Tuscan Village Floodplain Improvements - Floodplain Mapping

TO: New Hampshire Department of Environmental Services

FROM: Joseph M. Persechino, P.E.

DATE: November 28, 2016

Tighe & Bond is submitting this memorandum that summarizes the methods and results from the hydraulic analysis for the proposed Rockingham Park Redevelopment Project in Salem, New Hampshire. The Rockingham Park Redevelopment Project will include replacing the existing Rockingham Park with a mixed-use development completed in multiple phases. Proposed new and modified culverts were designed based on New Hampshire Department of Environmental Services (NHDES) and Town of Salem requirements. An analysis of the existing and proposed 100-year floodplain for Policy Brook and the West Channel of Policy Brook was performed following guidance by the Federal Emergency Management Agency (FEMA). The proposed design includes "daylighting" (replacing storm drain systems with open channels) two stream segments, and clearing sediment that has built-up at a culvert downstream of the site at Rockingham Park Boulevard. The proposed design is intended to improve or maintain drainage both on-site and off-site while improving the ecologic health of Policy Brook.

1 Study Area

OMJ Reality has acquired the rights to develop the property formerly known as the Rockingham Park Racetrack Property (Rockingham Park redevelopment area). The site is located northwest of the intersection of South Broadway Street (Route 28) and Rockingham Park Boulevard in Salem, NH. Figure 1 shows the locations of culverts upstream, within, and downstream of the study area, as well as the drainage area for Policy Brook upstream of Route 93. Figure 2 shows the proposed site development area. The proposed redevelopment area will be a mixed-use area that will include housing, retail, and commercial uses.

2 Hydraulic Analysis of 100-Year Floodplain

Tighe & Bond performed hydraulic analyses using the hydraulic modelling software HEC-RAS in preparation for filing a Conditional Letter of Map Revision (CLOMR) with FEMA. Three separate sets of models were developed: a copy of the hydraulic model used in the effective Flood Insurance Study (FIS) known as the duplicate effective model, a model with additional detail available at present for the existing site (existing conditions model), and a model that shows the proposed changes (proposed conditions model). Tighe & Bond will submit a CLOMR M-2 Revision Request application to FEMA, on behalf of the applicant, in conjunction with the NHDES wetlands filing.

2.1 Data Collection and Development

2.1.1 Effective FEMA Data

Tighe & Bond acquired the Rockingham County New Hampshire Flood Insurance Study (FIS) effective May 17, 2005, and associated Flood Insurance Rate Map (FIRM) panels. The study

area includes FIRM map numbers 33015C0561E (Panel 561 of 681) and 33015C0563E (Panel 563 of 681). The study area includes Detailed Study Areas (portions of Unnamed Brook and Policy Brook), Limited Detail Study Areas (portions of West Channel of Policy Brook), and approximate study areas (Policy Brook from the existing Rockingham Park Culvert to the South). All elevations were provided in the North American Geodetic Vertical Datum of 1929 (NGVD29).

The hydraulic analysis for the Detailed Study Areas of Policy Brook and Unnamed Brook were completed in July 1977 by the U.S. Army Corps of Engineers (USACE) using the model HEC-2. A printout of this model was acquired from FEMA along with hand calculations dated June 1977. The hydraulic analysis for the West Channel of Policy Brook was completed in September 1995 and was prepared by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) using the Soil Conservation Service (SCS) Water Surface Profile Model WSP2 (WSP2). HEC-2 is a predecessor of HEC-RAS, while WSP2 is on the list of models no longer accepted by FEMA.

2.1.2 Detailed Field Survey

MHF performed several detailed field surveys as part of the proposed redevelopment of Rockingham Park. The surveys were performed by a registered professional land surveyor using a total station and the vertical datum NGVD29. Photographs were taken at culverts and bridges, and design plans were investigated where access constraints limited the effectiveness of field survey.

2.1.3 Development of Digital Elevation Model

A Digital Elevation Model (DEM) derived from LiDAR is available from New Hampshire's Statewide Geographic Information Systems (GIS) Clearinghouse, NH GRANIT. The Coastal New Hampshire 2011 data was completed as part of the North East Project that was primarily funded by the American Recover and Refinement Act (ARRA) of 2009 using the North American Datum of 1983 (NAD83) horizontal projection and the North American Vertical Datum of 1988 (NAVD88). The DEM resolution is 2 meters with a vertical root-mean-square deviation accuracy of 15 centimeters. The DEM for the study area was acquired from NH GRANIT and was re-projected to the NAD83 New Hampshire State Plane FIPS 2800 and was converted to feet. The vertical datum was also converted from NAVD88 to NGVD29 for consistency with the field survey, and effective FEMA data (e.g., models, FIRM, profiles, and FIS tables).

2.2 Duplicate Effective Model

The duplicate effective model is meant to be a near exact copy of the effective model. The printout of the HEC-2 model completed in July 1977 by the USACE was digitized using HydroPro for Windows, and tested by running HEC-2 in a DOS environment. The HEC-2 model was imported into HEC-RAS and due to differences in modeling methodology minor changes were required to model the system correctly. These changes include:

- Updating the structure stationing to correctly line-up with the upstream and downstream cross sections
- Assuming a distance between structures and upstream cross sections (this data was not included, nor required in HEC-2)
- Modeling the Main Street Culvert as two culverts instead of as a deck with a rough approximation of culvert openings

The maximum difference between the effective model water surface elevations (WSELs) provided in the FIS and the updated effective model WSELs was 0.1 feet, and the maximum difference in the floodway WSELs was 0.2 feet. Given the change in modeling methodology these differences are considered reasonable.

The SCS WSP2 model completed in 1995 by the USDA NRCS was imported to HEC-RAS using the NRCS conversion tool WRAS from South Policy Street to Pleasant Street. Structures do no import correctly from WSP2 so several changes were required for the model to run. These changes include:

- Updating the structure stationing to correctly line-up with the upstream and downstream cross sections
- Updating structure distances from up-stream culverts so that the sum of the length of culvert and the distance of culvert from upstream structure was less than the distance between the two bounding cross sections
- Assuming a distance between structures and upstream cross sections (this data was not included, nor required in WSP2)
- Bridge elevations were modified to match the FIS profiles.

The maximum difference between the effective model water surface elevations (WSELs) provided in the FIS and the updated effective model WSELs was 0.1 feet over the study area. Given the change in modeling methodology these differences are considered reasonable.

2.3 Corrected Effective Model/ Updated Existing Conditions Model

The corrected effective model more accurately displays conditions presented in the effective model at the time of the previous hydraulic study, while the updated existing conditions model provides existing conditions. For this study the corrected effective model and updated existing conditions model are assumed to be the same.

The updated existing condition model was recreated to incorporate the LiDAR data with 2-meter resolution from NH GRANIT and detailed survey information. The HEC-2 and WSP models simplified structures and cross sections based on available data (e.g., several bridge opening were modeled as triangles) so updating the model was deemed appropriate.

Tighe & Bond created a HEC-RAS model that included the West Channel of Policy Brook from South Policy Street to the confluence with Policy Brook, Unnamed Brook, and Policy Brook. The principal input for the hydraulic model are geometric cross sections of the river and bank areas, structure geometry, manning's roughness coefficient ("n"), and the peak flows.

The HEC-GeoRAS tool was used to develop cross section geometry and structure locations in a GIS environment. Approximately 25 cross sections and three culverts were included for the study area in the effective FEMA models, and the updated existing conditions model was created by overlapping cross sections with minor modifications to match existing topography and by adding new cross sections. Approximately 60 cross sections and 7 culverts were included in the HEC-GeoRAS tool. HEC-GeoRAS extracts elevation data from the DEM transforming the cross sections (with x and y coordinates but no elevations) to cross sections that can be used in HEC-RAS (with x and y coordinates with elevations).

The HEC-GeoRAS results were imported to HEC-RAS to create a spatially referenced hydraulic model. The model uses manning's equation and internal boundary equations to represent flow through structures, such as bridges, to estimate the water surface elevations along a stream reach. The manning's n values for the channel and overbank areas were estimated based on the effective FEMA models, field observations, and satellite orthographic imagery. The manning's "n" values for the channel ranged from 0.035 to 0.05 and the overbank manning's "n" values ranged from 0.03 to 0.1. These channel manning's "n" values fall within the range specified in the FEMA FIS, while the overbank manning's "n" values provide more detail (the previous study assumed all overbank manning's "n" values were approximately 0.1).

The hydraulic control structure information measured during the site survey was used to define the geometry of the bridges in HEC-RAS. The information included defining bridge openings (e.g., inverts, widths, and heights), and culvert properties (e.g., size and material). The DEM used for this study did not provide elevations below the water surface of the streams. Therefore, the channel bottom elevations were estimated at structures based on the field survey measurements. These channel bottom elevations were used to interpolate the channel bottom elevations where data was available.

The effective FEMA model for Policy Brook ends detailed calculations at the upstream end of the Rockingham Park Culvert, and used hand calculations for the culvert to set the model boundary condition. Tighe & Bond modeled this culvert in HEC-RAS and added the Rockingham Park Boulevard culvert located downstream. The Rockingham Park Boulevard culvert was found to have a significant tailwater impact on the upstream areas of Policy Brook. In addition, it was found that over a foot of sediment has accumulated within the 12-foot by 6-foot culvert further inhibiting flow. This tailwater effect resulted in a 2.5-foot increase in the WSEL just upstream of the Rockingham Park Culvert (the Policy Brook effective model boundary), and an increase of less than 1 foot moving upstream. Tailwater caused by Cluff Crossing Road and Kelly Road were taken into account in the model boundary condition.

The effective FEMA model for the West Channel of Policy Brook ends detailed calculations upstream of the existing culvert. This culvert was added to the model to provide a realistic downstream boundary condition. The surveyed deck elevations of Main Street is over 1 foot higher than that indicated in the effective model, while the surveyed deck elevation of Pleasant Street is over 3 feet below the effective FEMA model. As a result, the water surface elevations upstream of Main Street are up to 1.2 feet higher than the effective model, while the water surface elevations upstream of Pleasant Street are up to 2.3 feet lower than the effective FEMA model.

The floodway and 500-year floodplains were also calculated for Policy Brook and Unnamed Brook. Figure 3 shows the effective FIS FIRM panels overlaid with the updated existing model floodplain (the proposed condition floodplain and cross sections are also included).

2.4 Proposed Conditions Model

The proposed hydraulic design for the Rockingham Park Redevelopment project accommodates the 100-Year FEMA flows, while also meeting NHDES guidelines. The proposed design includes redirecting the West Channel of Policy Brook to a proposed pond southeast of Pleasant Street that flows southeast to Policy Brook. Under existing conditions, the majority of this flow enters two culverts ("Culvert A" and "Culvert B" in the FIS) that drains to Policy Brook downstream of the railroad crossing. A stream restoration is proposed along Policy Brook from the railroad crossing to Rockingham Park Boulevard

implementing a meandering channel and removing the existing 60" diameter Rockingham Park Culvert. Sediment that has accumulated at Rockingham Park Boulevard and downstream is also proposed to be removed. Two onsite open bottom culverts are proposed that are large enough to pass the effective FEMA 100-year flows. The proposed hydraulic design will primarily require excavation along the riverine areas with minor filling as required to tie into high ground.

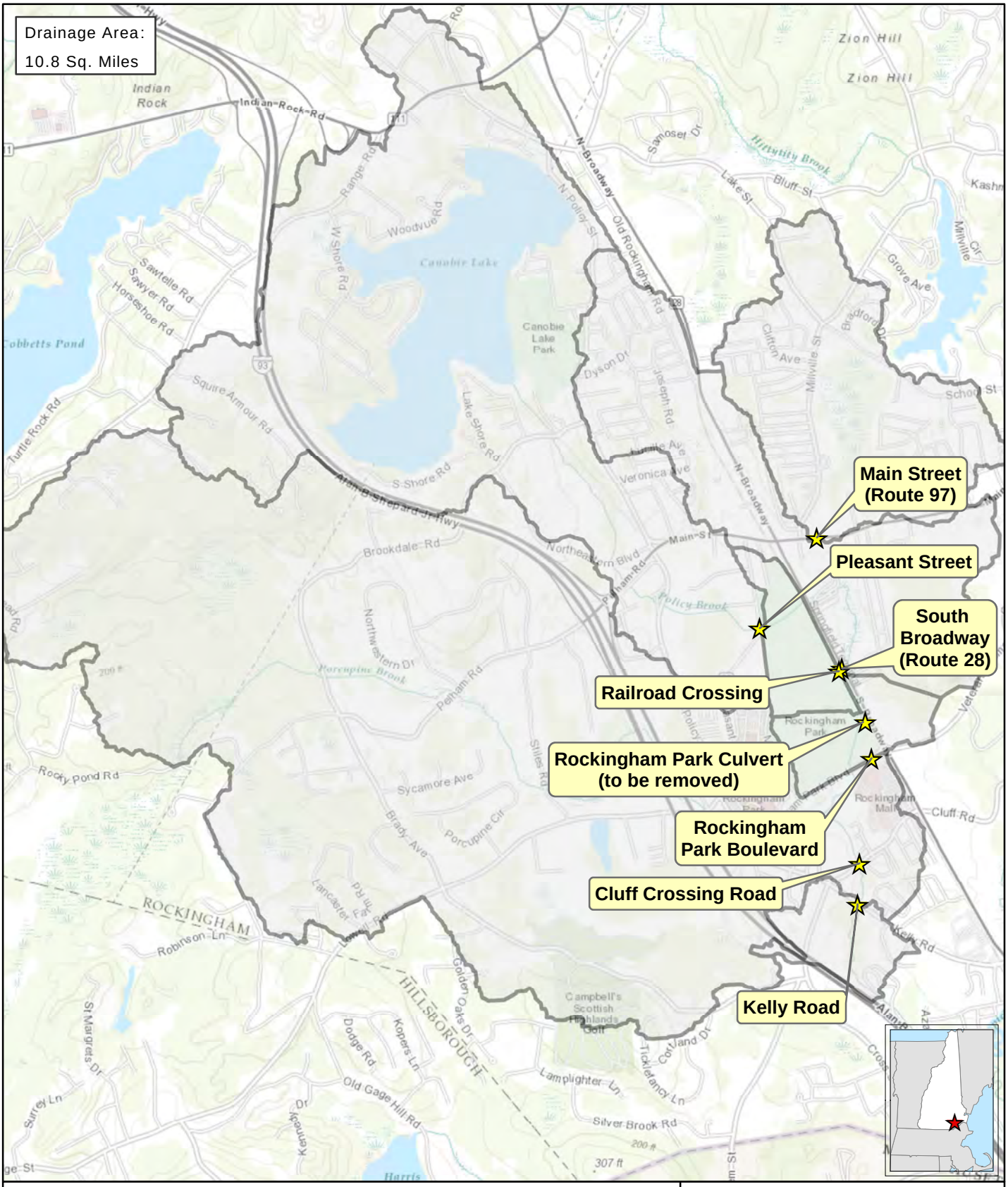
The proposed design is anticipated to lower the water surface elevations for the majority of the study area compared to existing conditions. Table 1 compares the WSELs at five key culvert crossings from the FEMA FIS, the updated existing model, and the proposed conditions model. Figure 3 shows the effective FIS FIRM panels overlaid with the proposed condition floodplain and cross sections (the existing conditions floodplain is also included). The submittal to FEMA will also include the updated 500-year floodplain and floodway for the proposed conditions.

TABLE 1

Preliminary 100-year floodplain water surface elevation results at key culverts using effective FEMA hydrology

Location	Approximate Minimum Elevation to Overtop Road (NGVD29)	Water Surface Elevations (NGVD29) Using FEMA 100-Year Flows			
		Effective FEMA	Existing	Proposed	Difference between Existing and Proposed
Main Street (Route 97)	126.6	127.1	128.1	128.1	0.0
Pleasant Street	130.3	132.4	130.7	128.2	-2.5
South Broadway (Route 28)	125.3	126.5	127.0	126.8	-0.2
Railroad Crossing	125.7	126.3	127.0	126.8	-0.2
Rockingham Park Boulevard	126.5	Not Included	126.5	124.0	-2.5

Figures



Legend

- Culvert Location
- Drainage Area

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

0 1,500 3,000 Feet

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FIGURE 1
DRAINAGE AREA MAP

Rockingham Park Redevelopment
Salem, New Hampshire

November 2016

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Legend

- Culvert Location
- Proposed Pond
- Proposed Streams
- Proposed Redevelopment Area
- Existing Streams

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Transportation data developed by Esri using Esri highway data; DeLorme basemap layers; HERE street data for North America. For more information on this map, including our terms of use, visit us online at tp://goto.arcgisonline.com/maps/Reference/World_Transportation

0 600 1,200
Feet

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FIGURE 2
SITE MAP

Rockingham Park Redevelopment
Salem, New Hampshire

November 2016

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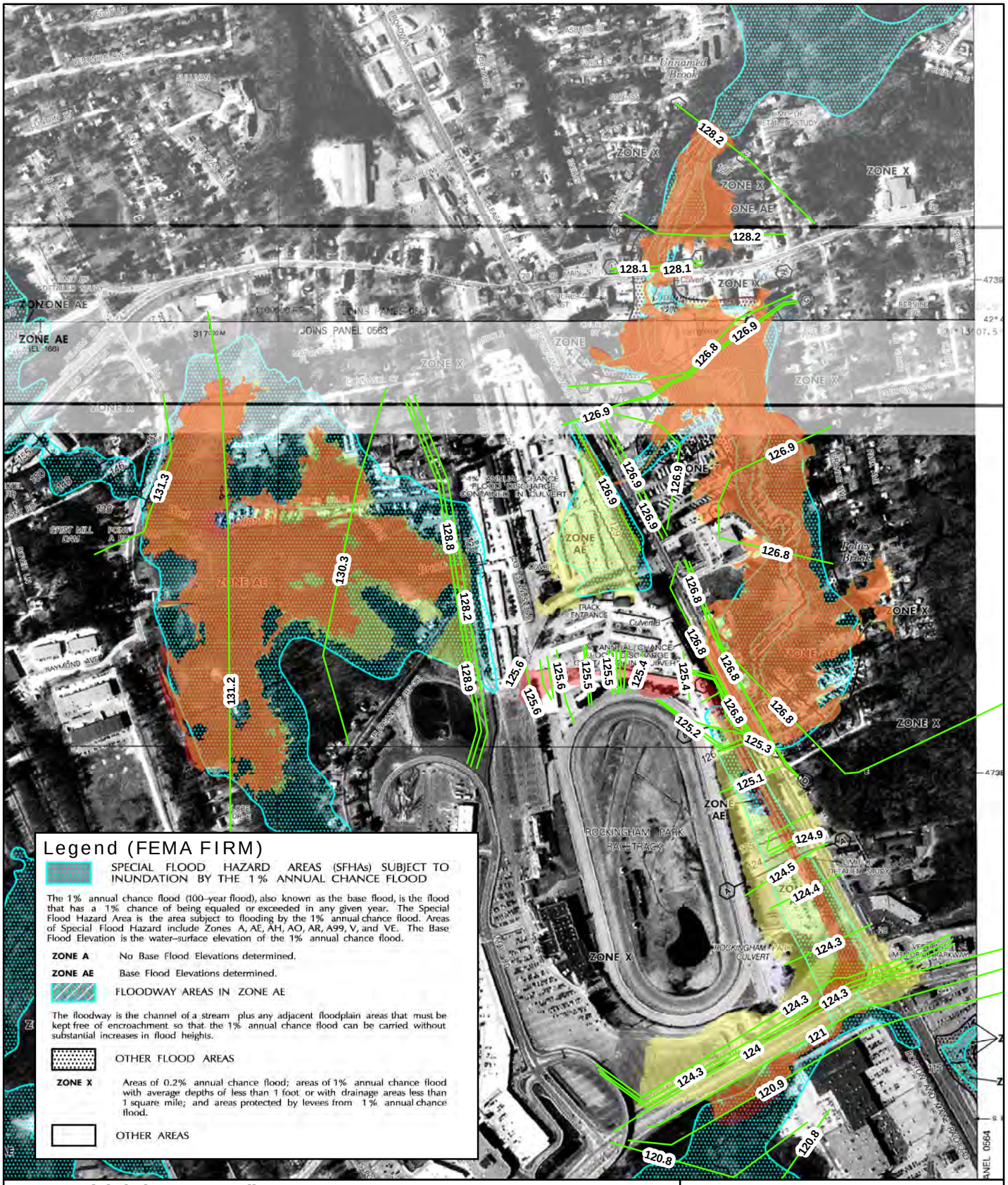

Legend (FEMA FIRM)

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

Legend (Tighe & Bond)

- Proposed Conditions Cross Sections (Elevations in NGVD29)
- Proposed Conditions Floodplain
- Updated Existing Conditions 100 Year Floodplain

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The FEMA Flood Insurance Rate Map (FIRM) for Rockingham County, New Hampshire are provided as a basemap. Map Number 33015C0561E and Map Number 33015C0563E are included with an effective date of May 17, 2005, although the model was completed prior to 1980.

0 450 900 Feet

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FIGURE 3
FLOODPLAIN MAP

Rockingham Park Redevelopment
Salem, New Hampshire

November 2016

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