JUNE 2015

CLIMATE PROJECTIONS & SCENARIO DEVELOPMENT

CLIMATE CHANGE ADAPTATION PLAN FOR THE DISTRICT OF COLUMBIA

RFA: 2013-9-OPS

PREPARED FOR

WE ARE WASHINGTON DC

DEPARTMENT OF ENERGY & ENVIRONMENT

PREPARED BY

PERKINS + WILL

KLEINFELDER

INTERIOR FLOODING HAZARDS

Due to its location at the confluence of two tidally influenced rivers, the District is influenced by three primary types of flooding: interior (inland drainage), riverine and coastal. Different storm events will result in various combinations of flooding – some resulting in more inland impacts, while others may be more coastally influenced. It is interesting to note that storm surge has the potential to turn drainage outlets into inlets with the potential for causing flooding miles away from the coast as it travels through the piped infrastructure and surfaces in remote, interior sections. Table 5 summarizes major historical flooding events in the District dating back to 1889.

The Federal Emergency Management Agency (FEMA) updated its Flood Insurance Rate Maps (FIRMs) for Washington, DC in 2010. FIRMs were issued for 100-year (1%) and 500-year (0.2%) recurrence intervals. FIRMs are based on historical data (up to 2003) and account for both riverine and tidal flooding (Figure 8). Flood inundation estimates were developed with the Hydrologic Engineering Center-River Analysis System (HEC-RAS) computational model to obtain backwater elevations using flood frequency inputs, and created as follows:

- Flood frequencies for nontidal river segments were based upon frequency analysis at nontidal gauges.
- Flood frequencies for tidal river segments were based upon gauges in the tidal portions.
- Flood frequencies for ungauged river segments and watersheds were based upon rainfall-runoff relationships or regression equations. It was not reported how flood frequencies were determined in the tidal portions of ungauged streams.

NOAA tidal gauge 8594900 is an important data source due to its location near the confluence with the Potomac and Anacostia Rivers. Data from this gauge was used to correlate flood frequencies and tidal elevation for both rivers (FEMA, 2010). Tidal gauge 8594900 data was also used for sea level rise projections in this study.

Current FEMA flood mapping is based on riverine modeling with historical flood frequency inputs, and does not account for potential future effects of climate change. For example, if FEMA riverine modeling inputs were revised to account for 100-year, 24-hour precipitation projections, then projected 100-year flood depths and extents would increase relative to current estimates.

There are historic precedents for similar events. In June 2006, 6 inches of rain fell in a 6 hour period, which is comparable to the 200-year, 6-hour storm event as shown in Table 3. The event caused extensive flooding in the Federal Triangle Area. As captured in Figure 7, several Federal buildings were damaged and businesses were interrupted as a result of inundation of two DC Metro train stations that were inaccessible for several hours.

EVENT DATE	TYPE OF EVENT	DESCRIPTION
February 18, 1889	Ice Jam, Potomac River	$55,000 damages.
June 1-2, 1889	Flood, Potomac RiverBasin	--
March 28-30, 1924	Snowmelt and intense rainfall runoff, Potomac, River Basin	5 Deaths, $4 million in damage. .
May 12-14, 1924	Rainfall	Greatest damage since flood of 1889.
23-Aug-33	Tidal Surge	Chesapeake-Potomac Hurricane of 1933.
March 17-19, 1936	Thick Ice, Snowmelt and intense rainfall runoff, Potomac River Basin	Greatest flood since 1889. Exceeded flood of May 1924.
April 25-28, 1937	Rainfall	Third Largest flood after 1936 and 1889. Comparable to May 1924.
October 13-17, 1942	Flood from extended rainfall	Potomac River Stage at Washington 0.3 ft. higher than in 1936.
August 12-13, 1955	Flood, Rock Creek, Potomac, Anacostia River Basins	Hurricanes Connie and Diane.
June 21-23, 1972	Flood, Rock Creek	Hurricane Agnes
September 5-6, 1979	Flood Rock Creek	Hurricane David, $374,000 in damage
November 4-7, 1985	Flood, Potomac River Basin	Hurricane Juan combined with stationary front. $9 million damage along C&O canal and $113 million along Potomac.
5-May-89	Flood	Three people killed, hundreds of homes and businesses destroyed.
January 19-21, 1996	Snowmelt Flood	Fifth highest flood on official record.
September 6-8, 1996	Flood, Potomac River	Hurricane Fran, flooding similar to Hurricane Juan.
11-Aug-01	Flash Flood, Rock Creek	Rock Creek discharge at Sherrill Drive gauge about 1.5 times the 100-year discharge.
September 18-19, 2003	Flood, Potomac, Anacostia River Basins	Hurricane Isabel. Caused a system malfunction in the 14th Street pumping station. The incident closed 395 in both directions for 48 hours. $125 million in property damages.
June 22-23, 2006	Rainfall	Localized flooding throughout region damaged major Federal buildings. $10 million in damages.

TABLE 5: Major historical flooding events in the District (Source: District of Columbia Multi-Hazard Mitigation Plan, December 2007)

Figure 9 shows known vulnerable flooding areas identified by key stakeholders for this study. These include vulnerable Washington Metro Area Transit Authority (WMATA) assets (WMATA stations with flooding issues), repetitive loss properties (i.e. areas of recurrent flooding) in the National Flood Insurance Program (NFIP) database as well as neighborhoods with historic flooding—such as Palisades. The map also documents high-risk storm drain sites according to the 2010 DC Multi-Hazard Mitigation Plan. There are other known flood risks indicated on the map including the Federal Triangle area of downtown (Greeley and Hansen, 2011) and the low capacity storm/sewer system identified by the Bloomingdale LeDroit Park study (Mayor's Task Force, DC, 2012). Further analyses and modeling of the flood risk in these areas would translate the projected extreme rain into flooding impacts (i.e. expected depth and extent of flooding).

FIGURE 7: Flooding of Federal Triangle Area from the June 24-26, 2006 storm (Federal Triangle Stormwater Drainage Study, Greeley and Hansen, 2011)

FEMA FLOOD AREAS

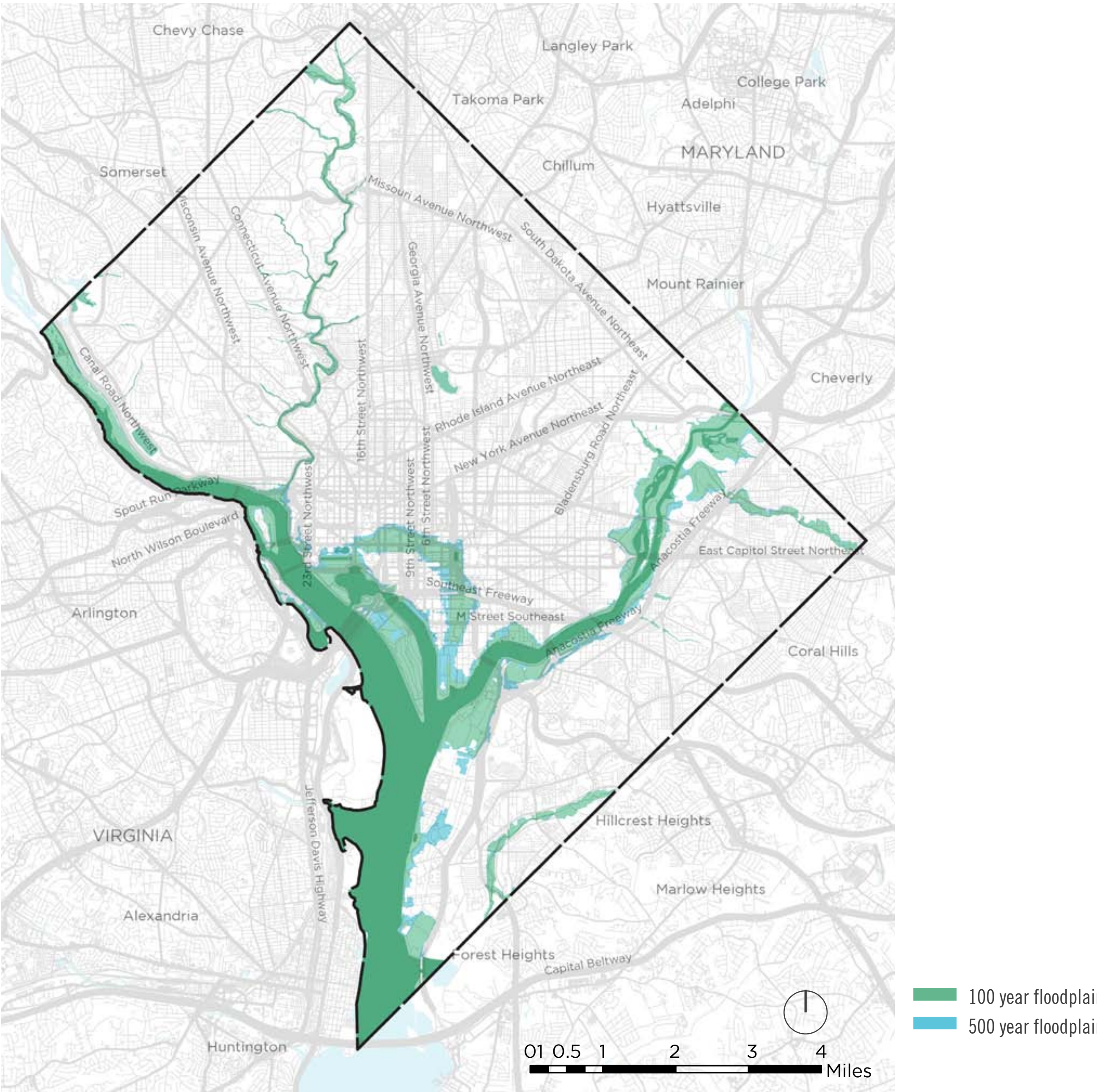

FIGURE 8: FEMA flood insurance rate maps, 100-yr and 500-yr Floods (FEMA map overlaid on GIS map base, Kleinfelder, 2015)

HISTORIC FLOOD AREAS

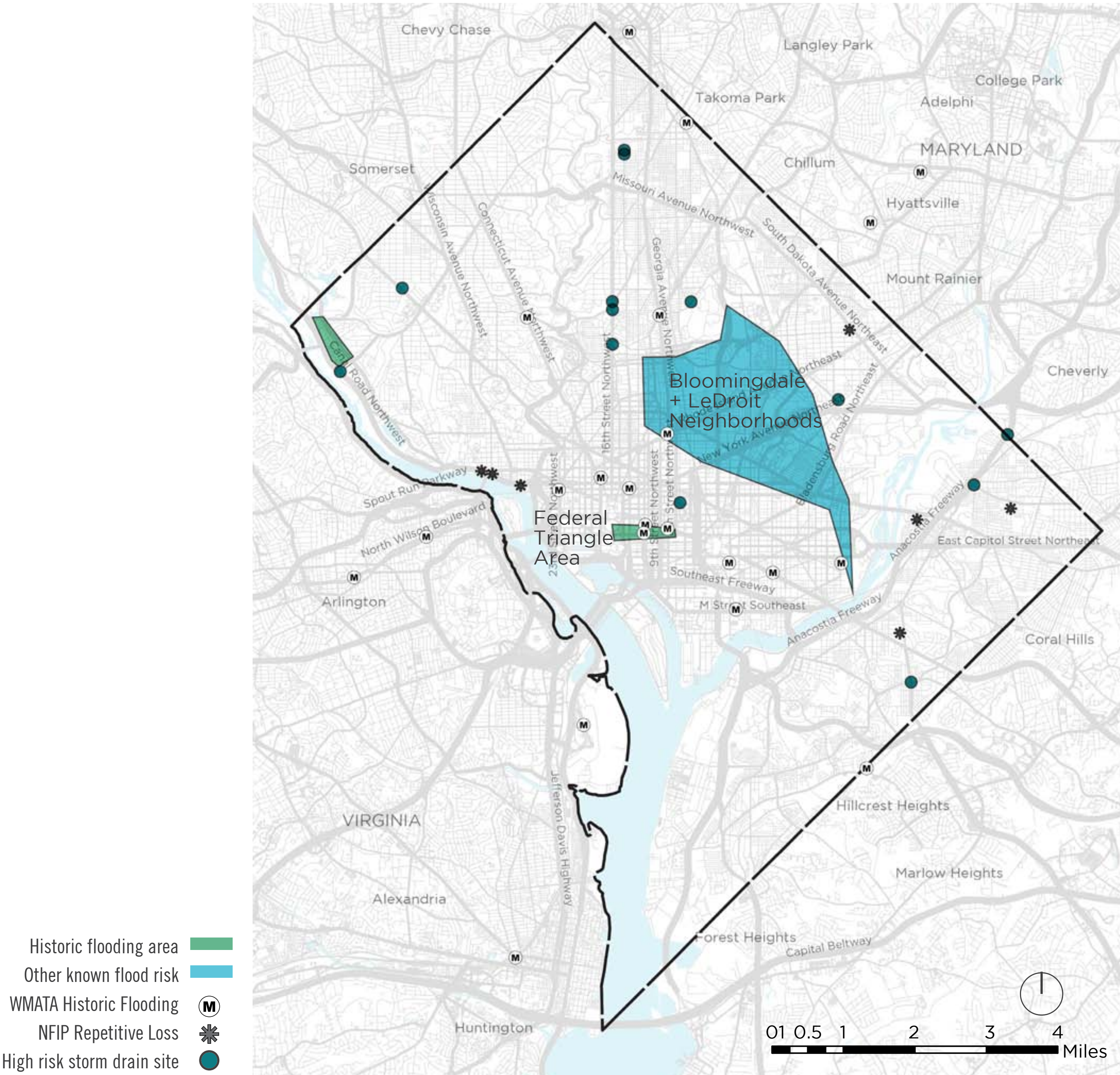

FIGURE 9: Historical flooding areas in Washington, DC (Source: Kleinfleder as indentified by stakeholders, November 2014)

PRECIPITATION

The following design storms are intermediate options of scenarios to be vetted by DOEE and stakeholders but are recommended as options.

2050s

- High scenario: 7.1 inches for the 15-year – 24-hour storm (high scenario for higher probability)
- Low scenario: 6.5 inches for the 100-year 6-hour storm (low scenario for lower probability)

2080s

- High scenario: 8 inches for the 15-year – 24-hour storm (high scenario for higher probability)
- Low scenario: 9 inches for the 100-year 6 hour storm (low scenario for lower probability)

The precipitation scenario will be addressed qualitatively as there are no available comprehensive models for the District to map potential flooding that could be caused by future projections. Future modeling work should involve translating the precipitation volumes into actual flooding extents and depths. Existing hydrologic and hydraulic models can be run using the precipitation projections developed in this study to determine the flooding implications. However, those models would need to be linked to one another, as well as to the larger sea level rise and storm surge model to fully capture the extent of flooding vulnerability – both for existing and future conditions.