DRAFT REPORT TO THE NATIONAL CAPITAL PLANNING COMMISSION ON FLOOD AND STORMWATER IN WASHINGTON, DC

EXECUTIVE SUMMARY

At the September 2006 National Capital Planning Commission (NCPC) meeting, the Commission requested additional information on flooding. This paper provides the requested information and recommends the next steps for reducing the risk of flooding.

GEOGRAPHICAL FLOODING RISK: The District's location at the confluence of the Potomac and Anacostia Rivers, combined with three buried waterways, broad floodplains, and relatively flat elevations, renders it highly susceptible to periodic flooding. A large part of the National Mall and adjacent areas were originally underwater and were filled as L'Enfant's plan was realized. Urban development has increased impervious surfaces, reduced vegetation coverage, and further exacerbated flooding and stormwater runoff through the entire watershed. This problem is especially acute in the National Mall area given its downstream location.

NATIONAL MALL LEVEE: To keep water from the Potomac and Anacostia River systems out of the downtown business district, the U.S. Army Corps of Engineers (ACOE) erected an earthen levee along the north side of the mall, running from the Lincoln Memorial to the Washington Monument. This flood control measure relies upon temporary closures of several north-south streets, which constitute gaps in the levee. To make the levee more reliable, ACOE proposes making two of the temporary closures permanent by extending the levee to meet the higher topography to the north. To ensure the continued flow of cross-mall vehicular traffic, the 17th Street closure would remain temporary, but the barrier would be redesigned to improve its effectiveness and ease of assembly. Given the prominent location of the levee on the Mall, ACOE's improvement plan merits a careful assessment by NCPC.

COMBINED SEWER SYSTEM: Downtown D.C. suffers from inadequate storm sewer capacity making the area especially susceptible to interior flooding. Flooding of the magnitude experienced in June 2006 is costly and can be a security threat if critical building systems are affected and national historic and cultural resources are threatened. While flooding in downtown D.C. is relatively infrequent, the concentration of key federal agencies and the huge federal, local, and private costs associated with recovering from even periodic floods warrants a close examination of cost-effective solutions. Moreover, future growth will further strain the system's already limited capacity.

REGULATIONS & RESPONSIBILITIES: Numerous laws, policies, and executive orders are in place to reduce property loss and environmental degradation caused by flooding, but Washington, D.C. poses some unique challenges. First, the division of responsibilities among various federal and local authorities is not always clear or uniform, and federal facilities in the business district must rely on the local D.C. government to manage, regulate, and otherwise control stormwater. Second, flooding in the nation's capital is particularly unacceptable given the hazards it poses to the security of federal buildings and our nation's treasured historic resources.

POTENTIAL ACTION STEPS: There are a number of strategies NCPC may consider to reduce flooding risks and excess stormwater impacts. First, NCPC may review its own agency's guidelines and policies to increase the level of scrutiny for proposals within or near the floodplains. Second, NCPC may undertake a number of planning initiatives and local and regional partnerships to further evaluate flooding and stormwater issues and research new and innovative measures for stormwater management. Third, NCPC may encourage more proactive stormwater management tactics to improve the "water" baseline and ensure that future development does not exacerbate the situation. No one solution can eliminate the potential problem entirely, but a strategic combination, weighed by the costs and benefits, could help minimize the risk by lowering the frequency and magnitude of flooding that does occur.

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I. FLOOD RISK OVERVIEW

The District is susceptible to four different types of flooding, three of which are caused by excess rainfall or snowmelt, and one by the level of the tide.

- **OVERBANK FLOODING**
  Overbank flooding occurs when the river channels receive more rain than they can handle, or when the river channel is blocked and does not permit the water to flow through.
- **URBAN DRAINAGE FLOODING**
  Urban drainage flooding occurs when the sewer system built to handle stormwater runoff is overloaded past its design capacity.
- **LEVEE-CAUSED FLOODING**
  Areas with levees can be inundated behind the levees because they are relatively flat, and the levee serves as a block to the water flowing to the river. Channels may be built and /or pumps are installed to move the water past the levee.
- **TIDAL / STORM SURGE FLOODING**
  Tidal flooding occurs when there is an abnormal rise in water level preceding a storm, usually a hurricane, due to the combined effects of wind and low atmospheric pressure. The Potomac, up to the base of Little Falls, is tidal, which causes the river to rise and fall with ocean tides. Normal tides have a mean range of 3 feet, but have been known to surge as much as 12 feet in a hurricane.

Major flooding in the Potomac basin occurred in 1889, 1936, 1937, 1942, and 1972. See Appendix A for detailed flooding history in Washington, D.C.

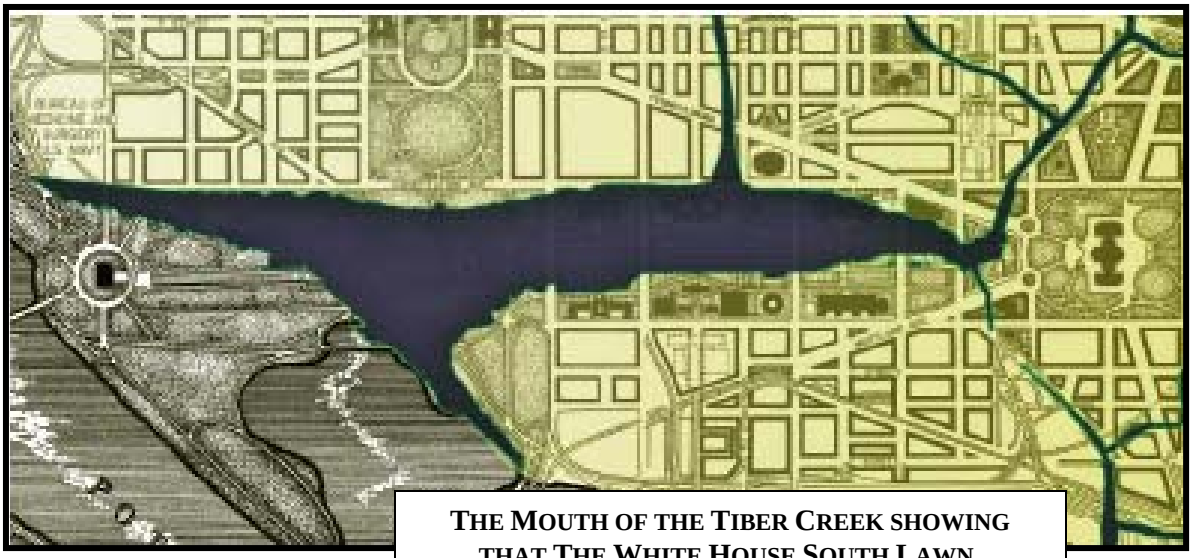
SEA LEVEL RISE

Flooding in Washington is exacerbated with higher sea levels. According to USGS, Chesapeake Bay sea levels are forecast to rise approximately 1 foot over 100 years.[1] The American Museum of Natural History forecasts that a rise in the Potomac River of one foot, combined with a major storm surge, would make the Jefferson Memorial an island and flood the National Mall up to the Reflecting Pool. Hurricane Isabel (2003) produced much more severe flooding in the region than an unnamed August 1933 Hurricane that was similar in its storm track, tidal surge, maximum sustained wind speed, and minimum pressure, possibly as a result of the relative sea rise of one foot since 1933.

WASHINGTON'S HIDDEN HYDROLOGY

Washington has historically had at least three major streams – the Tiber Creek, James Creek, and Slash Run. Tiber Creek[2] was the largest stream system in Washington, at one time draining—along with its tributaries--2,500 acres, or nearly 43 percent of the District. Tiber Creek ran south, beginning near the Armed Forces Retirement Home, through the site of Union Station. Near the East Building of the National Gallery, it turned west and ran roughly along Constitution Avenue for the length of the National Mall. At the base of the White House lawn, where it met the Potomac River, the Tiber was between 700 and 800 feet wide.

[1] The observed Chesapeake Bay sea level rate of increase is roughly twice the global average.
[2] Local farmer Francis Pope is credited with renaming Goose Creek as Tiber Creek, a more grand designation to better suit his 400-acre farm that he dubbed "Rome."



THE MOUTH OF THE TIBER CREEK SHOWING THAT THE WHITE HOUSE SOUTH LAWN, FEDERAL TRIANGLE AND MALL AREAS ONCE WERE ALL UNDER WATER.

James Creek, in Southwest Washington, D.C., formed near where the Tiber turned west, and flowed southeast along South Capitol Street, broadening into a marshy area and into the Anacostia River near Fort McNair. Slash Run was a tributary of Rock Creek and ran roughly south down 18th Street NW and entered Rock Creek near 23rd Street NW.[3]

By the 1870s all three waterways were essentially open sewers and were impounded. The D.C. Board of Public Works embarked on a massive sewer construction program by enclosing the creeks.[4] Washington's present-day hydrologic problems have their roots in the burial of the natural drainage system. Areas in the city plagued by chronic water problems can be located by the original drainage system maps. In 1992, the D.C. Water Resources Research Center reported that the gravelly deposits of the old creek beds still act as conduits for water, with the result that groundwater routinely infiltrates sewer pipes and building foundations along the former waterways.

JUNE 2006 FLOODING

On June 19th, 2006 a wet weather pattern started in Washington. Soon thereafter, from June 25th through June 27th, intense tropical downpours inundated the District. The heaviest rainfall fell from early evening on Sunday, June 25th through the early morning hours of June 26th, with a total recorded accumulation of 7.09 inches on June 25th.

The extensive flooding shut down operations at four key federal office buildings--IRS Headquarters, the Commerce Department, the Justice Department, and the National Archives. Several Smithsonian museums along Constitution Avenue also closed their doors,

[3] Note the historical points at which these waterways enter Washington's Rivers; they indicate the critical points where the ACOE levee protects downtown D.C. from floodwaters.
[4] Sadly, this massive sewer capital improvement system led the District into bankruptcy and caused Congress to take over control of the city. The city was run by a Board of Commissioners appointed by the President until 1974, when, under the 1973 Home Rule Charter, the city elected a Mayor and City Council.

the National Gallery of Art closed due to a weather-related steam outage, and the National Zoo banned cars because of flooding in the parking lot. Rock Creek Parkway became impassable and had to be closed when Rock Creek overflowed its banks and flooded the road.

NATIONAL ARCHIVES BUILDING

Constitution Avenue flooded on Sunday evening, June 25th. Rainwater poured down the driveways of the 7th and 9th Street sides of the building and flooded the transformer vaults and the subbasement areas. The two transformer vaults were submerged in up to eight feet of water.

The freshly renovated (2004) William McGowan Theater is located under the Constitution Avenue steps, was also significant damaged. Flood water flowed down the theater steps, submerging the stage and the first two rows of seats. Electrical power went out immediately, but the sprinkler and security systems remained operational. Sump pumps continued to operate because of the emergency generator, but they were overwhelmed and had no place to pump the water. Fortunately, no original records were affected by the flood.

IRS HEADQUARTERS BUILDING

The IRS Building sustained the greatest amount of water damage, most likely because it has the lowest elevation. Rainfall flowing down Constitution Ave spilled into the moats surrounding the building. The IRS subbasement, which holds all of the building's electrical and maintenance equipment such as electrical transformers, electrical switchgears, and chillers, was submerged in over 20 feet of water. Virtually all major building systems were affected and most of the equipment either had to be extensively rebuilt or replaced.

The basement flooded with five feet of water. The fitness center, cafeterias, offices, systems furniture, carpet, ceiling tiles, computer equipment and vehicles garaged in the building were all destroyed. Complete restoration is not expected until spring 2007.

OTHER FLOODED FEDERAL BUILDINGS

The Smithsonian's Natural History Museum, American History Museum, the Smithsonian Institution Building and the Castle also were closed. PEPCO shut off power to those large government buildings because some basements containing electrical switch gears were flooded, and the buildings all share the same electricity network. The National Gallery of Art also closed because flooding cut off the building's steam supply, which maintains air humidity levels necessary to preserve the artwork.

CAUSES OF THE JUNE 2006 FLOODING

Shortly after the June flood, the General Service Administration (GSA) retained an independent, private consultant to ascertain its causes and to recommend solutions to prevent future flooding. The study was recently completed, although the results are not public. GSA summarized the report so that we could include the consultant's initial findings in this memo.

In short, after interviewing DC WASA, the GSA consultant was unable to determine conclusively why the Federal Triangle area flooded so badly and so quickly. DC WASA was unable to provide an explanation as to why the flooding occurred. In categorizing the rain event, the consultant determined that over a 24-hour period the rainfall was equivalent to the expected rainfall for a 50-year storm event. However, over the most intense 6-hour period of

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the storm, the rainfall was equal to a 200-year storm. The capacity of the D.C. sewer system in the Federal Triangle area is unknown, as it was constructed before such standards were typically adopted.[5] As a result, it would be easy to conclude that the storm exceeded the capacity of the sewer. However, the consultant noted that flooding started before the rainfall should have exceeded the sewer's capacity. In addition, when the flooding dissipated, it also did so at a speed greater than what would be expected.

Power outages caused the 12th Street pumping station to be inoperable, but DC WASA concluded that while a fully-functioning pumping station would have offered some relief, it would not have completely ameliorated the severe flooding. The main pumping stations were operational during the entire storm. The Potomac River remained below flood stage during the entire storm, so backflow was not a contributing cause to the interior flooding.

In summary, the flooding may have been caused by the extreme intensity of the rainfall over a very short period of time, but no one can be sure. The report to GSA includes recommendations for future flood prevention at each of the buildings that flooded and these recommendations, along with the rest of the report, are being reviewed by GSA management.

II. EXISTING & PROPOSED FLOOD CONTROL MEASURES

RIVER OVERBANK FLOODING MEASURES

Washington, D.C. is particularly susceptible to overbank flooding in Potomac Park, along the Tidal Basin, and over the National Mall area up to the Reflecting Pool. These areas have the lowest elevations in D.C. Most of the area with the highest risk of river overbank flooding is parkland under the jurisdiction of the National Park Service (NPS).

NATIONAL MALL LEVEE

As a result of the 1936 Great Flood in Washington, Congress passed the Flood Control Act of 1936, which authorized the US Army Corps of Engineers (ACOE) to design a solution to overbank flooding on the National Mall. In response, ACOE used landfill from the Reflecting Pool to create a levee between the Lincoln Memorial and the Washington Monument. The project began operation in 1940 to protect against a flood discharge of 700,000 cfs on the Potomac River.[6]

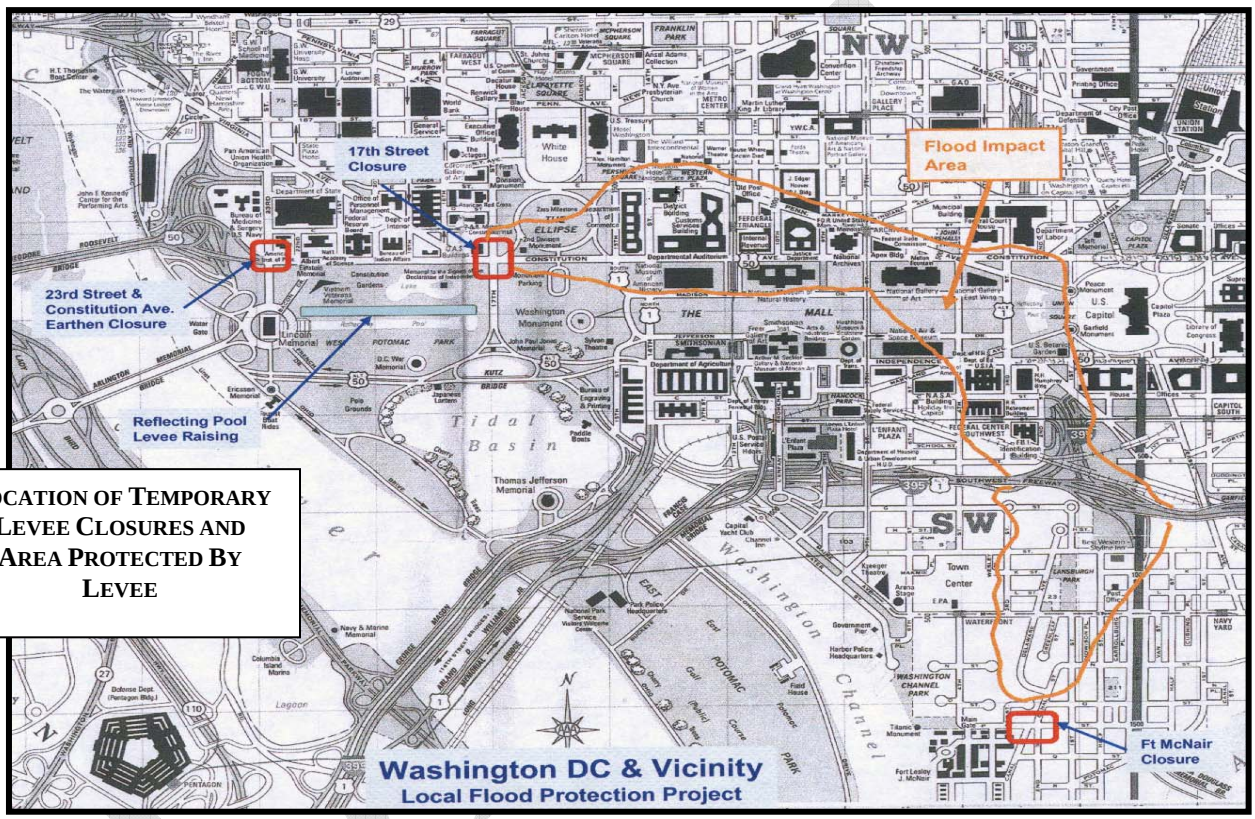
According to ACOE, a considerable portion of the levee was removed during World War II for Navy Department construction. Consequently, it is necessary to construct as much as 1,500 feet of temporary levee in three segments in the event of a major overbank flood to provide protection to the height of the permanent works now in place. See the map below that

[5] Well after most of the sewers in downtown were constructed, DC WASA's predecessor agency established a 15-year storm as the design standard for the system. New sewer construction is designed to this 15-year standard.

[6] It is estimated that the Potomac River's discharge during the 1942 Great Flood was 450,000 cfs when the maximum flood stage was attained. The maximum discharge of record for the Potomac River is 484,000 cfs, which occurred in March 1936. ACOE estimated that an overbank flood of 700,000 cfs has a larger percentage chance of annual occurrence (two percent) than the 15.0-foot tide, which has less than a one percent change of annual occurrence. Consequently, Congress deemed that the ACOE Washington, D.C. flood control measure (the levee) should be built to the 700,000 cfs design standard. According to USGS, the maximum tidal gauge height was recorded at 17.72 ft (D.C. MLW) on Oct. 17, 1942.

illustrates the areas protected from flooding by the current levee when the temporary closures are in place.

Washington flooded again in 1942. Congress passed the Flood Control Act of 1946 which authorized improvements to the levee to restore the level of protection and improve the levee's operation. The levee's overall effectiveness depends on implementing the 1946 improvements; however, ACOE has not completed the improvements because Congress has not funded them. At present, the project is unable to provide the level of protection it was designed to provide because in a flood emergency the levee's effectiveness relies on timely, complete, and correct construction of the three temporary barriers.



LOCATION OF TEMPORARY LEVEE CLOSURES AND AREA PROTECTED BY LEVEE

NOTE: PLEASE ALSO SEE ACOE COLOR MAPS AT THE BACK OF THIS REPORT THAT ILLUSTRATE THE FLOOD INUNDATION AREAS FOR A 100-YEAR STORM EVENT AND THE FEMA DC FLOOD INSURANCE RATE MAPS (FIRM).

WASHINGTON, D.C. EMERGENCY FLOOD PROCEDURES

In the event of a storm, National Weather Service (NWS) forecasts are posted on the Washington Area Warning Alert System (WAWAS) and the National Oceanic and Atmospheric Administration (NOAA) Weather Radio whenever a Potomac River Stage of 7.0 feet mean low water (MLW) or greater is predicted at the Wisconsin Avenue gauge. Currently, the National Park Service (NPS) is responsible for the 23rd Street and 17th Street temporary closures in the National Mall levee.

23rd Street Closure: NPS is to construct the emergency levee at 23rd Street when the Potomac River Stage of 19.0 MLW or greater is predicted at the Wisconsin Avenue gauge.

17th Street Closure: NPS is to construct the temporary levee at 17th Street. The 17th Street closure consists of two structures constructed in two phases. Phase One is a 3-foot high jersey wall barrier with sandbags and plastic sheathing and is triggered when the Potomac River is projected to rise to flood levels over 10.4 feet MLW. Phase One can be put into place relatively quickly, and provides protection up to 15.42 feet MLW. Phase Two is a temporary earth levee located 50-feet north of the Phase One closure and should be initiated immediately after the river exceeds elevation 11.42 feet MLW. Phase Two construction is complex and requires significant construction equipment and embankment material and has the greatest potential for failure.

Fort McNair – The D.C. Emergency Management Agency (EMA) is responsible for the Fort McNair sandbag closure at P and Canal Streets when the Wisconsin Avenue river stage exceeds 23-feet MLW.

PROPOSED NATIONAL MALL LEVEE IMPROVEMENTS

In 2000, ACOE proposed making the temporary closures at 23rd Street and Fort McNair permanent to improve the levee's design and reliability. At 23rd Street, the Corps proposed a 600-foot earth embankment with a maximum height of 3 feet that would run along 23rd Street until it met the existing embankment for the Route 50 ramp. The topographic modifications would then complete the protection line at 23rd Street. At Fort McNair, the Corps proposed a permanent earth berm that would be 1.2 feet high and extend for 570 feet.

The closure at 17th Street NW remains temporary, but will be redesigned to improve its reliability and minimize the construction time needed during floods. Presently, there are a number of options being considered. One alternative is a "borrow pit." The Corps would excavate a portion of the Mall near 17th Street so that the hole could be refilled with aggregate material. During a storm event, NPS staff would excavate that specific location of fill and use it to create an earthen dam across 17th Street. A second alternative is an inflatable dam, known as an aquadam [See below]. A third similar option is a cofferdam, which is an A-frame structure that is erected with a light-weight steel frame and covered with a plastic membrane. [See below] Last, the Corps is considering a "post and panel" temporary dam.

The Corps also proposes to fortify the portion of the levee along the Reflecting Pool by eliminating low spots.

When all of the modifications are complete, the levee would have a less than a 1% chance of being overtopped in any one year. The modifications will bring the top of the existing levee

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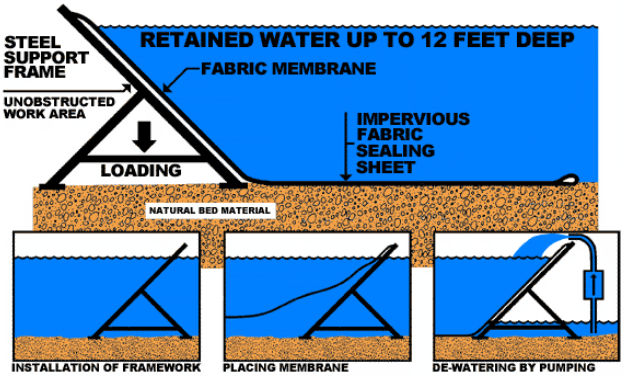
along the Reflecting Pool (between 23rd and 17th Streets) to a uniform elevation and increase the level of freeboard[7] protection provided.

AQUA-DAM



COFFERDAM

ACOE is waiting for Congress to appropriate construction funding for the project. The estimated total cost is $7 million; the project has received just over $3 million in prior funding. ACOE estimates that without the levee closures a major flood could cause more than $200 million in damages to museums, memorials, and office buildings. The flood control project requires NCPC review and approval.

ACOE has not yet completed final designs or construction plans for the two permanent closures and the enhanced 17th Street temporary closure. However, given the levee's prominent location along the National Mall, staff believes ACOE's plans will warrant a close review to ensure that the proposal does not adversely affect the National Mall and its environs.

[7] "Freeboard" is the vertical distance between the normal maximum level of the water surface in a channel, reservoir, tank, canal, etc., and the top of the sides of a levee, dam, etc. It is provided so that waves and other movements of the liquid will not overtop the confining structure.

URBAN DRAINAGE FLOODING

Urban drainage flooding is typically caused by sewer overflows and thus is the responsibility of the D.C. government.[8] One-third of the District, including the entire downtown business district, has a combined sanitary and storm water system.[9] In other words, a single pipe carries both raw sewage and stormwater to the Blue Plains treatment facility. When it rains, the combined wastewater flow can easily exceed the capacity of the combined sewer system and / or the treatment facility.[10] Two harmful things can occur if the capacity of the system is exceeded.

First, excess stormwater causes untreated wastewater to flow directly into nearby rivers. Such discharge of the untreated stormwater is a violation of the Clean Water Act and consequently, the District is under a consent decree to construct storage tunnels to hold the excess untreated water. The consent decree imposes a 20-year implementation schedule for construction to be complete; however, funding is a significant issue.[11]

The project is estimated to cost $1.9 billion and current proposals provide that the entire cost to be borne by the ratepayer base. Presently, D.C. WASA's storm-related activities are funded solely through water and sewer fees.[12]

DC WASA estimates that to finance baseline capital improvements and maintenance, in addition to the long-term plan for the combined sewer overflow (CSO), rates would need to rise annually, with at least eight rate increases above 10% per year for D.C. WASA to raise sufficient capital. D.C. WASA has calculated that if it receives 62% of the capital costs (approximately $960 million) from external sources (i.e. the federal government) that the agency would likely be able to keep rate increases at no more than 8% per year. Congress has made a number of dedicated appropriations to D.C. WASA that currently amounts to approximately $35 million.

Second, excess stormwater may be so great that that the sewer system can not even collect it, and then it floods the streets. The storage tunnel solution described above would not prevent street flooding caused by excess rainfall because the capacity of the sewers under the streets remains unchanged.[13] The storage tunnel merely holds the water for future treatment once it is in the system; not increase the actual capacity of the old receiving sewer tunnels.

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[8] DC WASA sent comments to NCPC's draft report, noting that "urban flooding can be caused by many factors including: improper grading; inadequate location, number or size of catch basins; clogged catch basins; inadequate sewer capacity, and storms which exceed the design capacity of the system. Some of these are the responsibility of the DC Government, while others are the responsibility of DC WASA or private landowners. Other factors are caused by nature and are not the responsibility of any entity."

[9] Combined sewer systems, introduced in 1855, were a vast improvement to the open cesspools originally used to convey wastewater, and are common in most older cities. As a result, many cities still struggle with the attendant pollution from combined sewer overflows.

[10] Combined sewer overflows (CSOs) should occur only during wet weather. However, according to D.C. WASA's overflow predictions, in an average year, less than 0.5" of rain can cause more than 3 hours of untreated sewage to flow into the Anacostia River. Such an occurrence is predicted to occur more than 50 times in an average year.

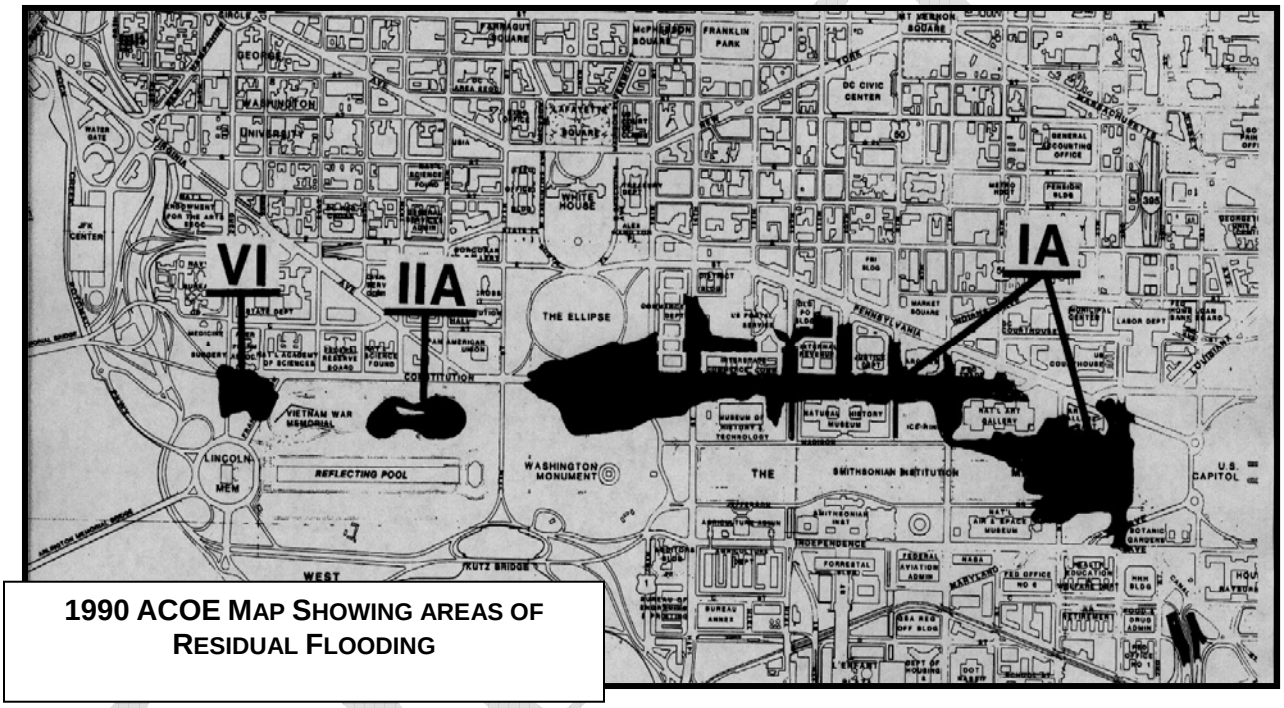
[11] The consent decree was entered March 23, 2005.

[12] Typically, in other cities, the costs of municipal stormwater programs are funded through a combination of real property taxes, general revenues, and user fees.

[13] For the Northeast Boundary area, the proposed CSO tunnels have a dual purpose: CSO control and flood relief. The LTCP is designed to provide flood relief to known flood areas in Northeast Boundary.

One additional predicament is that when the river level rises above the outfall pipes, water can back up into the system and cause reverse flooding. This should be resolved by the gates that D.C. WASA installed at the outfall pipes, but there have been problems with the gates in the past either being open during a storm or not functioning completely. The tide gates at the outfall pipes specifically prevent backflow of river water to Blue Plains Wastewater Treatment Plant during high river levels. This protects the Plant against treating extraneous river water. However, tide gates are not typically relied upon to protect life or property during river floods.

In those situations, a "positive" means of shutting off flow is used such as sluice gates or stop logs. For example, in the current ACOE Flood Emergency Manual for D.C., locations are identified where stop logs are to be inserted in sewers to prevent backflow during river floods.



1990 ACOE MAP SHOWING AREAS OF RESIDUAL FLOODING

ACOE developed a map to illustrate the areas that would experience street flooding in a storm event that produced rainfall greater than what the sewer system could handle. This ACOE map delineating the flooded areas corresponds almost exactly to the areas that flooded in June 2006. See map above. Consequently, it appears that interior flooding is a separate, persistent issue that needs a separate solution.

TIDAL FLOODING MEASURES

Washington is also susceptible to tidal flooding and tidal surges. Tidal flooding in the Potomac River can be caused by hurricane tidal surges that form in a number of ways. The surges produce the highest water levels in the upper Potomac when they coincide with the astronomical high tide.

In 1955, a year after three successive hurricanes ravished the northeastern seaboard, Congress directed ACOE to evaluate cost effective structural measures to reduce the human and property losses from future hurricanes. ACOE prepared a report that evaluated the risk of

tidal flooding in the Washington, D.C. metropolitan area and concluded that while the area was vulnerable to severe damage from hurricanes, the relief from tidal flooding by structural means could be accomplished by protective works needed for overbank flooding control.

The report concluded that effective zoning was the most important solution for reducing flood hazards:

> *The continuing encroachment on the tidal flats and floodplains of the Potomac River in the Washington area has seriously reduced the capacity of the stream to pass fluvial floods and absorb tidal floods without losses. Zoning regulations to stem the encroachment on the waterfronts and to establish future structures at safe elevations are needed.*

ACOE has not reevaluated Washington tidal flooding since the original report, completed over 50 years ago.

FLOODING CONCLUSIONS

The most frequent types of flooding in Washington, D.C. are the consequences of river overflow and urban drainage failures. Excess stormwater can trigger either type of flooding, but they occur independently. Overbank flooding is an easier risk to manage because fairly reliable warning systems typically provide longer lead times before the flooding begins. For example, the average rate of flood crest travel time from Point of Rocks, MD to the Wisconsin Avenue gauge is approximately 11 hours. Urban drainage flooding, however, provides emergency workers with less advance warning since the onset of urban flooding is harder to pinpoint reliably, as illustrated by the June 2006 flood.

A number of factors unique to D.C. make flood control and stormwater management more vexing. First, while many of the riparian areas in D.C. are parklands that retain some of their natural floodplain functions, many priceless monuments, museums, and national structures are located in areas likely to flood. Many monuments are designed to withstand intermittent flooding, but clean-up can be costly and the impacts of repeated flooding may compound over time. For other structures, flooding can be devastating and irreversible, as would have been the case at the National Archives if the agency had been unable to mitigate the June 2006 flooding.

Second, the federal government is the largest developer, tenant, and property owner in downtown DC. This creates a significant federal interest in the cause and effect of flooding. Moreover, as a significant amount of stormwater in this area is routinely generated through run-off and de-watering at federal facilities, the federal government may, over time, be able to address some of the issues of peak period and overall runoff, through individual and coordinated design and operational actions. These actions may also support larger federal goals supporting green building and environmental objectives.

Lastly, the responsibilities and jurisdiction for addressing stormwater and flooding in the District, and specifically in the downtown area, are complex. Many possible solutions, whether structural changes to the sewer system, or using “low-impact” development or green building design strategies, are costly or beyond the ability of a single jurisdiction to require. Therefore, developing coordinated and comprehensive strategies will require coordination between federal and local agencies alike.

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III. WHAT IS THE FEDERAL ROLE IN FLOOD PREVENTION AND STORMWATER CONTROL?

The full panoply of floodplain laws, regulations, executive orders, policies, and agency guidance, implemented over the past 100 years on federal, state, and local levels, is complex, comprehensive, and somewhat disjointed. [See Appendix C for a chart of the relevant federal laws.] The National Flood Insurance Program (NFIP), implemented by Federal Emergency Management Agency (FEMA), is the most well-known federal flooding statute. The 100-year floodplain maps and the federally-mandated and subsidized insurance program are the hallmark of NFIP. However, there are a number of other federal statutes and requirements that also play a role and these are discussed in more detail below.

In addition to federal laws and regulations, the District has its own responsibilities and rules. Some of the local rules are federal requirements, such as the building regulations for construction in a FEMA-designated floodplain, while others, such as the Anacostia Waterfront Initiative's stormwater regulations, are entirely local requirements.

NATIONAL FLOOD CONTROL

NFIP is the key federal statute with regard to flooding. Under NFIP the federal government accepts a significant share of the responsibility for flood prevention, control, emergency response, and property loss. The statute's underlying principle is that there should be development restrictions within the floodplain for the dual purpose of reducing flood damage losses and minimizing disruption to the floodplain's natural function of storing excess water and draining water over land areas and into the floodway.[14] NFIP directs FEMA to develop maps nationwide that delineate the floodway and the floodplain[15]. A Flood Insurance Rate Map (FIRM) is the official map on which FEMA has delineated both the special flood hazard areas and the flood risk premium zones applicable to the community. Structures built before the FIRM or before 1975, whichever is later, are eligible for flood insurance with premiums that are reasonable, and if necessary, federally-subsidized.[16]

Typically the maps are developed in conjunction with the local government. Buildings within the floodplain must obtain private flood insurance. Flood insurance eligibility is based on communities adopting development restrictions that meet minimum federal requirements.

FEMA 100-YEAR FLOODPLAIN MAPS

An enduring problem nationwide is that the FEMA-issued flood insurance maps are out-of-date. The District maps are approximately 21-years old.

The D.C. Department of the Environment (DCDOE) and FEMA are digitizing, but not updating, the 1985 D.C. floodplain maps. Once the maps are complete, the agency will schedule a

[14] "Floodway" means the regular channel of a river, stream, or other watercourse, plus the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot.
[15] "Floodplain" means the low area of land surrounding water bodies that holds the overflow of water during a flood.
[16] Consequently, NFIP is one of the largest domestic fiscal costs along with Social Security, Medicare and Medicaid.

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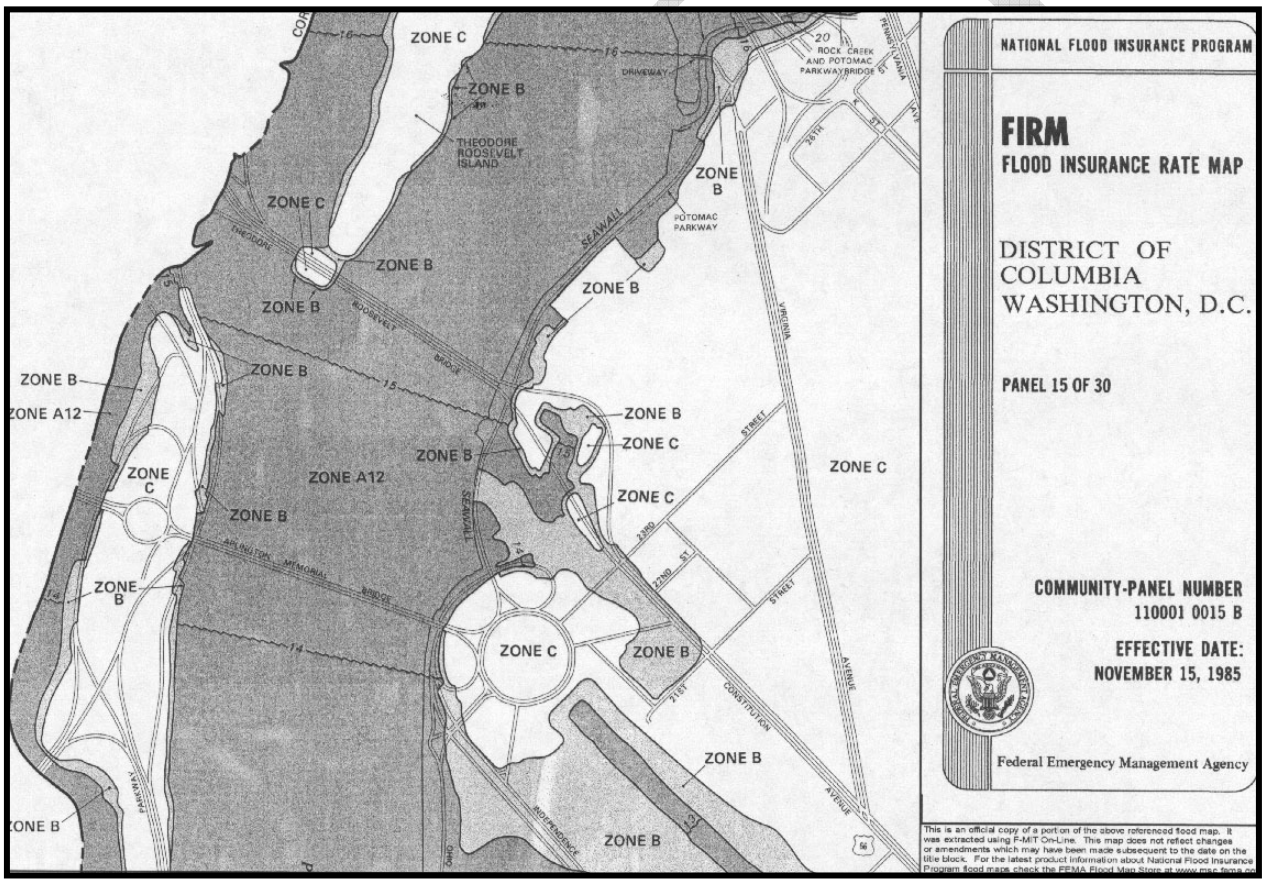
public hearing and then they will be sent to the D.C. City Council for adoption. The process that leads to final adoption can last as long as a year. Once the maps are adopted, new flood insurance requirements become effective.

Development and impervious surface coverage within the watershed has been sizeable, which could also easily require a change in the delineation of the floodplain area. In March 2005, the Maryland Department of the Environment completed a study determining that:

> *In flat areas, structures located within **several hundred feet or more** horizontally of the 100-year floodplain line may also be at risk.*[17]

However, the D.C. floodplain delineations will not be revised to reflect any changes in sea level or development in the watershed as part of the digitalization process. The D.C. Flood Emergency Manual contains maps prepared by the Corps delineating the area ACOE predicts will flood for the 100-year storm. (See Corps map that is attached to the report.) The inundated area is larger than the FIRM's 100-year boundary, and more closely corresponds to the FIRM's 500-year floodplain line.



DC 1985 FIRM
ZONE A: WOULD FLOOD IN 100-YEAR EVENT
ZONE B: WOULD FLOOD IN 500-YEAR EVENT

[17] Emphasis added.

EXECUTIVE ORDER FOR FLOODPLAINS

In 1977, President Carter, faced with ever increasing flood costs, issued Executive Order 11988 to hold federal agencies to a higher standard than the NFIP rules.

Executive Order (EO) 11988 affirms that the federal government should not encourage floodplain development in all of its actions and funding mechanisms. The President's statement that accompanied the EO noted that flood losses and adverse alteration to floodplains arise mainly from "unwise land use practices." Further, it states, "Floodplain development … is simply a bad Federal investment and should be avoided." The EO required all executive branch agencies to develop compliance procedures. As a result, on September 17, 1981, NCPC adopted floodplain management procedures that apply to all actions that "have the potential for adversely impacting floodplains…or which are subject to potential harm by location in floodplains." According to the procedures, if NCPC finds that an action meets the above test, then the Commission is required to (1) identify the full range of potential direct or indirect adverse impacts, and (2) identify and evaluate practicable alternatives outside the floodplain including the "no action" alternative. The procedures require public notice for any plans, proposals, or actions in floodplains followed by a 30-day review and comment period. A "Statement of Findings" is required for all plans, proposals, or actions in floodplains and must include why the action is proposed to be in the floodplain; whether the action conforms to applicable state and local floodplain management standards; the list of alternatives considered, a list of mitigation measures; and a map delineating the proposal's location and its relationship to its environs.

NCPC's procedures also amend NCPC submission guidelines for federal agency projects to require a copy of the submitting agency's Statement of Findings pursuant to EO 11988 if the proposed project is within a floodplain.

In theory, the NEPA environmental review can satisfy the EO's requirements. However, the EO requires more affirmative action to avoid floodplain harm than NEPA requires.

THE NATIONAL ENVIRONMENTAL PROTECTION ACT

The National Environmental Protection Act (NEPA) also plays a role in flooding, floodplain management, and stormwater control. NEPA requires federal agencies to assess potential environmental impacts before undertaking any federal building projects or site changes that significantly affect the quality of the human environment. The environmental review should discuss whether any proposal would be affected by flooding, as well as whether the proposed action would likely increase flooding. Floodplain development is typically scrutinized more closely for adverse impacts than development outside the floodplain. Stormwater runoff and its potential impacts are also likely to be part of an environmental review assessment. In general, the submitting agency is responsible for ensuring that a thorough and comprehensive environmental assessment is completed for each proposed action, and that alternatives are considered, before final action is taken. However, as a federal agency, NCPC has an independent obligation under NEPA to assure this information is available before it makes any decisions about a project. Moreover, when analyzing the proposal and alternatives, federal agencies must consider the direct or indirect

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consequences — that is, connected, similar, and cumulative actions. These actions should be incorporated into the description of the proposal and alternatives.[18]

THE CLEAN WATER ACT

The Clean Water Act (CWA) regulates stormwater discharges from industrial activities (which include construction activities and municipal sewer system discharges) under the National Pollutant Discharge Elimination System (NPDES) permit program. NPDES regulates water quality. Municipal sewage system operators, private developers, and the federal government are all required to comply with the NPDES permitting program.[19]

EPA administers the CWA and NPDES program and in many instances delegates permitting authority to the states. However, the District is not a delegated state and EPA retains NPDES permitting authority with regard to both construction activities and municipal sewer discharge in D.C..[20] For construction, stormwater runoff is regulated both during construction and after construction is complete. Consequently, a developer in D.C. is required to prepare a stormwater pollution prevention plan in accordance with the EPA General Permit, submit the plan to EPA, and file a notice of intent to start construction. The stormwater plan governs runoff for the period of construction and then for the building once construction is complete.

REVIEW OF NATIONAL CAPITAL PLANNING COMMISSION ACTIONS

Staff reviewed a number of executive director's reports and environmental documents prepared for projects in the monumental core to better understand how flooding and stormwater issues have been considered. While many, but not all, of the documents do include information on stormwater and flooding issues, the analyses have not always been consistent in either the range of issues reviewed, the scope of the evaluation, or the final conclusions reached. Further, the analyses that we reviewed focused on specific impacts to projects, and there was typically little discussion on how development might increase the likelihood of flooding. We have not identified any documents discussing the cumulative impact of development on stormwater and flooding in this area.

In addition, to assist our review, the National Park Service provided details to NCPC on how a number of memorials located within or near the floodplain have dealt with potential flooding issues (See Appendix B). We also spoke with a number of federal agencies regarding flooding and stormwater, and found that all of the agencies were aware of flooding and stormwater issues specific to their own facilities. Many of the agencies expressed an interest in better understanding how other agencies were addressing flooding and stormwater, as well as looking more comprehensively at the issue in the downtown area.

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[18] For an EIS, 40 CFR § 1502.16 which incorporates the definitions from 1508.7 and 1508.8 and for an ES, 1508.9(b) which also incorporates the definitions from 1508.7 and 1508.8. Also, see generally NCPC Environmental Submission Guidelines Section 10 and Appendix B, Section 3(A).

[19] The CWA specifically mandates that all departments or agencies of the executive, legislative, and judicial branches of the federal government comply with Federal, State, interstate, or local stormwater regulations. Further, EO 12088, "Federal Compliance with Pollution Control Standards," directs each executive agency to develop annual plans for the control of pollution and to ensure that sufficient funds for compliance are requested from OMB in the agency budget.

[20] In fact, the consent decree for the sewer storage tunnels was developed to settle an enforcement action brought by the United States against DC WASA because it is in violation of the NPDES permit EPA issued to it.

IV. WHAT IS THE DISTRICT OF COLUMBIA'S ROLE WITH REGARD TO FLOOD PREVENTION AND STORMWATER CONTROL?

DISTRICT STORMWATER LAWS AND REQUIREMENTS

In the District, stormwater management is a responsibility shared jointly among four District agencies: the D.C. Department of Health (DC DOH), the D.C. Water and Sewer Authority (DC WASA)[21], the D.C. Department of Public Works (DC DPW)[22], and the District Department of Transportation (DDOT). Recently, DC DOH's flood and watershed responsibilities, including stormwater, were transferred to the newly formed Department of the Environment (DC DOE). In February 2007, DC DOE will take over all responsibilities of managing the MS4 permit-related (described below) activities that DC WASA previously handled.

DC DOE is responsible for monitoring water quality in the Anacostia and Potomac Rivers. DC DOE is also responsible for reviewing developers' plans for compliance with D.C.'s stormwater management and erosion and sediment control regulations, monitoring implementation with management plans through inspections, and investigating illegal discharges to the sewers. Developers cannot obtain a building permit from the Department of Consumer and Regulatory Affairs (DCRA) until DC DOE ascertains that the developer has complied with D.C. stormwater rules. Construction activities that do not disturb more than 5,000 square feet of land area are exempt. Federal agencies follow the same procedure as private entities to comply with D.C.'s stormwater rules. Federal agencies, such as GSA, submit their stormwater management plans to DCRA for DC DOE to review and approve the plan, even though GSA does not ultimately need a local building permit.

Stormwater plans must meet several requirements, including an important directive that stormwater flow from the site will not increase after development over the pre-construction baseline.

DC WASA is responsible for maintaining the District's sewer system, and cleaning the catch basins.

D.C. FLOODPLAIN REQUIREMENTS

The District promulgated development regulations, known as the D.C. Flood Hazard rules, for buildings proposed to be constructed in a floodplain.[23] These rules, mandated by NFIP for a community to be eligible for federal flood insurance, restrict uses, activities, and development in areas subject to flooding (generally within the 100-year floodplain). If development is permitted in an area likely to flood, it must be flood-proofed. The Flood Hazard rules are triggered when an applicant seeks a building permit in the District.

D.C. CLEAN WATER ACT REQUIREMENTS

The District is required to obtain two NPDES permits for its stormwater discharge as a municipality: one for the Municipal Separate Stormwater Sewer System (MS4) which drains storm water from approximately two-thirds of the city into the rivers, and one which covers the Blue Plains Wastewater Treatment Plant and the combined sewer system.

[21] Unlike the other three agencies, DC WASA is an independent authority that was formed to assure that the money collected for the purpose of maintaining the water and sewer system would not be transferred into the DC General Fund.
[22] DC DPW's responsibility is primarily street sweeping, waste collection, litter control, and road repair.
[23] As approved by FEMA.

ANACOSTIA WATERFRONT INITIATIVE

The Anacostia Waterfront Corporation (AWC) has proposed additional stormwater requirements that are stringent and comprehensive. AWC has proposed that any development that receives AWC financing or is on AWC-controlled property must adhere to stringent stormwater guidelines, which require retention and on-site reuse of stormwater.

The federal government has not yet committed to voluntarily follow the AWC stormwater guidelines. However, AWC is likely to request compliance and possibly seek a Memorandum of Understanding (MOU) from the federal government, as a result of which, federal agencies would follow the more stringent AWC stormwater rules.

D.C. FLOOD EMERGENCY PLAN

Atypically, the Army Corps of Engineers (ACOE) developed the Flood Emergency Plan for the District. Generally ACOE is responsible for developing emergency flood plans for the dam structures; while the local government entity is responsible for developing a local flood emergency plan. The first D.C. plan was developed in the late 70s and is revised periodically.[24]

ACOE is responsible for flood control measures nationwide, and consequently has designed and provided construction oversight of the National Mall levee since Congress authorized it. FEMA recently asked ACOE to certify the levee as the line of delineation for the 100-year flood event. The significance of this certification is that private development on the other side of the levee (in the downtown district) would not need to obtain flood insurance and would not need to meet the D.C. Flood Hazard regulations.[25] While ACOE has not responded officially in writing, ACOE stated it will not certify the levee to FEMA because it believes the temporary closures do not sufficiently ameliorate the flooding risk. Once the ACOE decision is transmitted in writing it is likely that there will be increased pressure on Congress to fund the permanent levee closures so that ACOE can certify the levee and exempt private development from needing flood insurance and flood-proofing requirements.

With or without the ACOE proposed modifications, urban drainage flooding nonetheless remains an unmitigated flooding risk.

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[24] DC reviews the ACOE Flood Emergency Plan and may provide input to ACOE.

[25] Recall that ACOE was criticized heavily for certifying the levees in New Orleans. Consequently, many of the homes that flooded after the levees failed did not have insurance because it was not required. Certification deemed them "outside" the 100-year floodplain and they were believed to be safe from flooding because the levees would protect them.

V. NEXT STEPS / ACTION PLAN

In short, our research led us to three key conclusions. First, while the definitive cause of the June 2006 flooding may not be determinable, the rainfall totals in Washington, DC were extraordinary and at times equal to a 200-year storm event. However, even though the rainfall was much greater than normal, it exposed our second finding, that is flooding poses a risk to the federal government in the Federal Triangle and National Mall areas. Flooding is a risk to the national cultural and historic resources in the area, a financial risk for the property damage, and a security risk given the concentration of key federal functions. Last, even in amounts far below flood stage levels, stormwater control is an on-going issue for which there is not a long-term federal or local management plan in this important area. NCPC could play a leadership role in the development of such a plan, if the Commission chooses. At a minimum, the Commission can consider revisions to our project review procedures and adding stormwater considerations to our relevant planning initiatives.

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APPENDIX A: List of Major Flood Events in Washington, D.C.

FLOOD YEAR	NAME (HURRICANE)	FLOODING ELEVATION [26]/ PEAK DISCHARGE	COMMENTS	RECURRENCE INTERVAL (YEARS)
1889			▪ Potomac crested at 12.5' above flood stage	50 to >100
1933	Unnamed Hurricane	+11.0' LWD	▪ Most destructive hurricane on record for Chesapeake Bay and D.C. ▪ Storm surge highest of record on Bay and Potomac; superimposed on astronomical high tide	
1936		28.10 484,000 cfs -- Little Falls	▪ Thick ice, snowmelt & intense rainfall runoff	90
1937		23.30 40,100 cfs	▪ Huge storm over entire northeast	
1942		25.88 394,200 cfs	▪ Floodwaters reach the Lincoln Memorial steps ▪ Rainfall 6.27" ▪ Rainfall 10-15" to west	
1954	Hazel	+8.7' LWD	▪ Second most destructive ▪ Storm surge of 5.6' ; imposed on astronomical high tide	25 to >100
1955	Connie	+6.6' LWD	▪ Tidal surge of 5.6' on astronomical low tide ▪ Would have reached +10' LWD if superimposed on high tide	5 to 10
1955	Diane	+7.0' LWD	▪ Surge approximately 4.5' ▪ Heavy rainfall increased damage and flooding after Diane passed through area	
1972	Agnes	22.03 359,000 cfs – Little Falls	▪ Greatest MD flood ▪ More deaths and property damage in MD than in D.C.	50 to >100
1996		19.29 317,000 cfs - -Little Falls	▪ Potomac rose 85' in 48 hours ▪ Fifth largest flood in D.C.	30
2001			▪ 7" rain fell on D.C.	
2003	Isabel		▪ Washington Harbor Flood gates raised, Levee closed ▪ Potomac above flood stage	
June 2006		86,200 cfs (6/29/06)	▪ Short period of excessive rainfall	1.5

[26] Flood Stage at the Wisconsin Avenue gauge is 10.0 feet. Sea Level Conversion (SLC) at this gauge is 37.95. To convert to sea level, add the SLC to the river stage to determine if a property is in danger of flooding.

APPENDIX B: Information Submitted to NCPC By National Park Service on Memorials

MEMORIAL	NPS COMMENTARY
Background	Before West Potomac Park was completed the topography of lower Northwest D.C. formed the shoreline. Higher ground elevations were present at the Naval Hospital site, Square 63 and Square 88, but the squares east of 21st Street were low and subject to tidal action. The architectural walls that separate the garden forecourts to the Federal Reserve, Interior South and the Pan American Union Annex buildings built between 1931 and 1945 are set at elevations between 21.40 and 23.75. Elevation 19.1 represents the level of the 250 year storm event.
Korean War Veterans Memorial	The civil engineering analysis by ACOE determined that the memorial (based on the November 1985, D.C. Federal Emergency Management Agency Map, Panel Number 11001-0015B) is located outside the limits of the 100-year floodplain, but within the 500-year flood. No significant site modifications were required. There is a mechanical room with an area way entrance whose top elevation is between 13.5 and 14.5 that would be below the 15.6 foot 100-year event. This space will be protected by a temporary barrier of sand bags in the event of a 100-year event.
Franklin Delano Roosevelt Memorial	The granite walls of the Memorial are built to elevation 19.5 and at critical equipment areas to elevation 22.50 and elevation 22.95. The park grounds around the memorial are between elevation 8.5 and 12.0 and subject to a 100-year event of elevation 15.6. The Entry Building at the FDR Memorial has a floor elevation of approximately 11.0 and is managed to be cleared in the advance of predicted flooding.
World War II Memorial	The centerline of Memorial on 17th St. SW is at elevation 8.7 feet, while the original Rainbow Pool was at elevation 5.6 feet, and is subject to impact by a 100-year storm event elevation of 15.6 feet. The location of the memorial just outside the existing levee's protection area was noted in the May 1998 Environmental Assessment. The memorial was designed to withstand the impacts of flooding so that significant property damage and potential environmental impacts would not occur. The equipment room of the WW II Memorial is designed to be sealed from flood waters, while the memorial itself can be flooded and subsequently flushed of debris and deposited sediments.
Vietnam Veterans Memorial	The Memorial is protected by the National Mall levee.

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APPENDIX C: Relevant Laws and Regulations for Flooding and Stormwater Management

FEDERAL LAWS / RESPONSIBILITIES	FEDERAL AGENCY OVERVIEW	NCPC	NPS	FEMA	ACOE	GSA
National Flood Insurance Program (NFIP)	FEMA has implementation responsibility. Other federal agencies must evaluate actions in 100-year floodplain.		While not directly from NFIP, NPS implements temporary flood control closures on the Mall at 17th and 23rd Street.	Develops D.C. FIRM, approves D.C. Flood Hazard Rules, works with D.C. Emergency Mgt .	Designed & constructed National Mall levee	
EO 11988 -- Floodplains	Federal agencies should avoid floodplain development – agencies must evaluate actions in floodplains, to disclose if action will occur in a floodplain, and if so, what alternatives were considered to avoid adverse effects and incompatible development.	Must evaluate any action in floodplain, disclose impacts, consider alternatives	Must evaluate any action in floodplain, disclose impacts, consider alternatives	Must evaluate any action in floodplain, disclose impacts, consider alternatives	Must evaluate any action in floodplain, disclose impacts, consider alternatives	Must evaluate any action in floodplain, disclose impacts, consider alternatives
NEPA	Agencies must conduct an environmental assessment or EIS for any proposed action that may significantly affect the human environment, disclose unavoidable adverse impacts, and consider alternatives	NCPC's NEPA submission guidelines require discussion of environ'al impacts of proposal & alternatives on floodplains, flooding and stormwater impacts	NPS must evaluate envn'tal impacts of its actions & alternatives on floodplains, flooding, and stormwater impacts		Must evaluate environmental impacts of flood control measures & alternatives on floodplains, flooding, and stormwater impacts	GSA must evaluate environmental impacts of its actions & alternatives on floodplains, flooding, and stormwater impacts
Clean Water Act	Regulates stormwater discharges from construction activities and sewer system discharges		As developer and property owner must comply with CWA			As developer and building owner must comply with CWA
Misc. Considerations			Costs from flooding impacts on memorials borne by NPS	Called to action when federal disaster area declared	Developed D.C. Flood Emergency Plan	As landlord, responsible for such flood clean-up and prevention

Appendix D: Useful Acronyms and Other Important Abbreviations

100-year flood	A flood that has a 1-percent chance of being equaled or exceeded in any given year. A base flood may also be referred to as a 100-year storm and the area inundated during the base flood is sometimes called the 100-year floodplain.
ACOE	U.S. Army Corps Engineers
AWC	Anacostia Waterfront Corporation
cfs	cubic feet per second – the common unit of measure for the flow of a river
CSO	combined sewer overflow – what happens when an excess of stormwater and / or sewage exceeds the systems capacity and flows without treatment into the rivers
CWA	Clean Water Act
DC DOE	D.C. Department of the Environment
DC DOH	D.C. Department of Health
DC DPW	D.C. Department of Public Works
DC EMA	D.C. Emergency Management Agency
DCRA	Department of Consumer and Regulatory Affairs
DC WASA	D.C. Water and Sewer Authority
DDOT	D.C. Department of Transportation
DOD	Department of Defense
EPA	U.S. Environmental Protection Agency
EO	Executive Order
FCIP	Federal Capital Improvement Plan, prepared by NCPC
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map – prepared by FEMA, required by NFIP, shows 100-year and 500-year floodplain
GSA	General Service Administration
LEED	Leadership in Energery and Environmental Design - the green building system of the U.S. Green Building Council
LTCP	Long Term Control Plan
MLW	Mean low water– the average height of the low tides over a 19-year period
MOU	Memorandum of Understanding
MS4 Permit	Municipal Separate Stormwater System Permit, required by CWA for municipal stormwater systems
NEPA	National Environmental Protection Act
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NWS	National Weather Service
OMB	Office of Management and Budget
USGS	U.S. Geological Survey
WAWAS	Washington Area Warning Alert System

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APPENDIX E: Flood Stages for the Potomac River from USGS

24.1 Water begins to inundate Constitution Avenue near the Lincoln Memorial at the low spot on Henry Bacon Drive.

22.2 Water begins to reach the Pentagon East parking area.

20.5 Water begins to inundate the north end of the N-S runway at Reagan National Airport.

19.0 Water begins to flood the south end of the N-S runway at Reagan National Airport.

17.0 Water approaches the SE end of the NW to SE runway at Reagan National Airport.

16.7 Water begins to inundate the Kennedy Center for Performing Arts at Rock Creek and Potomac Parkway.

16.0 Water approaches low spots of the 14th Street Bridge approach on the D.C. side of the river. Water also reaches George Washington Memorial Parkway south of Reagan National Airport near Four Mile Run.

15.0 Water inundates portions of Maine Avenue.

13.7 Water approaches East Potomac Park at the railroad bridge.

13.0 Wisconsin Avenue and K Street are flooded.

12.0 The parking lot at the foot of Wisconsin Avenue in Georgetown floods.

11.0 There are no longer tidal effects. The river will rise to crest then fall, not seeing the separate high and low tides again until the water drops below 11 feet.

10.5 Water approaches Independence Avenue at 17th Street and the George Washington Memorial Parkway at the railroad bridge north or Reagan National Airport.

10.0 Water approaches K Street in Georgetown near Washington Harbour.

7.0 Water begins to inundate Washington Harbor.

6.0 Water reaches bulkhead along Washington Harbor.

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