated to rise during the 1% annual chance flood event. FEMA's contractors project fluvial and coastal flooding by evaluating hydraulic and hydrology (H&H) factors.

FEMA then combines the flood zones established in the FIRMs with other information about the properties themselves and other flood protection measures in the area (such as levees) to develop a picture of risk and in turn, establish premiums.

While the National Flood Insurance Reform Act of 1994 requires that FEMA assess the need to revise and update the flood maps every 5 years,³⁴ 75% of FEMA flood maps are older than 5 years and 11% have not been updated since the 1970s or 1980s.³⁵ In 2017, the Department of Homeland Security's Inspector General's Office reported that only 42% of FEMA's flood maps currently reflected accurate flood risk projections, in spite of the program's goal of 80%.³⁶ Furthermore, to date, FEMA has mapped 1.2 million miles of rivers and coastline, out of 3.5 million miles total, meaning only 33% of the rivers and streams in the U.S. have flood hazard information available.³⁷

FEMA's Plan to Improve Flood Risk Assessment: Risk Rating 2.0

FEMA announced it would be replacing the current risk rating system with a new rating plan, called Risk Rating 2.0 that pairs state-of-the-art industry catastrophe (CAT) models with the NFIP's mapping data in order to provide a more comprehensive understanding of flood risk. Risk Rating 2.0 will be the first time the current rating methodology will undergo a significant change since it was first developed in the 1970s. FEMA's website also says it will use data from other federal agencies (USGS publicly available data; NOAA Sea, Lake, and Overhead Surges from Hurricanes (SLOSH) data; and USACE data sets) and third-party sources (commercially available structural and replacement cost data).³⁸

While little information has been reported on Risk Rating 2.0, FEMA's website says that "Risk Rating 2.0 will incorporate a broader range of flood frequencies," instead of relying on the 1-percent-annual-chance-event. It remains to be seen how much Risk Rating 2.0 will take into consideration future conditions.

³³ Ibid. at 31

³⁴ U.S. FEMA, "National Flood Insurance Reform Act of 1994," September 16, 2009, Accessed Here: <https://www.fema.gov/media-library/assets/documents/7281>

³⁵ U.S. FEMA, "National Flood Insurance Program Community Status Book," September 24, 2019, Accessed Here: <https://www.fema.gov/national-flood-insurance-program-community-status-book>

³⁶ Office of Inspector General, "FEMA Needs to Improve Management of Its Flood Mapping Programs," September 27, 2017, Accessed Here: <https://assets.documentcloud.org/documents/4066233/OIG-17-110-Sep17.pdf>

³⁷ Association of State Floodplain Managers, Inc. (ASFPM), "Flood Mapping for the Nation: A Cost Analysis for Completing and Maintaining the Nation's NFIP Flood Map Inventory" January 2020, Accessed Here: https://asfpm-library.s3-us-west-2.amazonaws.com/FSC/MapNation/ASFPM_MaptheNation_Report_2020.pdf

³⁸ U.S. FEMA, "NFIP Transformation and Risk Rating 2.0," November 15, 2019, Accessed Here: <https://www.fema.gov/nfiptransformation>

FEMA deferred implementation by one year to October 1, 2021 in order to “conduct a comprehensive analysis of the proposed rating structure so as to protect policyholders and minimize any unintentional negative effects of the transition.”

NOAA’s Role in Characterizing Flood Risk

As a science agency, the National Oceanic and Atmospheric Administration (NOAA) has no regulatory flood mapping products, unlike FEMA. Instead, it has informational products and forecasts that provide data on flooding across weather and climate timescales. In 2016, NOAA developed the NOAA Water Initiative,³⁹ which outlines a vision and five-year plan to provide integrated, high-resolution, water information products to help inform community water management decisions, including the efforts below.⁴⁰

Office of Water Prediction and the National Water Center

The Office of Water Prediction (OWP) within the National Weather Service (NWS) works to support, develop, and disseminate information about water resources through monitoring, prediction, and analysis.⁴¹ This information includes hydrologic analyses, forecasts, data, guidance, and decision support for emergency management, NWS’s 122 Weather Forecasting Offices, and water resource managers across all relevant timescales.⁴² OWP operates water forecast modeling and data assimilation systems in collaboration with the NWS, other federal agencies, academia, and stakeholders.⁴³ OWP also transitions key water resources research, whether inside or outside NOAA, to operations.⁴⁴

Built in 2015, the National Water Center, located in Tuscaloosa, Alabama, serves as a base for the Integrated Water Resources Science and Services (IWRSS) partnership between NOAA, the U.S. Geological Survey (USGS), FEMA, and the U.S. Army Corps of Engineers (USACE). This partnership works to leverage the mission and resources of each agency, as well as academia, to improve and modernize water information and forecasts.⁴⁵

Since 2016, the National Water Center provides water information data and products from the National Water Model (NWM).⁴⁶ The NWM provides high-resolution, street-level, forecasts of soil moisture, surface runoff, snow water equivalent and other parameters. The NWM provides

³⁹ National Oceanic and Atmospheric Administration, “NOAA Water Initiative: Vision and Five-Year Plan,” December 2016, Accessed Here: https://www.noaa.gov/sites/default/files/atoms/files/NOAA_Water_Initiative%20Plan-final-12202016.pdf

⁴⁰ National Oceanic and Atmospheric Administration, U.S. Climate Resilience Toolkit, “National Water Model,” August 2, 2019, Accessed Here: <https://toolkit.climate.gov/tool/national-water-model#:~:targetText=NOAA%20is%20seeking%20to%20establish,respond%20to%20extreme%20water%20events.>

⁴¹ National Oceanic and Atmospheric Administration, “Office of Water Prediction Organization,” 2020, Accessed Here: <https://www.weather.gov/organization/owp>

⁴² National Oceanic and Atmospheric Administration, “Office of Water Prediction,” 2020, Accessed Here: <https://water.noaa.gov/>

⁴³ *Ibid* at 1

⁴⁴ *Ibid.*

⁴⁵ University Corporation for Atmospheric Research (UCAR), Cooperative Programs for the Advancement of Earth System Sciences (CPAESS), “NOAA Office of Water Prediction Overview,” 2020, Accessed Here: <https://cpaess.ucar.edu/nwc>

⁴⁶ National Oceanic and Atmospheric Administration, “The National Water Model,” 2020, Accessed Here: <https://water.noaa.gov/about/nwm>

water flow forecasts for 2.7 million river locations, utilizing both USGS stream gauges and atmospheric modeling.⁴⁷

National Hurricane Center National Storm Surge Hazard Maps

Predictions of rainfall and storm surge are crucial to hurricane forecasts; flooding causes the majority of deaths from hurricanes. To supplement traditional hurricane forecasts, NWS created a Storm Surge Unit within the National Hurricane Center (NHC), which provides storm surge forecasts using the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model.⁴⁸ NOAA's storm surge modeling is a key input to FEMA flood mapping efforts.⁴⁹ The NHC also issues National Storm Surge Hazard Maps, which depict areas of the U.S. that are vulnerable to storm surge during hurricane.⁵⁰

NOAA Digital Coast Platform and USGS Flood Inundation Maps Library

The Office for Coastal Management (OCM), part of NOAA's National Ocean Service, oversees the state and local implementation of coastal management programs mandated under federal statutes, providing technical assistance and other guidance.⁵¹ Digital Coast is a web platform that provides coastal intelligence through visualization tools, predictive tools, trainings,⁵² and data sets from satellite to lidar to economic data.⁵³ Digital Coast aims to help the coastal management community stay informed and make better decisions.⁵⁴ Its nearly 70 tools include the Sea Level Rise Viewer, FUSION lidar data sets, Surging Seas sea level rise and storm surge visualization, and Coastal Flood Exposure Mapper.⁵⁵

Digital Coast also links to the USGS Flooding Inundation Maps Library, created through a partnership between USGS, NOAA OCM, NOAA NWS, USACE, and FEMA. This program provides technical assistance to communities to help them develop and validate maps. It also provides public access to the maps and real-time data, forecasts, and predicted costs.⁵⁶

The U.S. Interagency Elevation Inventory and 3DEP

⁴⁷ National Oceanic and Atmospheric Administration, "Weather-Ready Nation (WRN), The National Water Model," August 2016, Accessed Here: <https://water.noaa.gov/documents/wrn-national-water-model.pdf>

⁴⁸ National Hurricane Center, "Storm Surge Unit," 2020, Accessed Here: <https://www.nhc.noaa.gov/surge/ssu.php>

⁴⁹ U.S. FEMA, "Guidance for Flood Risk Analysis and Mapping: Coastal Water Levels," May 2016, Accessed Here: https://www.fema.gov/media-library-data/1472001436394-84b6440ba15f6af5723869b3443f89c4/Coastal_Water_Levels_Guidance_May_2016.pdf

⁵⁰ National Hurricane Center, "National Storm Surge Hazard Maps-Version 2," November 2018, Accessed Here: <https://www.nhc.noaa.gov/nationalsurge/>

⁵¹ National Oceanic and Atmospheric Administration, Office for Coastal Management, "Protecting Coastal Communities," 2020 Accessed Here: <https://coast.noaa.gov/>

⁵² National Oceanic and Atmospheric Administration, Office for Coastal Management, "Digital Coast Academy Training," 2020, Accessed Here: <https://coast.noaa.gov/digitalcoast/training/home.html>

⁵³ National Oceanic and Atmospheric Administration, Office for Coastal Management, "Digital Coast Data," 2020, Accessed Here: <https://coast.noaa.gov/digitalcoast/data/home.html>

⁵⁴ National Oceanic and Atmospheric Administration, Office for Coastal Management, "Strategic Plan for the Digital Coast 2016 to 2021," 2016, Accessed Here: <https://coast.noaa.gov/data/digitalcoast/pdf/digitalcoast-strategic-plan.pdf>

⁵⁵ National Oceanic and Atmospheric Administration, Office for Coastal Management, "Digital Coast Tools," 2020, Accessed Here: <https://coast.noaa.gov/digitalcoast/tools/>

⁵⁶ National Oceanic and Atmospheric Administration, U.S. Climate Resilience Toolkit "Flood Inundation Mapper," August 2, 2019, Accessed Here: <https://toolkit.climate.gov/tool/flood-inundation-mapper>

Elevation data from LIDAR (Light Detection and Ranging), a remote sensing method, is crucial to flood mapping efforts; the way the surface of the earth changes greatly impacts inundation and storm surge patterns. The U.S. Interagency Elevation Inventory is a federal, nationwide listing of topographic and bathymetric data. It is a collaboration between USGS, NOAA, FEMA, U.S. Department of Agriculture (USDA), and USACE, and supports the 3D Elevation Program (3DEP) and NOAA's Integrated Ocean and Coastal Mapping effort.⁵⁷

3DEP is managed by USGS to provide three-dimensional representations of elevation data; a key input to FEMA flood maps. It is a partnership between USGS and many federal agencies including NOAA, FEMA, EPA, and the Bureau of Land Management (BLM). Its goal is to acquire nationwide LIDAR by 2023, a challenge both in cost and data management.⁵⁸

⁵⁷ United States Geological Survey, "3D Elevation Program (3DEP)," September 9, 2019, Accessed Here: <https://www.usgs.gov/core-science-systems/ngp/3dep/collaboration-and-partnerships>

⁵⁸ United States Geological Survey, "What is 3D Elevation Program (3DEP)," Accessed Here: <https://www.usgs.gov/core-science-systems/ngp/3dep/what-is-3dep>