Third-Party Peer Review

Flood Mitigation
Ellicott City, Maryland
4 October 2018

SGH Project 181502

SIMPSON GUMPERTZ & HEGER
Engineering of Structures
and Building Enclosures

PREPARED FOR:

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Project 181502 – Ellicott City Flood-Mitigation Document Third-Party Review, Ellicott City, MD

Dear Mr. Redding:

In response to the recent 30 July 2016 and 27 May 2018 severe flooding events within Ellicott City, MD, the Howard County government (Howard County) issued a proposed flood-mitigation plan to improve stormwater management and conveyance within the surrounding area. As part of the plan, Howard County proposes acquisition and demolition of ten historic building structures on the south side of lower Main Street immediately west of the intersection with Maryland Avenue in order to widen the adjacent stream channel thereby reducing floodwater height and flow velocity.

Preservation Maryland engaged Simpson Gumpertz & Heger Inc. (SGH) to perform a third-party review of the flood-mitigation plan proposed by Howard County in order to review the possibility of alternative solutions that marry life safety improvements with historic preservation efforts.

Based on our review of the documents provided to us by Preservation Maryland and our experience with flood-mitigation projects in Ellicott City and other communities, we believe that flood-mitigation strategies which address both life safety concerns and preservation of the historic character of Ellicott City have not been fully vetted by Howard County. In our full report which follows, we propose a number of items which should be considered before implementing any flood-mitigation strategy. We summarize these items below:

1. **2016 Hydrology and Hydraulics (H&H) Report:** Update the various improvement scenarios and their hydrologic analyses presented in the 2016 H&H Report to reflect the extent of damage associated with the 27 May 2018 flood event. Potential variances in the effectiveness of the proposed mitigation strategies should be evaluated. The update may consider:

    1.1. Analyze the hydraulic effects of the two tunnel bores presented in the 2016 H&H Report independent of others stormwater management and/or conveyance improvements and independent of each other. Consider other potential locations and/or shortened segments of tunnel bores or similar high-capacity conveyance improvements and analyze the hydraulic behavior. Evaluate the feasibility and cost of the alternate tunnel bores.
    1.2. Reassess the localized effects of the stormwater management and conveyance improvements proposed in the 2016 H&H Report, with a focus on the effective depth and flow velocity reduction in areas that currently pose the greatest risk to life safety such as areas with high occupancy and limited means of evacuation. As noted within Section 2.1.2 of our report, The Ellicott City Flood Mitigation Plan evaluates four options and their potential ability to improve stormwater management and conveyance within the historic downtown. However, the plan does not quantify the flow velocity reduction for options one through three.
    1.3. The concepts presented to-date do not reduce floodwater velocity and depth within the Lower Main Street area to an extent where swiftwater rescue is not required in future

flood-related instances with similar rainfall volume to that of the 30 July 2016 flood event in Ellicott City.

2. **National Register of Historic Places Status:** Review the contribution of the ten historic properties slated for demolition to Ellicott City's historic status to understand the range of available floodproofing options. Also, review the potential implications (financial and social) should demolition of these buildings result in loss of National Register of Historic Places status. Preservation Maryland and the Maryland Historic Trust should be enlisted to assist Howard County with this effort.

3. **Open First-Floor Improvements:** Review mitigation strategies including stormwater management and conveyance improvements in combination with Open First-Floor (structural reinforcing and wet floodproofing) improvements. The quantity of buildings slated for Open First- Floor concept improvements should consider the extent of damage sustained in the 30 July 2016 and 27 May 2018 flood events. Options that protect individual building structures will reduce damage from both flooding within the Tiber-Hudson watershed (e.g., 2016 and 2018 flood events) as well as backwater flooding from the Patapsco River.

   3.1. Coordinate with the historic preservation community, including Preservation Maryland and the Maryland Historic Trust, to explore the viability of implementing structural reinforcing elements in tandem with wet floodproofing measures to create Open First- Floor concepts within the ten buildings proposed for demolition and additional buildings (if required).

   3.2. The precipitation and stream gage data reported in the 2016 H&H Report show that Hudson Branch floodwater depth peaked in approximately 2 hrs during the 30 July 2016 flood event. Therefore, implementation of a flood warning system capable of providing rapid and reliable notification of imminent flood risk is necessary to allow continued first- floor occupancy of wet floodproofed buildings and public access to Lower Main Street.

   3.3. Develop a cost/benefit comparison of demolition/relocation versus Open First-Floor concept for the ten buildings at Lower Main Street to accompany the proposed mitigation report revisions.

Enclosed, please find our third-party review for your consideration.

We are available at your convenience for additional questions or comments.

Sincerely yours,

Laura Marie Burgess

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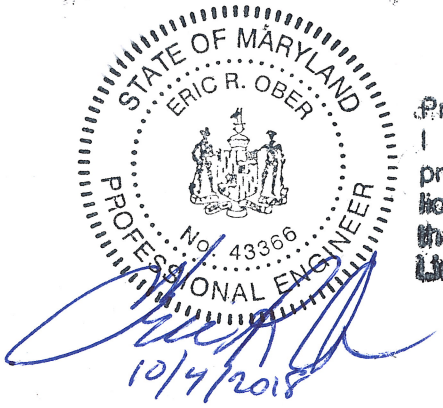

Professional Certification.
I hereby certify that these documents were prepared or approved by me, and that I am a duly licensed professional engineer under the laws of the State of Maryland.
License No. 43366 Exp. Date: 3-26-19

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1. INTRODUCTION

Preservation Maryland engaged Simpson Gumpertz & Heger Inc. (SGH) to perform a third-party review of flood-mitigation efforts proposed by the Howard County, Maryland government (Howard County) for Ellicott City, Maryland in response to the recent 30 July 2016 and 27 May 2018 severe flooding events. This report documents our review recommendations for further consideration.

1.1 Background

Ellicott City is located within Howard County, Maryland. The historic downtown district, located on Frederick Road / Main Street, is situated on a hill sloping downward to the Patapsco River valley at the east. Several streams converge near the intersection of Old Columbia Pike and Frederick Road / Main Street. A canal collects the converging streams directing water parallel to and south of Frederick Road / Main Street down to the Patapsco River. Several of the buildings on the south side of Frederick Road / Main Street have been constructed directly over the existing canal thereby restricting the rising of waters in the canal during a severe flood event. These buildings are tightly spaced and thus direct surface stormwater runoff and flood waters through the narrow confines of Frederick Road / Main Street down to the Patapsco River.

Within a 2-yr period, Ellicott City, Maryland experienced two major rainfall events, each reportedly with an approximate recurrence interval of 1,000 years (0.1%-annual-chance of exceedance). The converging streams, downward slope, and narrow confines of the historic district in tandem with the frequency and severity of the two events have resulted in floodwaters in excess of 8-ft deep and high velocity flow in excess of 10 ft per second (fps). Four lives were lost and many of the historic structures located along the downtown corridor sustained significant damage as a result of the two events.

Howard County proposed a multi-faceted strategy to improve stormwater management and conveyance along the Frederick Road / Main Street corridor between Route 29 and the Patapsco River in response to the frequency and severity of the storms. As part of the strategy, Howard County proposes acquisition and demolition of ten historic building structures on the south side of Frederick Road / Main Street immediately west of the intersection with Maryland Avenue in order to widen the adjacent stream channel.

Preservation Maryland opposes Howard County's strategy and published a Special Report (e.g., white paper) titled "A Place for the Past: Preserving Ellicott City's Heritage and Securing Its Future" noting the negative impact complete demolition of the ten proposed historic building

structures may have on the on the historic Ellicott City community including potential de-listing of Ellicott City from the National Register of Historic Places.

1.2 Objective

The objective of our assignment is to provide a third-party structural and civil engineering review of Howard County's proposed flood-mitigation strategy and to recommend conceptual alternative solutions to address life-safety concerns while preserving the historic character of the community.

1.3 Scope

Our scope of work includes:

- Review of available documents that have been provided to us by Preservation Maryland and/or obtained from the Howard County, Maryland Ellicott City 2016 Flood Recover website,
- Review of relevant flood hazards information,
- Review of relevant codes, standards, and guidance documents, and
- Provide recommendations for consideration by Preservation Maryland and the Howard County government.

Our document review scope of work excludes:

- In-depth review and analysis of hydrologic and hydraulic data and calculations,
- Structural condition assessments, and
- Analysis of existing building structures.

The content of this report is based on our involvement with on-going restoration efforts within historic Ellicott City and the professional judgment and experience of our Engineers.

2. DOCUMENT REVIEW

We reviewed the following documents for information relevant to our assignment.

2.1 Ellicott City Flood-Mitigation Documents

2.1.1 2016 Hydrology and Hydraulics (H&H) Report

Following the 30 July 2016 rainfall event, the Howard County Bureau of Environmental Services engaged McCormick Taylor to perform a Hydrologic and Hydraulic (H&H) study of the watershed at Ellicott City. McCormick Taylor performed the following tasks as part of the study as summarized in the 16 June 2017 report titled "2016 Ellicott City Hydrology/Hydraulic Study and Concept Mitigation Analysis" (2016 H&H Report).

- Evaluated the hydrology of the watershed and modeled the 30 July 2016 rainfall event.
- Developed a hydraulic model of the Tiber-Hudson Branch and calibrated the model to the 30 July 2016 event based on gage data and visual observations.
- Conceptualized stormwater quantity management (SWM) and conveyance improvements for implementation within the hydraulic model to evaluate the effectiveness of the improvements in reducing the flood hazards in Ellicott City.

McCormick Taylor reports the following relevant results generated by the hydrologic and hydraulic analyses:

- The total time of concentration, time required for stormwater to flow from the furthest west point in the watershed to the confluence with the Patapsco River, is 71 min.
- On 30 July 2016, rainfall began in Ellicott City at approximately 6:10 p.m. (refer to ELYM2 rainfall gauge data in Appendix A of the 2016 H&H Report). The depth of the Hudson Branch at Howard County stage gauge No. 8206 peaked at approximately 8:10 p.m., about 2 hrs after rainfall began (refer to Figure 3.3 in the 2016 H&H Report).
- Floodwater depths at Lower Main Street for the simulated 30 July 2016 event under existing conditions are 6 to 8 ft or greater.
- Flow velocities at Lower Main Street for the simulated 30 July 2016 event under existing conditions range from 10 to 15 ft per second (fps).

Evaluated Stormwater Quantity Management (SWM) Improvements

Table 1 summarizes the conceptual SWM improvements proposed in the 2016 H&H Report. Figure 1, as obtained from the Appendix B of the 2016 H&H Report, shows the locations of the conceptual SWM improvements over the watershed. For each improvement, McCormick Taylor computed the reduction in flow at the affected stream during the 1%-annual-chance ("100-yr")

flood event in order to quantify the effectiveness of the SWM improvements to reduce the downstream flood hazards. With the implementation of all the conceptual SWM improvements, the 100-yr total discharge of the Tiber-Hudson Branch at the confluence with the Patapsco River is decreased by 4,397 cubic feet per second (cfs) (57%), effectively reducing the 100-yr discharge to that of the current 10-yr event.

Table 1 – Conceptual SWM Improvements Proposed in 2016 H&H Report

Watershed	SWM Improvement No.	Storage (ac-ft)	Flow Reduction at Respective Stream for 100-year Flood Event (cfs)	SWM System
Tiber Branch	T1	70	744 (69%)	On-line SWM pond
New Cut Branch	NC1	34	528 (15%)	On-line SWM pond
	NC2	42	529 (15%)	On-line SWM pond
	NC3	63	705 (20%)	On-line SWM pond
	NC4	14	161 (4%)	On-line SWM pond
Hudson Branch	H1-UG1	25	294 (10%)	Underground vault
	H1-UG2	41		Underground vault
	H1-UG3	24		Underground vault
	H2	15	86 (3%)	On-line SWM pond
	H3	8	43 (1%)	On-line SWM pond
	H4	16	244 (8%)	Off-line SWM pond
	H5	12	109 (4%)	Off-line SWM pond
	H6	12	84 (3%)	Off-line SWM pond
	H7	13	309 (11%)	On-line SWM pond
	H8-UG1	8	448 (11%)	Underground pipe farm
	H8-UG2	10		Underground pipe farm
	H8-UG3	11		Underground pipe farm
	H8-UG4	11		Underground pipe farm

Evaluated Stormwater Conveyance Improvements

Table 2 summarizes the conceptual conveyance improvements proposed by McCormick Taylor. Figure 2, as obtained from Appendix B of the 2016 H&H Report, shows the locations of the conceptual stormwater conveyance improvements over the watershed. The 2016 H&H Report does not include a quantitative summary of the effectiveness of the individual or combined conveyance improvements to reduce the downstream flood hazards.

Table 2 – Conceptual Conveyance Improvements Proposed in 2016 H&H Report

Stream	Conveyance Improvement No.[1]	Description
Hudson Branch	1	Install additional 6 ft diameter bypass culvert below Frederick Road at near 8800 Frederick Road.
	2	Install two additional 5 ft diameter bypass culverts below Papillon Drive near intersection with Frederick Road.
	3	Install additional 6.5 ft by 14 ft bypass culvert at below Frederick Road near 8777 Frederick Road.
	4	Replace existing conveyance below Frederick Road near intersection with Rogers Avenue with two new 3.5 ft by 2.25 ft pipes.
	5	Increase diameter of existing culvert below Frederick Road near 8611 Frederick Road from 7.33 ft to 9 ft.
	6	Install new 6.5 ft by 8.5 ft culvert along Frederick Rd. between 8611 and outfall near 8474 Frederick Road.
	7	Install new 9 ft diameter bypass culvert near 8532 Frederick Road.
	8	Install levee (berm) between 8572 and 8534 Frederick Road.
	Tunnel Bore No. 1	Install new 13 ft diameter tunnel bore upstream of Lot E to the Patapsco River (approximate length: 1300 ft).
New Cut Branch	Tunnel Bore No. 2	Install new 15 ft diameter tunnel bore upstream of confluence with Tiber- Hudson Branch to the Patapsco River (approximate length: 790 ft).

Appendix D of the 2016 H&H Report presents the 100-yr flood depth results from the hydraulic model considering the cumulative effect of implementing all of the conceptual SWM and conveyance improvements listed above.

The 2016 H&H Report notes that implementation of all the conceptualized SWM and conveyance improvements may not be feasible due to logistics, cost, and similar controlling factors. Consequently, the 2016 H&H Report suggests a subset of improvements be considered based on their individual ability to reduce the peak flow during future storm events. Appendix E of the 2016 H&H Report presents the 100-yr flood depth results from the hydraulic model considering the cumulative effect of the subset of recommended improvements. The subset recommended in the 2016 H&H Report includes the following conceptual SWM and conveyance improvements:

- SWM Improvement No. T1 (see Table 1)
- SWM Improvement No.NC3 (see Table 1)
- SWM Improvement No. H7 (see Table 1)
- SWM Improvement No. H8-UG1, -UG2, -UG3, and -UG4 (see Table 1)

[1] The 2016 H&H Report does not assign numbers to the conceptual conveyance improvements except for the tunnel bores. Number assignments for the other conceptual conveyance improvements are assigned by SGH for the purposes of this report.

- Conveyance Improvement Nos. 1 through 8 (see Table 2)

The analysis results presented in Appendices D and E of the 2016 H&H Report indicate at least 4 to 6 ft of floodwater will be realized at Lower Main Street except for the analyses that include Tunnel Bore Nos. 1 and 2. Analysis results for models including Tunnel Bore Nos. 1 and 2 indicate no floodwater at Lower Main Street during either the 100-yr flood event or the simulated 30 July 2016 event. However, we note that the analyses that include Tunnel Bore Nos. 1 and 2 also include all the proposed additional SWM and conveyance improvements. The 2016 H&H Report does not contain analysis results for the Tunnel Bore Nos. 1 and 2 with a subset of SWM/conveyance improvements or with no other SWM/conveyance improvements. Additionally, the 2016 H&H Report does not include analysis results for only one tunnel bore.

Although the evaluated SWM and conveyance improvements may alleviate the flood hazards associated with major precipitation events within the Tiber-Hudson watershed, McCormick Taylor notes that the improvements would not significantly reduce the effects of backwater flooding from the Patapsco River caused by a major precipitation event within that watershed. At least one historic flood event (Tropical Storm Agnes in 1972) reportedly caused notable flooding on Lower Main Street in Ellicott City.

2.1.2 2018 Flood-Mitigation Plan

In response to the frequency and severity of the 30 July 2016 and 27 May 2018 flood events, Howard County has proposed a multi-faceted strategy to improve SWM and conveyance along the Frederick Road / Main Street corridor between Route 29 and the Patapsco River. Howard County documents the strategy in “The Ellicott City Flood-Mitigation Plan,” (2018 Flood-Mitigation Plan) dated 23 August 2018.

The 2018 Flood-Mitigation Plan evaluated the following options and their potential ability to improve SWM and conveyance within the historic downtown. At the request of Howard County, McCormick Taylor created a hydrologic and hydraulic analysis model for each of the following conditions and compared each model to the 30 July 2016 Hydrologic and Hydraulic Flood Model. The 30 July 2016 flood model indicates floodwaters along Lower Frederick Road / Main Street were in excess of 8 ft with an approximate floodwater velocity of 11.1 fps.

1. Open First Floor

    - Assumes a 10-ft vertical clearance beneath the existing building structures on the south side of Frederick Road / Main Street from the Caplan Building (8125 Main Street) extending east to Maryland Avenue.
    - Decreases water depth along Lower Main Street to approximately 4 to 8 ft.
    - A change in floodwater velocity was not indicated.

2. New Lower Main Street Culvert

    - Constructs new culvert beneath the roadway of Lower Main Street with an outlet directly west of the Patapsco River.
    - Retains existing buildings at the south side of Frederick Road / Main Street.
    - Decreases water depth along Lower Main Street to 4 to 8 ft.
    - A change in floodwater velocity was not indicated.

3. No Structures Over the River

    - Assumes partial demolition of existing structures where they extend over the stream channel thereby eliminating the height constriction on elevated waters within the channel.
    - Retains facades of existing buildings at the south side of Frederick Road / Main Street.
    - Decreases water depth along Lower Main Street to 4 feet with the area west of Maryland Avenue exceeding 8 ft in depth.
    - A change in floodwater velocity was not indicated.

4. Expanded Stream Channel

    - Assumes an expanded stream channel area through removal of ten existing buildings on the south side of Frederick Road / Main Street from the Caplan Building (8125 Main Street) extending east to Maryland Avenue.
    - Decreases water depth along Lower Main Street to 4 to 6 ft.
    - Decreases flow velocity to approximately 4.5 ft/sec.

The models for each condition noted above do not account for the combined influence of upstream SWM improvements (e.g., infrastructure improvements, see below) and their ability to further reduce floodwater elevation and flow velocity. Nor do the conditions noted above account for a combination of one or more of the conditions (e.g., Open First Floor plus New Lower Main Street Culvert).

The 2018 Flood-Mitigation Plan notes five infrastructure improvements to improve SWM and conveyance along with the potential for two additional improvements.

- Planned Infrastructure Improvements

- Hudson 7 Retention Facility (SWM Improvement No. H7 described in the 2016 H&H Report).
- Quaker Mill Retention Facility (new SWM improvement concept not included in the 2016 H&H Report).
- 8600 Main Street Culvert Expansion (Conveyance Improvement No. 5 described in the 2016 H&H Report).
- Expansion of channel under Parking Lots E and D (new conveyance improvement concept not included in the 2016 H&H Report). Requires relocation or removal of two additional building structures.
- Two new 10 ft diameter culverts under Maryland Avenue to connect the Tiber- Hudson Branch with the Patapsco River (new conveyance improvement concept not included in the 2016 H&H Report).

- Potential Infrastructure Improvements

  - SWM Improvement No. T1 described in the 2016 H&H Report.
  - SWM Improvement No. NC3 described in the 2016 H&H Report.

A hydrologic and hydraulic flood model was not provided for the planned and potential infrastructure improvements noted above.

2.1.3 Preservation Maryland Special Report

Preservation Maryland prepared a Special Report, authored by Executive Director, Nicholas Redding, titled "A Place for the Past: Preserving Ellicott City's Heritage and Securing Its Future," dated 9 August 2018, in response to Howard County's 2018 Flood-Mitigation Plan. The Special Report outlined Preservation Maryland's opposition to Howard County's plan to demolish ten historic buildings at the south side of Lower Main Street.

In the Special Report, Preservation Maryland states "there can be no question whatsoever that life safety is of the highest importance." However, the Special Report seeks to emphasize that life safety does not negate historic preservation considerations. The Special Report notes that the loss of significant historic structures may "potentially result in the de-listing of Ellicott City from the National Register of Historic Places" which may have detrimental economic effects on the community.

The Special Report notes the Civil War, Railroad Industry, and muddy flood waters are but three of many defining elements that characterize what is now Historic Ellicott City. The downtown, in its current configuration, is considered in the district's listing within the National Register of Historic Places.

Through the Special Report, Preservation Maryland seek further clarification, on behalf of the public, to understand the reasoning for inclusion of only five of the eighteen SWM and conveyance improvements discussed within the 2016 H&H Report.

To mitigate the potential devastating effects of historic property demolition, the Special Report proposes the following preservation alternatives for consideration:

1. Preservation Option A: Full Implementation of McCormick Taylor 2016 Hydrology/Hydraulic Study

    - The Special Report notes that the 2016 H&H Report states that implementation of all the SWM and conveyance measures, with the exclusion of the tunnel bores, could "make an appreciable difference."

2. Preservation Option B: Public Acquisition of Flood-Prone Historic Building and Wetproof Stabilization

    - Long-term campaign to create a historic "shell" building through internal stabilization of the historic structures and the addition of wet floodproofing measures to allow flood waters to flow through the buildings. The concept is noted as the "Open First Floor Model" within the 2018 Flood-Mitigation Plan and as noted in Section 2.1.2 helps to reduce the depth of floodwater along Lower Main Street.

3. Preservation Option C: Public Acquisition of Flood-Prone Historic Buildings and First- Floor Wetproofing with Second-Floor Reuse

    - The campaign extends the Open First-Floor concept of Option B to include functional use of the second floor of buildings where the first floor is stabilized and wet floodproofed. Access to the second floors would be provided to create residential, living and/or office opportunities.

4. Preservation Option D: Acquisition of Flood-Prone Historic Buildings for Establishment of Ellicott City State Historic Site Park

    - The campaign transfers ownership and maintenance of the historic Open First- Floor buildings to the State of Maryland and the Patapsco State Park respectively. The concept utilizes state funds from the Program Open Space to create a "dynamic state park unit."

To emphasize the viability of Preservation Options C and D, the Special Report provides the following case studies as examples where life safety is achieved in tandem with historic preservation:

1. Case Study: Harpers Ferry National Historic Site

- The internal structural frame and open concept of the Restoration Museum facilitate high flood waters along the Shenandoah River while providing a permanent flood-resistant learning environment for visitors when flood waters are not present.

2. Case Study: Historic Structures of the Chesapeake and Ohio Canal National Historic Site

   - Restoration of the historic Swains Lockhouse includes wet floodproofing measures to facilitate high flood waters along the canal without negatively impacting structural stability of the historic building.

2.2 Codes and Standards

2.2.1 Maryland Building Performance Standards (Maryland Building Code)

The current edition of the Maryland Building Code adopts the 2015 International Building Code (IBC). The 2015 IBC requires the design and construction of new and substantially improved/repaired buildings and structures located in a 100-year floodplain to comply with American Society of Civil Engineers (ASCE) 24-14 “Flood Resistant Design and Construction”.

Substantial improvements and repairs include any modifications to an existing structure for which the cost equals or exceeds 50% of the market value of the structure prior to construction. Historic structures undergoing substantial improvements or repairs are exempt from the flood design requirements, provided that the structure retains the historic status after completion of the modifications. However, if substantial repairs to a historic structure result in the loss of the historic status of the structure, the Maryland Building Code requires that the structure be updated to comply with the minimum requirements for flood resistant design and construction.

2.2.2 ASCE 24-14

ASCE 24-14, “Flood Resistant Design and Construction”, is a reference standard that provides the minimum design and construction requirements for buildings constructed in flood hazard areas. ASCE 24-14 includes the following relevant provisions:

- New construction or substantial improvements/repairs are not permitted in high-velocity flow areas unless protective works are put in place to protect the structures. High- velocity flow is defined as floodwater with a velocity in excess of 10 fps.
- Dry floodproofing[2] is not permitted in areas where the flow exceeds 5 fps.

[2] Dry floodproofing is a flood protection strategy in which a structure is made substantially impermeable to ingress of floodwaters.

- If the dry floodproofing system requires human intervention to activate, the minimum flood warning time is 12 hrs.

- Dry floodproofing is not permitted in residential structures or residential portions of mixed-use structures.

- Wet floodproofing[3] is only permitted in areas used solely for parking, building access, or storage.

2.3 Flood Hazard Information

2.3.1 Federal Emergency Management Agency (FEMA)

FEMA uses historical flood hazard data to develop Flood Insurance Rate Maps (FIRM), which show areas subject to inundation during the 100-yr flood and the associated base flood elevations (BFE). The FIRMs also show areas subject to inundation during the 0.2%-annual-chance ("500- yr") flood. The IBC adopts the FIRMs as the official basis for determining the extents and elevations for a 100-yr flood.

- The current FIRM for Ellicott City is dated 5 November 2013. Figure 3 shows a portion of the applicable FIRM.

- All buildings on both sides of Lower Main Street, from the roadway bend near the confluence of the Tiber-Hudson and New Cut Branches to the Patapsco River, are located within the 100-yr floodplain. Much of Upper Main Street and Frederick Road are located in either the 100-yr floodplain or the 500-yr floodplain.

2.3.2 National Park Service (NPS) Swiftwater Rescue Manual

The National Park Service (NPS) Swiftwater Rescue Manual is used by federal agencies, such as NPS and the U.S. Coast Guard, in training for inland search and rescue operations. The manual demines swiftwater as "water over two feet deep that is flowing at a rate greater than one knot (1.15 mph) occurring in a natural water course, flood control channel, or flood-related incident."

The manual further notes that cars may be carried away by flood waters with depths as little as 2 ft.

[3] Wet floodproofing is a flood protection strategy in which floodwater is allowed to inundate the interior of a structure in order to prevent structural damage.

3. INFORMATION FROM OTHERS

We reviewed the YouTube video recording of the Ellicott City Master Plan Meeting held 12 September 2018. The video and accompanying slides were obtained from the Howard County Maryland Website:

- https://www.howardcountymd.gov/Departments/Planning-and-Zoning/Community-Planning/Community-Plans/EC-Master-Plan.

Through review of the video and accompanying slides, we understand the following:

1. With respect to overall precipitation accumulation (e.g., volume) within a limited period of time, the 2016 flood was more severe than the 2018 flood. As such, proposed flood models are compared to the baseline model of the 2016 flood event.

2. Construction of a culvert beneath Lower Main Street would require substantial shoring of existing building foundations, a lengthy period of closure of the Lower Main Street corridor and significant funding. Due to the constraints noted above, Howard County determined that construction of a culvert beneath Lower Main Street to improve stormwater conveyance is not a viable option.

3. Buildings proposed for demolition are listed in Table 3.

Table 3 – Proposed List of Buildings for Demolition (obtained from Ellicott City Master Plan Meeting presentation slides)

Building Name	Address	Type of Construction	Period of Construction
Phoenix Emporium	8049 Main St.	Building One: Brick Building Two: Wood Frame	c. 1851 c. 1870
Discoveries	8055 Main St.	Block	c. 1920s-30s
Bean Hollow	8059 Main St.	Stone and Wood Frame	c. 1930s
Great Panes	8069 Main St.	Brick and Stone	c. 1841
Tea on the Tiber	8051 Main St.	Stone and Wood Frame	c. 1834
Portalli's	8085 Main St.	Brick	c. 1920's
Shoemaker's	8095 Main St.	Block	c. 2000
Johnson's Buildings	8109 Main St.	Wood Frame	c. 1859
Johnson's Buildings	8113 Main St	Wood Frame	c. 1830s
Caplan's	8125 Main St.	Brick	c. 1926

4. DISCUSSION

4.1 Document Review Specific Comments

The following discussion presents our comments to the Ellicott City Flood-Mitigation Documents reviewed in Section 2.1 while providing additional items for further consideration.

4.1.1 2016 H&H Report

The 2016 H&H Report presents eighteen conceptual SWM improvements and ten conceptual conveyance improvements to potentially reduce the effects of flood hazards in Ellicott City. The H&H analysis results show that the proposed improvements reduce the stream discharge, floodwater depth, and floodwater flow velocity with varying degrees of effectiveness. The subset of improvements presented in Appendix E of the 2016 H&H Report, generally includes the improvements predicted to generate the greatest reduction in stream flow during major flood events.

The 2016 H&H Report only considered the effects of SWM (retention) and conveyance improvements and did not evaluate measures that would require modifications to or removal of existing buildings.

The tunnel bores appear to provide the most substantial reduction of flood hazards at Lower Main Street; however, the 2016 H&H Report does not include sufficient information to evaluate the effect of the two tunnel bores independent of the other SWM and conveyance improvements or independent of one another. We expect that the benefit of the tunnel bores would only significantly reduce the flood hazards in areas of Ellicott City downstream of the ingress points and would not significantly alleviate upstream flood hazards.

SWM and conveyance improvements (including tunnels bores) at Ellicott City or upstream along the Tiber, Hudson, or New Cut Rivers will not reduce the risk of backwater flooding from the Patapsco River. Mitigation for this flooding scenario will likely need to be addressed at individual buildings using floodproofing or other protection measures.

4.1.2 2018 Flood-Mitigation Plan

Flood-mitigation measures that seek to reduce the severity of flooding in Lower Main Street such as upstream retention and conveyance improvements or widening the river channel (i.e.,

demolishing Lower Main street buildings) will not remove the risk of backwater flooding from the Patapsco River.

Options that protect individual building structures will reduce damage from both flooding within the Tiber-Hudson watershed as well as backwater flooding from the Patapsco River.

The Flood-Mitigation Plan does not indicate the extent to which velocity was reduced in the following options: Open First Floor, New Lower Main Street Culvert, and No Structures Over the River (see Section 2.1.2). This information is essential for evaluating the viability of each option with respect to life safety and historic preservation within downtown Ellicott City.

4.1.3 Preservation Maryland Special Report

The case studies presented in the Preservation Maryland Special Report pertain to isolated building instances implementing structural reinforcing elements in tandem with wet floodproofing measures. For Ellicott City, the quantity of buildings that may require structural reinforcing and wet floodproofing measures to create the Open First-Floor concept may exceed the ten buildings proposed for demolition in the 2018 Flood-Mitigation Plan in order to account for the effects of the 27 May 2018 flood event.

Flood related hazards may be more severe than in the noted case studies due to flood depths and high-flow velocities observed within both the 2016 and 2018 Ellicott City flood events.

A revised hydrologic and hydrology study would be required to evaluate the viability of the Open First-Floor concept inclusive of the 2016 and 2018 flood data and proposed SWM and conveyance improvements noted within the 2018 Flood-Mitigation Plan.

4.2 Floodproofing Considerations

The Maryland Building Code requires any building undergoing substantial improvements/repairs to be brought into compliance with the provisions for flood-resistant design and construction. For non-residential buildings, these requirements would necessitate raising or floodproofing the building to a specific elevation based on the FEMA FIRM: typically 1 ft above the 100-yr flood elevation (BFE). Floodproofing would generally be required to be in the form of dry floodproofing; wet floodproofing would only be permitted at areas of the building used solely for parking, building access, or storage.

However, historic buildings are exempted from the Maryland Building Code's flood design requirements, provided that the historic status is maintained after construction. As a result, select floodproofing measures may be permitted at some or all existing buildings in the Ellicott City Historic District. Further review is required to determine which buildings in Ellicott City are considered to be contributing elements to the district's listing within the National Register of Historic Places and which buildings are likely to maintain historic status following potential improvements for flood-mitigation.

Nevertheless, the Owners and designers of historic buildings in Ellicott City should consider the following items when selecting and designing floodproofing measures.

4.2.1 Dry Floodproofing

The dry floodproofing approach relies on the structural elements and enclosure of a building, along with temporary or permanent closures devices (e.g., flood barriers), to render a building substantially impermeable to floodwater. Dry floodproofing is generally best suited to new construction because locating and sealing all points of ingress in an existing building is often extremely difficult. In addition, dry floodproofing is usually not suitable for buildings subject to excessive floodwater depths or high velocity flow because the closure devices are not capable of resisting hydrostatic and hydrodynamic loads, respectively. The Maryland Building Code does not permit dry floodproofing at typical (non-historic) buildings when the flow velocity exceeds 5 fps.

Dry floodproofing systems nearly always rely on some form of human intervention for deployment prior to a flood. Human intervention includes tasks such as transporting flood barriers to the site, erecting or installing barriers, or engaging gate valves for backflow protection. For this reason, the Maryland Building Code does not permit dry floodproofing when the expected warning time for the design flood event is less than 12 hrs. The 2016 H&H Report states that the time of concentration in the watershed is only 71 min. Moreover, the 30 July 2016 precipitation and stream gage data reported in the 2016 H&H Report show the Hudson Branch reached peak floodwater depth approximately 2 hrs after the initial onset of rainfall. As such, it is our understanding that a minimum 12-hr warning time is not possible within the watershed for Ellicott City.

Dry floodproofing is not a viable alternative in many areas of Ellicott City, notably in the Lower Main Street area, due to the magnitude of flow velocities. Although the building code

requirements are not enforced for buildings that maintain historic status, the high-velocity flow observed during the two recent flood events and quantified in the 2016 H&H Report suggest that many traditional dry floodproofing measures (e.g., flood shields at entrances) would not withstand future flood events. In addition, the warning time observed during the two recent flood events was extremely short and may not be adequate to fully implement a dry floodproofing system and ensure evacuation of all responsible personnel.

4.2.2 Wet Floodproofing

Wet floodproofing seeks to reduce the likelihood of structural damage by allowing floodwater to enter a building, thereby balancing the hydrostatic forces on the foundation and walls. For new construction and substantial improvements/repairs of typical (non-historic) buildings, the Maryland Building Code only permits wet floodproofing in areas where occupants are not expected to be present for extended periods. In practice, Owners and designers frequently employ wet floodproofing measures in all areas of existing buildings when the substantial improvement threshold (50% of the building value) is not exceeded because it can often provide an effective means to reduce the extent and magnitude of flood damage.

For historic buildings in Ellicott City, wet floodproofing may be a viable alternative; however, the following items should be considered:

1. Exemption from the wet floodproofing limitations relies on the building maintaining a compliant historic status after the improvements are implemented. The scope of wet floodproofing projects may include measures that alter the appearance and layout of the buildings such as structural strengthening, facade modifications to utilize flood-damage resistant materials, and installation of flood vents to permit the ingress of floodwater

2. Wet floodproofed spaces may necessitate a change in use or occupancy. Residential or commercial use of wet floodproofed areas is not recommended due to the high costs of contents damage during a flood event.

3. Below-grade levels and basements in wet floodproofed buildings present a high level of risk to life safety due to the possibility of rapid engulfment in flood waters. Basements in wet floodproofed buildings should be abandoned.

4. Due to the short time for concentration of the watershed (see Section 2.1.1), warning time for major flood events in Ellicott City is very short compared to other flood hazard areas. Any mitigation concepts that preserve full- or part-time occupancy in areas subject to high-velocity flow will require a rapid and reliable flood warning system. The warning system must provide individuals with adequate warning time to evacuate the area. The flood warning system should be linked to the existing National Weather Service precipitation and stream discharge instrumentation and may require installation of additional instrumentation. Visual and audible notification systems along with static warning signage should be installed throughout flood-prone areas. In addition, vehicle

access in areas subject to high velocity flow may need to be restricted in order to prevent the vehicles from become hazardous debris. Similarly, large equipment and other heavy objects should be anchored to structural foundations designed to resist the hydrostatic and hydrodynamic flood loads.

4.2.3 Flood Water Hazards

As noted previously, NPS considers swiftwater to be water flowing at a rate greater than 1 knot (1.15 mph) during a flood-related incident. This equates to approximately 1.69 fps. The 2018 Flood Mitigation Plan notes the proposed Expanded Stream Channel option will reduce flood velocity to approximately 4.5 fps with floodwater depth of approximately 4 to 6 ft within Lower Main Street for future flooding events with similar rainfall volume to that of the 2016 flood event.

In the event of a flood-related incident similar to the 30 July 2016 flood event in Ellicott City, Howard County's proposed Expanded Stream Channel option does not reduce velocity to the extent where swiftwater rescue is unnecessary. Furthermore, the hazard for cars swept away by floodwaters is still present with water depths above 2 ft.

While the Expanded Stream Channel option decreases flood water depth and velocity significantly, the threat to life safety is still present. However, it is important to note, a solution to reduce velocity below 1.69 fps with floodwater depth below 2 ft may not be feasible within Ellicott City's unique flood plane.

4.3 SGH Structural Floodproofing Experience in Ellicott City

4.3.1 Johnson Project Structural Restoration and Flood Proofing

Following the 2016 flood in Ellicott City, Howard County expressed concern for the structural stability for the historic Johnson Properties located at 8109, 8111, and 8113 Main Street in Ellicott City, Maryland and the associated life safety implications. The Johnsons engaged SGH (formerly Keast & Hood DC) to provide an emergency structural condition assessment and shoring concept design to alleviate Howard County's concerns regarding global stability of the historic building structure. Following emergency stabilization efforts, we performed a comprehensive structural condition assessment to guide permanent stabilization and restoration efforts. In collaboration with Cho Benn Holback + Associates, we designed permanent structural rehabilitation and renovation construction documents to repair the historic structure. The design considered permanent stabilization of the structure while incorporating unique techniques to mitigate the effects of future flood events. The work as executed was in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties.

The existing historic structure was reinforced with a new internal structural frame. Structural retrofits included a Speedfloor system (e.g., elevated concrete floor with integrated roll formed steel joists) with custom design by the manufacturer at the first floor, perimeter reinforced concrete masonry unit (CMU) walls at the interior face of existing masonry and wood perimeter walls and interior strengthening of the existing second-floor framing with supplemental wood and steel members. Major mechanical equipment was placed on the roof to elevate it above the building base flood elevation.

Stabilization repairs were completed spring 2018, prior to the 27 May 2018 flood. While the buildings sustained primarily cosmetic distress (e.g., broken windows, plaster and similar finish distress) from the high flood waters, the Speedfloor was damaged in part and will require isolated repairs. Overall, the structure remained stable following the 2018 flood event in contrast to its precarious structural stability condition following the previous 2016 flood event. It is important to note the buildings are listed in Table 3 for proposed demolition.

The work executed at the historic Johnson Properties indicates that modern structural intervention is a viable approach to providing structural stability to a historic structure in future flood events while preserving the historic integrity and fabric (street facade) of the structure.

5. CONCLUSION AND RECOMMENDATIONS

Based on our review of the documents provided to us by Preservation Maryland and our experience with flood-mitigation projects in Ellicott City and other communities, we believe that flood-mitigation strategies which address both life safety concerns and preservation of the historic character of Ellicott City have not been fully vetted by Howard County. We propose the following items which should be given consideration before implementing any flood-mitigation strategy:

1. **2016 Hydrology and Hydraulics (H&H) Report:** Update the various improvement scenarios and their hydrologic analyses presented in the 2016 H&H Report to reflect the extent of damage associated with the 27 May 2018 flood event. Potential variances in the effectiveness of the proposed mitigation strategies should be evaluated. The update may consider:

    1.1 Analyze the hydraulic effects of the two tunnel bores presented in the 2016 H&H Report independent of others SWM and/or conveyance improvements and independent of each other. Consider other potential locations and/or shortened segments of tunnel bores or similar high-capacity conveyance improvements and analyze the hydraulic behavior. Evaluate the feasibility and cost of the alternate tunnel bores.

    1.2 Reassess the localized effects of the SWM and conveyance improvements proposed in the 2016 H&H Report, with a focus on the effective depth and flow velocity reduction in areas that currently pose the greatest risk to life safety such as areas with high occupancy and limited means of evacuation. As noted within Section 2.1.2, The Ellicott City Flood Mitigation Plan evaluates four options and their potential ability to improve SWM and conveyance within the historic downtown. However, the plan does not quantify the flow velocity reduction for options one through three.

    1.3 The concepts presented to-date do not reduce floodwater velocity and depth within the Lower Main Street area to an extent where swiftwater rescue is not required in future flood-related instances with similar rainfall volume to that of the 30 July 2016 flood event in Ellicott City.

2. **National Register of Historic Places Status:** Review the contribution of the ten historic properties slated for demolition to Ellicott City's historic status to understand the range of available flood proofing options. Also, review the potential implications (financial and social) should demolition of these buildings result in loss of National Register of Historic Places status. Preservation Maryland and the Maryland Historic Trust should be enlisted to assist Howard County with this effort.

3. **Open First-Floor Improvements:** Review mitigation strategies including SWM and conveyance improvements in combination with Open First-Floor (structural reinforcing and wet floodproofing) improvements. The quantity of buildings slated for Open First- Floor concept improvements should consider the extent of damage sustained in the 30 July 2016 and 27 May 2018 flood events. Options that protect individual building structures will reduce damage from both flooding within the Tiber-Hudson watershed (e.g., 2016 and 2018 flood events) as well as backwater flooding from the Patapsco River.

3.1 Coordinate with the historic preservation community, including Preservation Maryland and the Maryland Historic Trust, to explore the viability of implementing structural reinforcing elements in tandem with wet floodproofing measures to create Open First-Floor concepts within the ten buildings proposed for demolition and additional buildings (if required).

3.2 The precipitation and stream gage data reported in the 2016 H&H Report show that Hudson Branch floodwater depth peaked in approximately 2 hrs during the 30 July 2016 flood event. Therefore, implementation of a flood warning system capable of providing rapid and reliable notification of imminent flood risk is necessary to allow continued first floor occupancy of wet floodproofed buildings and public access to Lower Main Street.

3.3 Develop a cost/benefit comparison of demolition/relocation versus Open First-Floor concept for the ten buildings at Lower Main Street to accompany the proposed mitigation report revisions.

6. CLOSING

The content of this report is based on our involvement with ongoing structural efforts within the historic downtown Ellicott City area and the professional judgment and experience of our Engineers.

This report concludes our third-party structural and civil engineering review of the proposed flood- mitigation efforts for historic Ellicott City.

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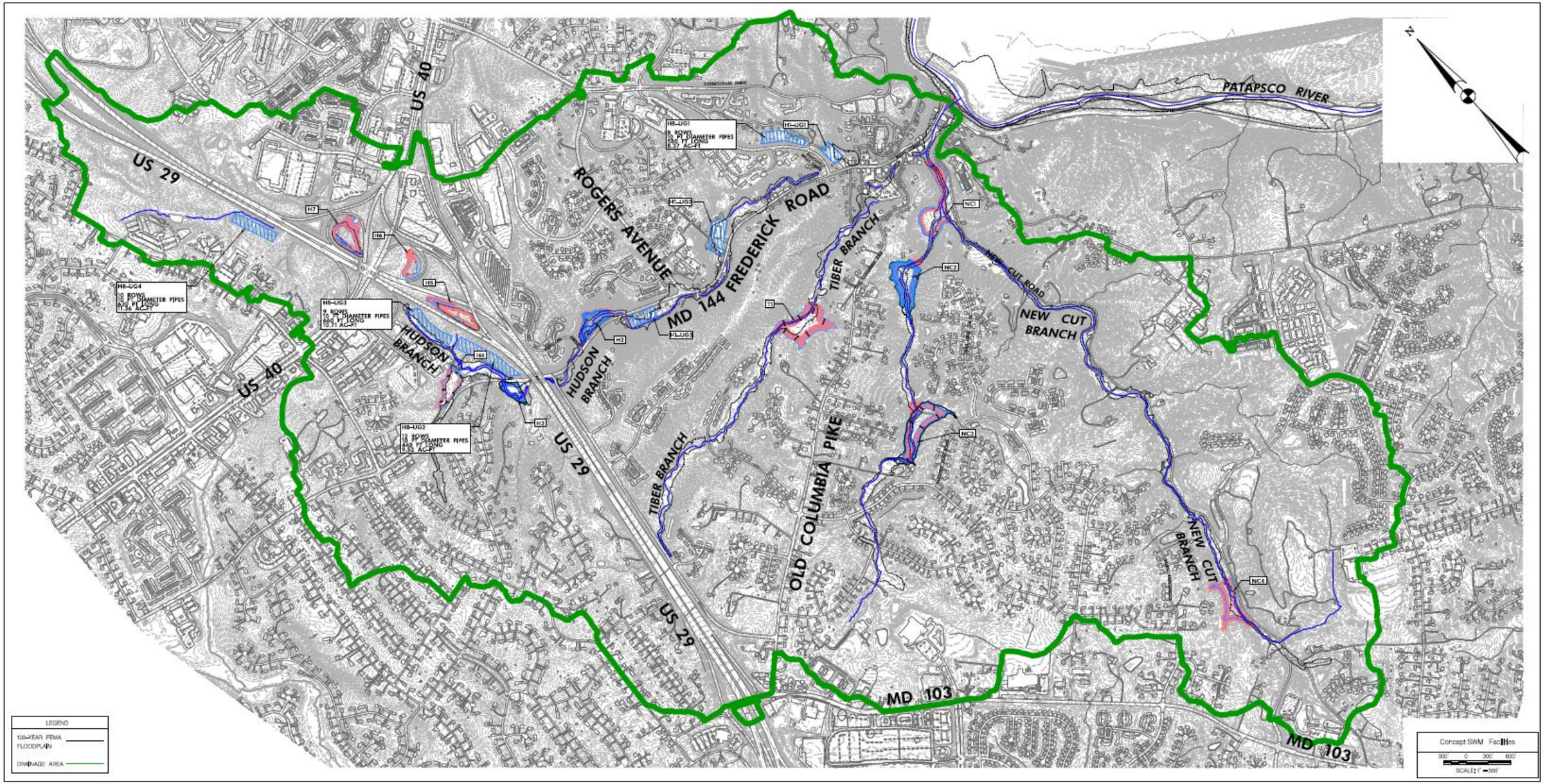

Figure 1

Conceptual SWM improvements proposed in the 2016 H&H Report. Figure obtained from Appendix B of the 2016 H&H Report.

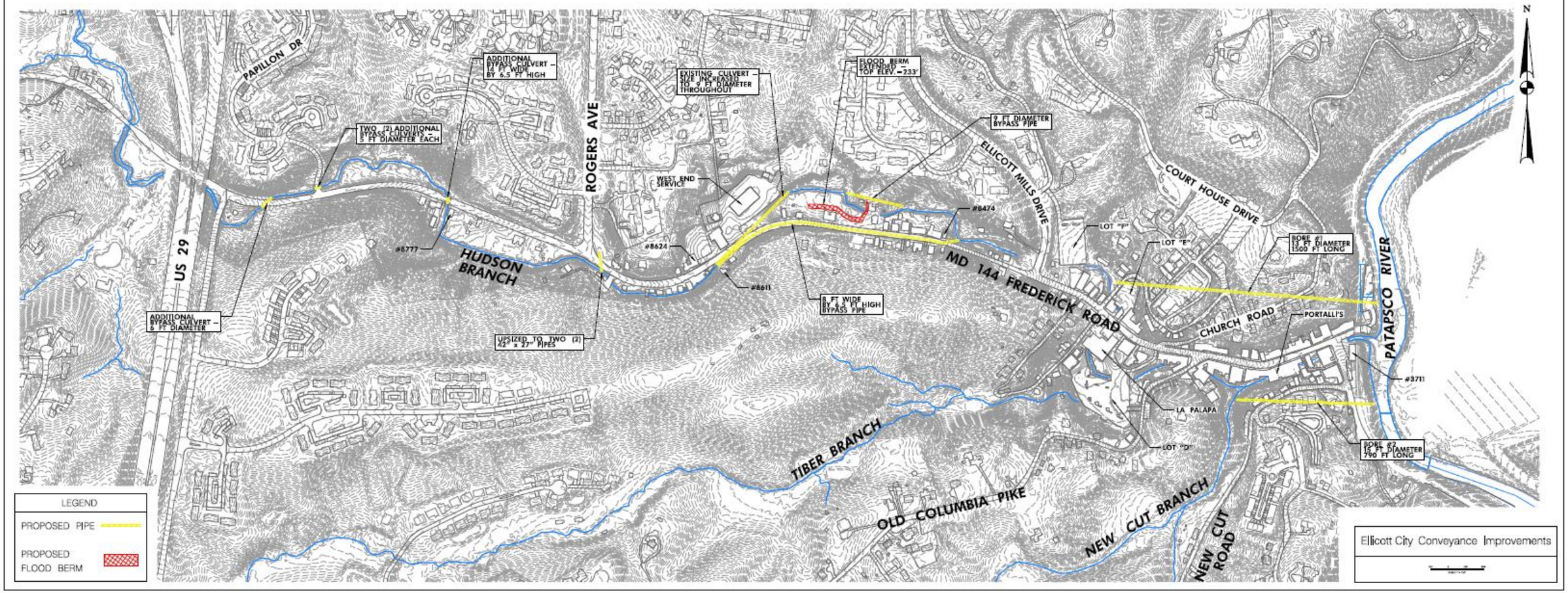

Figure 2

Conceptual stormmwater conveyance improvements proposed in the 2016 H&H Report. Figure obtained from Appendix B of the 2016 H&H Report.

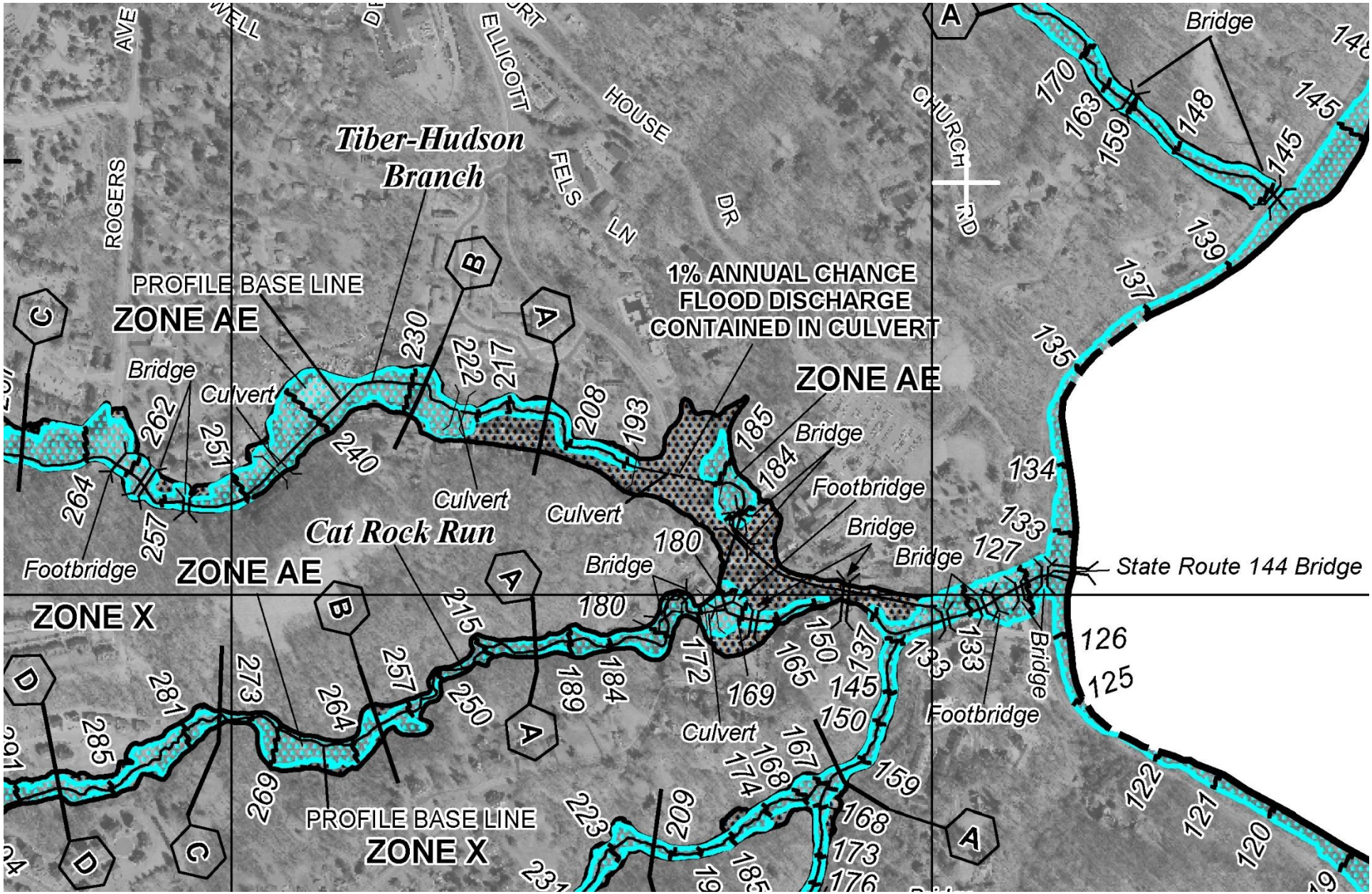

Figure 3

Portion of the effective FEMA FIRM (dated 5 November 2013) for Ellicott City. Elevations indicate FEMA BFE (ft NAVD 88).