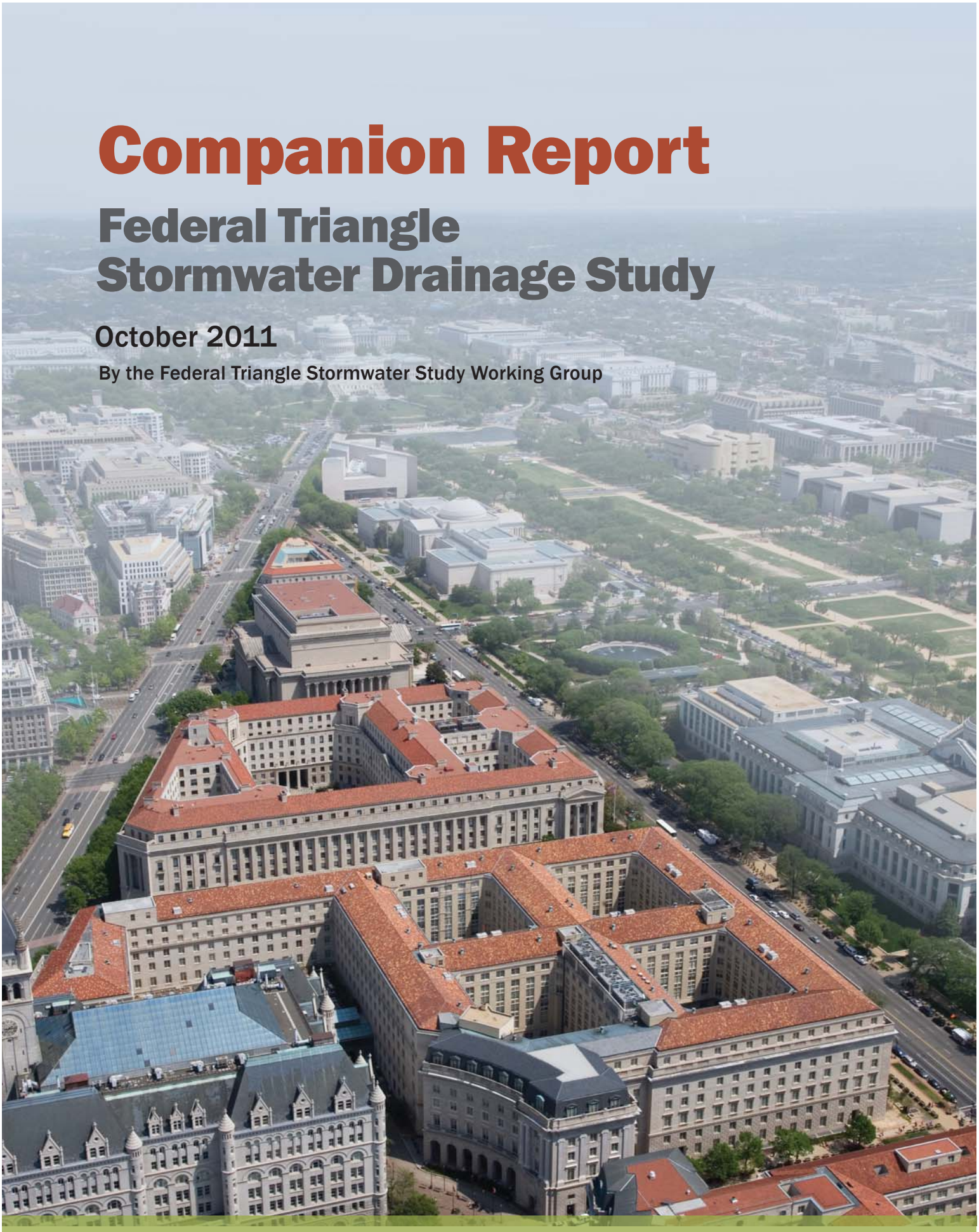
Companion Report

Federal Triangle Stormwater Drainage Study

October 2011

By the Federal Triangle Stormwater Study Working Group



▲ Since October, 2009 the Federal Triangle Stormwater Study Working Group has provided assistance and guidance in compiling the Study.

DISTRICT DEPARTMENT OF THE ENVIRONMENT green forward

HSEMA DISTRICT of COLUMBIA

District of Columbia Office of Planning

dc water is life

FEMA

NATIONAL ARCHIVES

National Capital Planning Commission

NATIONAL GALLERY OF ART U.S.A.

NATIONAL PARK SERVICE

GSA

metro

Overview

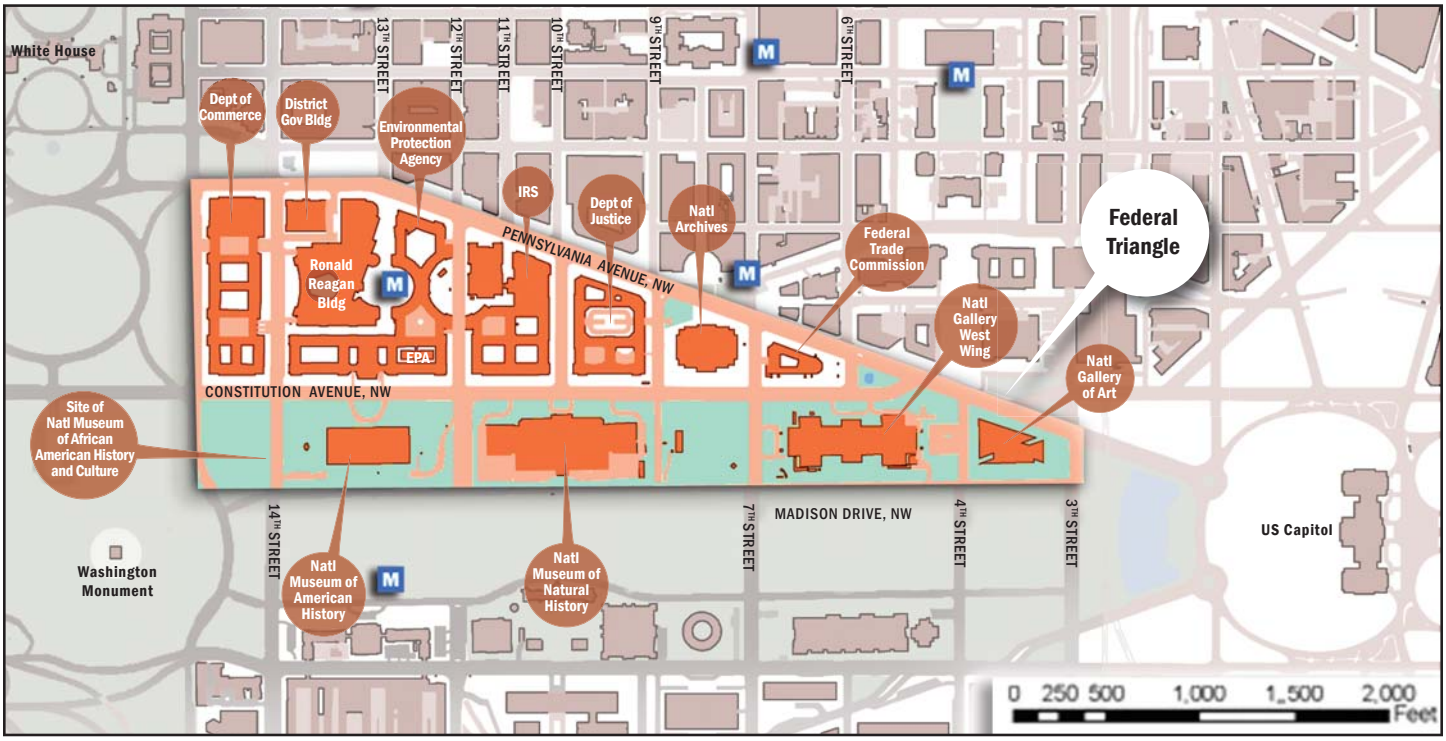
This companion report complements the Federal Triangle Stormwater Drainage Study (Stormwater Study) and summarizes the staff review of the findings. It identifies additional factors that should inform choices by decision makers, and describes next steps the partner agencies (Working Group) will undertake in the short term. Additional information can be found in the Federal Triangle Stormwater Drainage Study Executive Summary.

Why was the Stormwater Study conducted?

After several days of steady rain in late June of 2006, an intense, six hour downpour on the 26th overwhelmed a low-lying section in downtown Washington, DC. The speed and severity of the storm rendered emergency warnings practically useless. The resulting high water caused extensive interior flooding affecting the operations, buildings and infrastructure of federal agencies, the Smithsonian Institution, the National Gallery, the Washington Metropolitan Area Transportation Authority (WMATA), and the District of Columbia. The most damaging effects were felt in the Federal Triangle and along Constitution Avenue (the study area).

In response, the affected agencies initiated the Stormwater Study to identify the causes of flooding, predict future risks by modeling the stormwater impacts in the study area, and examine the feasibility of alternatives to mitigate flooding.

Interior flooding, as opposed to river flooding, describes conditions resulting from heavy rainfall. The study area is at risk from both kinds of flooding due to topographic conditions. The Federal Triangle, along with other parts of the monumental core of Washington, will soon be protected from river flooding with the completion of the 17th Street levee closure.



▲ Map of the Federal Triangle Study Area

▲ Department of Justice flood damage, June 2006

The headquarters buildings of the National Archives and Records Administration, the U.S. Department of Justice, the U.S. Department of Commerce, the U.S. Department of Justice, the U.S. Environmental Protection Agency, and the Internal Revenue Service experienced basement flooding. The Smithsonian's Museum of Natural History, Museum of American History, the Arts and Industries Building, and the Castle were also damaged. Power outages from the rising water affected the National Gallery of Art. The MetroRail stations and tracks in the study area flooded, as did Constitution Avenue, disrupting regional transportation services. Power outages occurred as Pepco electrical lines shorted out, and the steam tunnels flooded. The causes of flooding and the extent of damage varied at each facility along with the impact to operations and recovery costs.

In addition to building and infrastructure damages, the 2006 flood highlighted other issues and risks. Operations at federal agency headquarters, major cultural institutions, and private businesses were disrupted – in some instances for weeks. The affected facilities house some of our nation's most irreplaceable cultural artifacts. Many of the buildings are historic landmarks. The affected facilities function as major tourist destinations, contributing to the local economy. Federal government security risks were exposed, as most building monitoring systems and high-speed communications were compromised by power outages.

▲ Stormwater flooding after a designated 200 year storm event; June 2006.

What is the scope of the Stormwater Study?

In-depth analysis of the hydrologic conditions and sewer system capacity of the Federal Triangle watershed to predict flood risk areas. Information was collected on existing stormwater infrastructure in the study area. Five storm events of different intensities, (15 year, 50 year, 100 year, 200 year, and 500 year) were modeled to predict areas at risk of flooding.

Computer model of the surrounding area and the sewer system of the Federal Triangle drainage basin was created and calibrated using observed site conditions resulting from the 2006 flood. The calibrated model was then used to understand the performance of the stormwater sewer system in the study area under varying storm conditions.

Estimates of the direct costs and benefits for each of the alternatives listed below.

Identification and analysis of the viability of six structural alternative approaches to mitigate interior drainage flooding, specifically for a 50 year, 100 year, and 200 year storm event, on an area-wide basis.

1. Capturing stormwater in the upstream watershed through low impact development (LID), such as green roofs and bioswales.
2. Stormwater storage upstream of the study area in the watershed.
3. Utilizing the 48 inch gravity condensate line at Constitution Avenue.
4. Providing stormwater storage beneath the National Mall.
5. Providing a pumping station on the National Mall.
6. Constructing a new sewer tunnel to the Main and O Street Pumping Station Complex.

Who conducted the Stormwater Study?

Several federal, regional and District agencies joined together to fund and support the Stormwater Study. Engineering consulting firms Greeley and Hansen, in association with LimnoTech, developed the predictive flood models and the technical analyses.

The Working Group provided ongoing technical support throughout the study. This included collecting site survey data, providing guidance on the range of design storms to be modeled, working with the consultant to identify alternatives beyond traditional storm sewer system improvements, and evaluating the study results.

- District of Columbia Department of the Environment (DDOE)
- District of Columbia Homeland Security and Emergency Management Agency (DCHSEMA)
- District of Columbia Office of Planning (DCOP)
- District of Columbia Water and Sewer Authority (DC Water and Sewer)
- Federal Emergency Management Agency (FEMA)
- National Archives and Records Administration (NARA)
- National Capital Planning Commission (NCPC)
- National Gallery of Art (NGA)
- National Park Service (NPS)
- Smithsonian Institution (SI)
- U.S. Department of Justice (DOJ)
- U.S. Environmental Protection Agency (EPA)
- U.S. General Services Administration (GSA)
- Washington Metropolitan Area Transit Authority (WMATA)

▲ Topography is one of many factors contributing to flooding, as the study area is the lowest point in a large historic watershed.

How does this study build and compare to prior work?

The Stormwater Study referenced and built upon several other recent studies, summarized in Appendix A. These studies address river flooding, evaluate building specific impacts of the June 2006 event, evaluate the combined sewer system in other areas of Washington, and provide an historic overview of flooding in Washington's monumental core. The Stormwater Study provides a more accurate analysis by using the consultant's hydrologic and hydraulic modeling which previous studies didn't employ. Several of the common findings are:

- The Federal Triangle study area is the lowest point in a large watershed, and is affected by both river and interior drainage flood events.
- The stormwater sewer system in the study area is not designed to handle stormwater volumes exceeding a 15 year storm event.
- River flooding did not contribute to the June 2006 flood.
- Flood protection and mitigation can be provided through a system-wide solution by increasing the capacity of the storm sewer system, through a detention system and/or on a building-by-building basis.

▲ Pervious pavement is an example of Low Impact Development (LID).

What are the key benefits of the Federal Triangle Stormwater Drainage Study?

In-depth analysis of the capacity of the existing sewer system and the viability of structural alternatives. The range of alternatives not only considered a conventional sewer system solution, but also included more innovative and sustainable alternatives such as LID solutions, and collecting and reusing stormwater for irrigation of the National Mall.

Elevations of flooding for various storm events that can be used to design individual flood proofing solutions.

Evaluation of the effectiveness of different alternatives to mitigate storm events of lesser and greater magnitude than any previous studies, and consideration of the potential impacts of sea level rise and more frequent, severe storm events by modeling a 200 year storm event.

General cost estimates for construction and maintenance of each of the alternatives, which can help decision makers understand the public investment needed should one of these alternatives be considered for implementation.

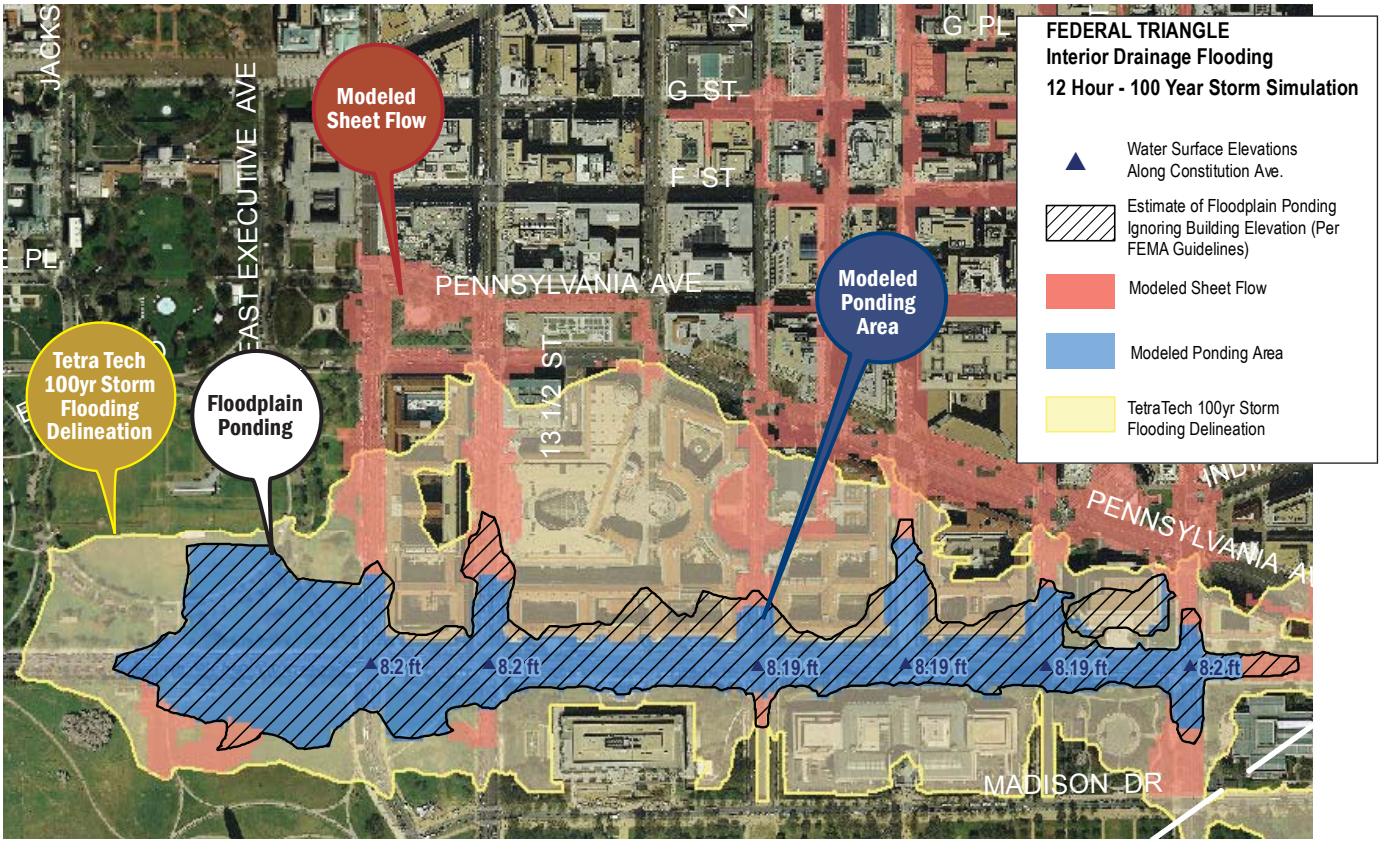
Recognition that many factors that contribute to flooding risks, including topography, sewer system reliability, increased frequency of severe storm events, and power failures.

What were the key findings?

- The predicted ponding level in the vicinity of the Federal Triangle for the 100 year storm event, at a 12 hour and 24 hour duration, is smaller than the area predicted by the Tetra Tech Study completed in 2008 (see below) which will serve as the basis for the future revision of the Washington, D.C. Flood Insurance Rate Map.
- The June 2006 event was a 200 year storm event creating flash flood conditions, with a high volume of rain falling in the Washington, D.C. area in a very short period of time.
- Although the DC Water pumping stations were working, the combined sewer system that serves the Federal Triangle was overwhelmed by the unusually high volume of water during this record rainfall event.
- The Constitution Avenue storm sewer, which also serves the Federal Triangle, cannot effectively funnel large volumes of water during major rainfall events due to its limited size, low elevation and gradual slope relative to its terminus at the Tidal Basin.
- An early warning system that collects accurate weather data is not cost effective, and cannot provide adequate warning in cases of localized, high-intensity floods, such as the one that occurred in June 2006.

Of the six structural alternatives analyzed in this study, the first three are not able to adequately mitigate flooding. The last three alternatives can viably control a large-volume, short-duration flood event. However, they require large capital investments, estimated in the range of $300-$500 million, and have short and long- term impacts.

▼ The 2008 Tetra Tech study identified the section outlined in yellow as the area defined by the effects of a 100 year stormwater flood. The Stormwater Study uses new topographic and modeling data to define the smaller affected area which is shown in blue. A 24 hour 100 year storm map is available in the full storm water study.

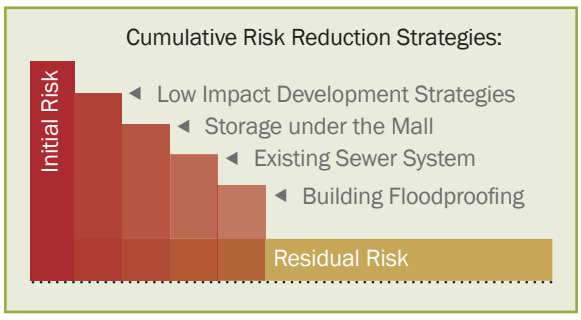


What other important issues should be considered?

The Working Group recognized that before infrastructure improvements can be implemented, impacts, benefits, and context must be evaluated. Identifying funding sources is also necessary for successful implementation. The Stormwater Study does not identify a preferred alternative for an area-wide solution. In the course of analyzing each alternative, the Working Group realized that there are other factors outside the study scope including economical, environmental, social and operational factors. Ultimately, the risk of flooding impacts must be balanced with the costs and benefits of each alternative. The Working Group acknowledges that no solution can completely eliminate flood risks and identified several important issues that should be considered before selecting the most appropriate and cost-effective interior flooding solutions.

▲ Using sandbags is a short-term, economical solution but does not reduce flooding.

Buying Down Flood Risk



Expanded drainage system capacity versus site-by-site flood-proofing: The Stormwater Study evaluated system-wide alternatives that would remove flood water and provide benefits to the entire study area, but these alternatives pose significant costs, a lengthy time horizon, and complex political and procedural processes. Flood-proofing improvements for individual building and facilities may be easier to implement quickly and cost significantly less but will not address flooding in the study area.

Short term versus long term solutions: Expanded drainage system capacity alternatives or individual building flood-proofing solutions that require structural modifications or interior space reprogramming require years of planning and construction and a commitment to significant, multi-year funding. The sections of Constitution Avenue within the study area experience ponding even during small storm events. Smaller, less costly strategies can be implemented immediately to effectively reduce the risk of these smaller flood events. These short term strategies include:

- Improved communication among facility managers, emergency management staff and subcontractors to ensure a quick response.
- More frequent and coordinated inspection and cleaning of sewers by the District Department of Transportation and DC Water and Sewer.
- Short term building flood-proofing, including the use of sandbags to protect vent shafts and ground surface openings.

Multi-hazard mitigation: Interior flooding is one of many natural and man-made hazards that must be addressed by facility and infrastructure managers. Solutions that address multiple hazards provide synergistic benefits and are usually the most cost effective approaches.

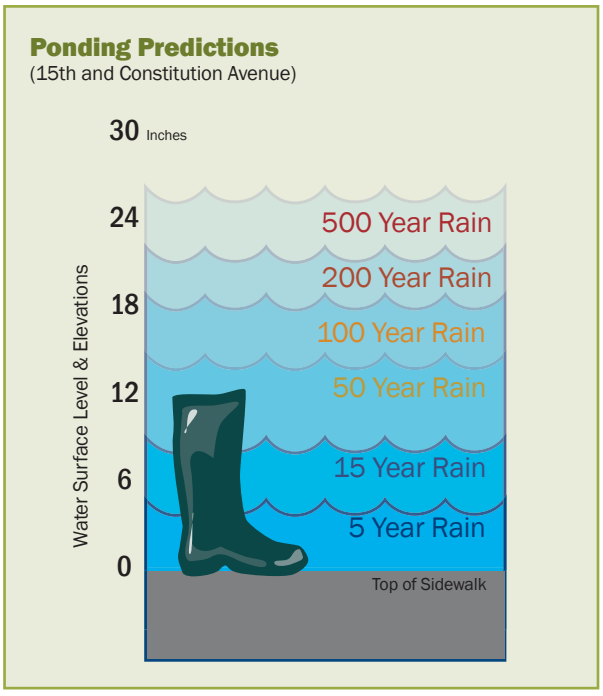
Hybrid solutions: The Stormwater Study analyzed a range of individual strategies to reduce flooding impacts, with the most viable strategies incurring the greatest capital costs. Alternatively, a hybrid solution of smaller interventions that “buy down” the flood risk may be less costly and provide protection from smaller flood events. Combining LID practices in the study area, a smaller-scaled storage system under the National Mall, and/or using the existing sewers might provide relief from smaller storm events, leaving building owners to address major storm events by flood-proofing their buildings.

How will the Working Group use the Stormwater Study?

The flood modeling and technical analysis of the structural alternatives included in the Stormwater Study has provided several immediate, useful results. The modeling results are already informing individual agency decisions about flood risk and protection strategies.

- There is now a strong working relationship and good communication between the facility managers and service providers. The Working Group continues to share information on short and long term flood-proofing strategies, most recently during Hurricane Irene.
- The Working Group is evaluating the hybrid approach which includes implementing LID features and practices in the study area, a smaller-scaled storage system under the National Mall to harvest and reuse water for irrigation, and using the existing Constitution Avenue storm sewer to supplement the combined sewer. These actions could provide relief from flooding from smaller storm events and provide other benefits. Facility owners could, as a final line of defense, provide short and long term building flood-proofing to address major storm events.
- The Working Group concluded that it is worthwhile to evaluate flood-proofing for individual facilities as a potentially cost-effective alternative. Many of the facility managers in the study area have implemented flood protection measures for their sites, including repairing conditions that allowed stormwater to flood basements during June 2006, but there has not been a full assessment of their current protection features. In the next few months, the Working Group will assess the flood-proofing needs of the Federal Triangle buildings and consider the best measures for site-by-site and campus scale alternatives.
- The Working Group believes there is much to learn from best practices being employed locally and nationally. The Federal Emergency Management Agency (FEMA) has offered to provide training in national best practices, including steps to avoid floodplain impacts during new construction or to adapt existing buildings in floodplains. The National Capital Planning Commission, the U.S. Army Corps of Engineers, and FEMA will host a flood-proofing seminar for interested stakeholders on October 31, 2011.

Armed with the flood elevation data from this Study, WMATA is developing flood protection for vents and entry areas, and the Smithsonian Institution is using this data to design flood protection for the new National Museum of African American History and Culture. The Working Group members also used the flood elevation data recently to protect their buildings from potential flooding, when the Washington area experienced back-to-back storm events due to Hurricanes Irene and Lee.



▲ The Stormwater Study predicted ponding levels for Constitution Avenue at each of the 7 intersecting north-south streets.

▲ Since the 2006 flood, the National Archives has installed floodproofing elements including self-rising flood gates and watertight doors.

Conclusion

Federal and District agencies continue working together to prevent and mitigate flooding in the monumental core of Washington, D.C. The June 2006 flood focused the need for more mitigation planning, since flooding was not caused by a singular condition, but rather an interrelated set of conditions.

The Working Group believes that the Stormwater Study provides important information about area-wide solutions, and complements previous studies. The Stormwater Study provides federal and District stakeholders a better understanding of the risks from interior drainage flooding, and a more accurate analysis of a 200 year storm. While the flood modeling predicted a flood area that is smaller than what is shown in the DC Flood Insurance Rate Map for the Federal Triangle, it shows that the Federal Triangle facilities are still susceptible to future risks. By demonstrating the scale and cost of structural solutions that can prevent floods, it also demonstrates that solutions to expand system capacity represent major public investments over a long time frame.

The Stormwater Study was undertaken to determine if one or more system-wide alternatives had costs and impacts that are more advantageous than individual solutions. The viable solutions to expand the system capacity identified by the Stormwater Study need to be further analyzed for their ancillary benefits, or compared to less ambitious but more affordable solutions, before implementing efficient and effective countermeasures. In the meantime, the threat of the next big flood is real, and its chances of happening are unpredictable. The Federal Triangle Stormwater Working Group recognizes the need to find a cost-effective solution as soon as possible.

Appendix A:

Previous Studies on Interior Drainage Flooding in the Study Area

Federal agencies have conducted studies on interior drainage flooding in the Study Area in the past as part of larger flood protection studies. These studies informed federal and local policies and actions at the time they were conducted, and provided the foundation for the Stormwater Study.

USACE Flood Study (1992)

In 1992, the U.S. Army Corps of Engineers (USACE) analyzed the relationship between river flooding and interior drainage flooding in a report entitled "General Design Memorandum for the Modifications to Washington, D.C. and Vicinity Flood Protection Project." The USACE concluded that river flood stages have minimal impact on interior flooding.

FEMA Flood Insurance Study (2006)

In September 2006, FEMA updated the 1985 Flood Insurance Study (FIS) for Washington, DC with USACE assistance. The FIS is a standard requirement in delineating the flood zone in communities for flood insurance and regulatory purposes and the basis for the FEMA Flood Insurance Rate Map (FIRM). The FIS evaluates flood risk areas due to river flooding using a combination of hydraulic and hydrologic analyses. The flood area in the monumental core for this FIS update encompassed a bigger land area than what was in the existing DC FIRM because the USACE, who certifies levees, determined that the three levees in the District of Columbia did not meet the new, more stringent standards for certification. The updated FEMA FIRM and FIS for Washington, DC went into effect September 2010.

Interior Drainage Analysis Study (2008)

The updated DC FIRM, which expanded areas designated in the 100 year floodplain in downtown Washington, was a major concern for businesses and local neighborhoods. To mitigate potential economic, physical and environmental impacts resulting from the map revisions, the Government of the District of Columbia initiated the design of the 17th Street levee closure which will bring the existing West Potomac Park Levee System to the 185 year flood protection standard authorized by Congress in 1936 and satisfy the USACE's new certification standards.

The 17th Street levee closure, when completed, will protect the monumental core areas and Southwest Washington, DC communities from river flooding. However, these areas are still at risk from interior drainage flooding. In December 2008, the District of Columbia Government funded an Interior Drainage Analysis by Tetra Tech as part of its Conditional Letter of Map Revision (CLOMR) request to FEMA related to improvements to the West Potomac Park levee. Using FIS data, the USACE Study, and other available data, the Tetra Tech Study considered four different scenarios in predicting the ponding level in the monumental core. The four scenarios simulated interior drainage runoff and ponding for a range of conditions, reflecting the uncertainties present in the operation and performance of the DC storm drain system, catch basins, and pumping stations. The Tetra Tech Study recommended that the predicted interior drainage flood area for the Federal Triangle area associated with Scenario 4 be adopted as part of the CLOMR of the DC FIRM. Scenario 4 looked at the joint probability of flooding due to river and interior drainage, and supplementing the DC sewer system with the Constitution Avenue storm sewer to discharge stormwater out of the Federal Triangle.

GSA Flood Mitigation and Prevention of Federal Triangle Report (2007)

In the aftermath of the June 2006 flood, the General Services Administration (GSA), hired the consultant firm Setty and Associates to analyze the causes of flooding in the GSA buildings in the Federal Triangle, and to propose solutions. The study provided the most complete documentation of the physical damages of the 2006 flood to the headquarters buildings of the Internal Revenue Service, the Department of Justice, the Department of Commerce, and the Old Post Office Annex, and analyzed causes on a by-building basis. The Setty Report noted that each building was capable of handling the stormwater on-site until the infrastructure in the adjacent roadways became overwhelmed. Subsequent disruption of electrical service to building sump pumps caused additional rise in floodwaters and further failure of interior building systems. This study noted the limitations of the sewer system in handling rainfall volumes that exceed the 15 year storm event, and attempted to provide a stormwater drainage solution to protect the federal buildings in the Federal Triangle from future flooding caused by storm sewer back-up. The Setty Report identified mitigation alternatives focused on the following elements:

- Enhancing protocols between the Federal Government and DC Water.
- Creating physical barriers around the buildings to block floodwaters.
- Relocating critical building systems to points above the flood level.
- Providing a better means to physically extract flood waters infiltrating buildings.
- Utilizing a pumping station and storm drain upgrades to reduce flood depths on Constitution Avenue, NW.

The Setty Report also provided an order of magnitude cost estimate and the level of protection for each mitigation alternative. GSA has incorporated the recommendations of this report in its major modernization project for the Department of Commerce. Likewise, the U.S. Department of Justice used the results of this study to inform their building flood protection upgrades.

NCPC Report on Flooding and Stormwater in Washington, DC (2008)

The National Capital Planning Commission staff prepared a report that described river flooding and the existing levee system in Washington, DC, and provided information on the stormwater system and interior flooding issues. This report also identified action items, and served as the impetus for the Stormwater Study.

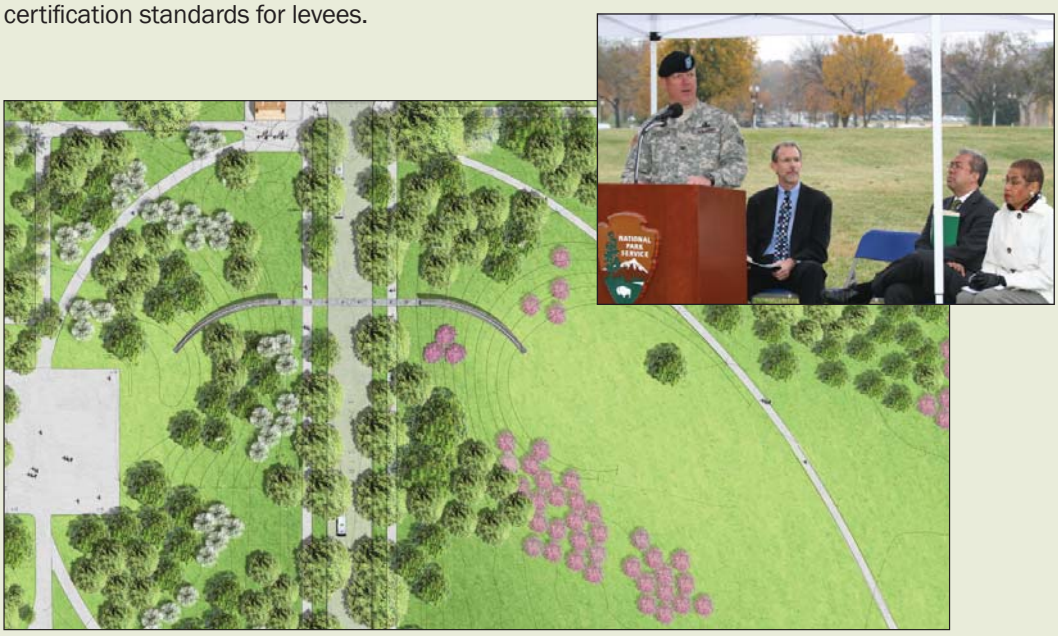
Appendix B:

A Response to Flooding in the Monumental Core

In June 2007, NCPC initiated a two-day Flood Forum, convening a multi-agency stakeholder workshop that brought together 32 governmental agencies and the Downtown DC Business Improvement District to shed light on the challenges and opportunities for developing a collective plan to address flooding in the monumental core. From this Flood Forum, key recommendations emerged for improving emergency planning and coordination, stormwater management practices, and stormwater governance. These recommendations are included in the 2008 NCPC report noted above.

▲ 2007 Flood Forum

In that same year, the National Park Service, the District of Columbia Government, and the USACE commenced the development of the West Potomac Park Levee System improvements to protect the monumental core from river flooding. The West Potomac Park Levee System was built as a result of several major floods, including extensive flooding in downtown Washington due to the Potomac River topping its banks on March 17, 1936. While studies established that the 2006 flooding in the Federal Triangle was caused by interior drainage, independent of the river, the monumental core has historically been vulnerable to river flooding. The 17th Street Levee Closure will bring the existing West Potomac Park Levee System to the 185 year flood protection standard authorized by Congress in 1936 and satisfy the USACE's new certification standards for levees.



▲ Potomac Park Levee Rendering and ground-breaking commencement.

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