Appendix D
Geographic Information Systems Hydrologic and Hydraulic (H&H) Modeling Processing

Memorandum

To: Jennifer Fogliano, Jeff Perlman | North Jersey Transportation Planning Authority (NJTPA)

From: Mark Zito, GISP, CFM, Melissa Harclerode PhD, BCES, Lauren Miller (CDM Smith)

Date: June 28, 2018

Re: Tasks 1 and 2 Technical Memo for NJTPA Passaic River Basin Climate Resilience Plan: Geographic Information Systems Hydrologic and Hydraulic (H&H) Modeling Processing

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Purpose

The North Jersey Transportation Planning Authority (NJTPA) vulnerability assessment evaluates each transportation asset in regards to the impact of flooding and heat events. In order to analyze the transportation assets for vulnerability, several steps were taken to estimate the depth of flooding at each asset. The methodology for establishing the flooding extents are detailed in the technical memo entitled "Sources and Recommended Framework for Hydrologic and Hydraulic (H&H) Modeling (3/5/18)", referred to herein as the "H&H memo".

The original intent was to study all transportation assets that are in the vicinity of a Federal Emergency Management Agency (FEMA) detailed flood study. However, it was determined that the necessary information to extend the models to cover the desired flooding events was not available. Therefore, the tiered approach outlined in the H&H technical memo was developed. The Tier 1 process allows for the study of all assets within the floodplain and the Tier 2 was limited to a few select areas. In addition, a separate process to evaluate the potential flooding impacts for coastal assets was developed. The processes below describe the Geographic Information Systems (GIS) process taken to establish the flood depth for the Tier 1, Tier 2 and Coastal Area assets. This information was used as an indicator to determine if the transportation asset was sensitive due to flooding, which impacts the vulnerability rating.

Tier 1 Methodology GIS Process

The Tier 1 portion of the study covers the assets along the lower Passaic River[1]. Below are the steps used by the GIS team to establish the flood risk to the transportation assets within the Tier 1 boundary.

1. Assign a unique Asset ID to each asset. This creates a relationship that can be used throughout the study to join information from various tables.
2. Obtained Water Surface Elevation (WSE) Grids for each scenario from the modeling team.
3. Select all assets within 400 feet of the FEMA 100-year flood hazard areas for Lower and Central Passaic River also known as Tier 1 reaches.
4. Create a perpendicular line for each asset to reference the asset to its location along the stream and create an end point to be used in the feature extract steps.
5. Extract the WSE from each grid and populate the respective field in the end point.
6. Transfer the results of the previous step back to the original asset location.
7. Extract the ground elevation from the Light Detection and Ranging (LiDAR) (NAVD 88 feet) and assign to the asset.
8. Calculate the depth of flooding for each scenario using the WSE – Ground Elevation.

Tier 2 Methodology GIS Process

The Tier 2 portion of the study covers the transportation assets outside of the Tier 1 and Coastal Area boundary, as determined with NJTPA. The Tier 2 method required additional steps and a higher level of complication than Tier 1 due to the lack of digital data representing the WSE. The elevation of flood inundation extents were calculated for Tier 2 based on the river station at each asset to determine if the asset would be inundated during a specific flood event. Due to topographic changes, structures along the river and other features that effect the river hydraulics, flood inundation extents were not calculated for an entire Tier 2 area. This would require capturing the flood elevation for each modeled cross section in order to eliminate over or under interpolation. Below are the steps used by the GIS team to establish the flood risk to the transportation assets within the Tier 2 boundaries.

1. Obtained all the profile baselines, flood hazard area polygons, and cross sections from the FEMA National Flood Hazard Layer.
2. Identified the Tier 2 areas based on specific criteria (see NJTPA Phase A memo dated 6/28/18 for further information).
3. Selected all assets within the Tier 2 areas, then saved these features to a new file. These are the assets that were evaluated.

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[1] See the H&H memo dated 3/5/18 for a map of the assets covered using this method.

4. Clipped all line features (i.e. transportation assets that are not points such as roadways[2] and rail lines) to the Tier 2 areas and converted the line vertices to point features.
5. Created a single feature class for all NJTPA asset points that we will use for our Tier 2 process, keeping the Asset type and a unique ID for the asset as was done for Tier 1.
6. Extracted the ground elevation from the LiDAR data (NAVD 88 feet).
7. The drainage area is used as a reference to look up the peak flow discharge values in the Flood Information Study (FIS) tables. The discharge values are used to solve for the existing 25-year and future flooding scenarios (the 100-year scenario was already available. This information is available using the National Hydrography Database (NHD) Plus. This was obtained using the following steps:
    a. Downloaded NHDPlus_H_0203_GDB.zip from https://prd-tnm.s3.amazonaws.com/index.html?prefix=StagedProducts/Hydrography/NHDPlus/HU4/HighResolution/GDB/
    b. Loaded the NHDFlowline and NHDPlusFlowlineVAA data and joined the table to the flowlines using the NHDPlusID field.
    c. Used the TotalDrainageAreaSqKm field to get the drainage area for each segment, then converted these values to Square Miles (multiply by 0.386102).
8. Create a perpendicular line for each asset to reference the asset to its location along the stream and create an end point to be used in the feature extract steps.
9. Some areas in the study had available FEMA WSE grids from FEMA for the modeled 10%, 2%, 1%, and 0.2% annual chance floods. This extraction process is similar to Tier 1, however the 25-year and future scenarios still need to be calculated; these were calculated using the following steps:
    a. Used WSE grids to extract the elevation for each flood grid to the end points using the 3D Analyst toolbox's "Add Surface Information tool".
    b. Linked WSE grid elevation results data back to asset points via the Unique ID, then transferred flood model elevation data to the corresponding asset and populated a data type field to track features that contained elevation values from WSE grids.
    c. Identified the HMS Model Reach, or Subbasin, and Model Name for each Tier 2 asset point. This was done to use a lookup in the H&H process for determining the discharges for future flooding scenarios.
    d. Selected the asset points that contained the flood elevation data from WSE grids then exported attribute data to populate a Microsoft Excel table. This table was transferred to the CDM Smith Water Resource Modeling team, and they calculated the flood elevations for each scenario on these assets.

[2] Note only the emergency evacuation routes were used for roadways to filter down the evaluation to a manageable number of asset points.

10. The remaining areas did not have available FEMA WSE grids, therefore the WSE had to be obtained using the effective FEMA flood profile data. This data is in paper format and is represented by a line graph with station along the stream as the X value and WSE as the Y value:
    a. CDM Smith used a semi-automated process to convert the paper flood profile data to digital data in the GIS. A summary of the steps is listed below.
        i. Convert flood profile PDF pages to TIF format and Georeference in ArcMap to model space.
        ii. Trace the flood profile lines in GIS and utilize the proprietary extraction tool to convert to a FEMA Rasplot database.
        iii. Use the proprietary profile plotting tool to reference the flood profile to the stream centerline in GIS as route events. This results in a stream centerline with the WSE as m-values that can be interpolated at any point along the stream centerline.
        iv. Repeat steps i – iii for all streams in the study area (25 streams with over 200 pages of profiles)
    b. Snapped virtual lateral end points to Rasplot stream line for each stream.
    c. Ran "Locate Features on Routes – All Flood Elev" tool (Model Builder) on snapped end points for each stream to populate a table for each flood elevation: 10%, 2%, 1%, and 0.2%.
    d. Joined each table back to asset points using the "Join Tables - Rasplot Tables" tool (Model Builder) and set a query (WTR_NM = [specific stream name]) on asset points before running tool.
    e. Ran the "Select Attributes and Field Calc WSE tool" (Model Builder) to push the flood elevation from each flood elevation output table to the corresponding water surface elevation field in the asset point attribute table. After each run, the team populated a data type field to track features that contained elevation values from Rasplot tables.
    f. Identified the HMS Model Reach, or Subbasin, and Model Name for each Tier 2 asset point.
    g. Selected the asset points that contained the flood elevation data from Rasplot then exported attribute data to populate Excel table from Water Modelling team. This allowed the Water Resources Modeling team to calculate flood elevations for each scenario on these assets.
11. Added fields for each flood elevation scenario and for surface elevations (obtained from the DEM) to the original asset feature classes then pushed the values to each feature class by joining the ID field to the asset points.

Coastal Area GIS Process

The Coastal Area of the study covers the transportation assets at the mouth of the Passaic River near the coast. The Coastal Area method used a linear superposition (i.e., bathtub model) approach to take the predicted sea level rise and add it to stillwater elevation results, then used the topography and elevation of the ground surface to determine the WSE. Below are the steps used by the GIS team to establish the flood risk to the transportation assets within the Coastal Area boundaries.

1. Obtained WSE table for each scenario from the Water Resources Modeling team.
2. Select all assets within 400 feet of the FEMA 100-year flood hazard areas for coastal flooding.
3. Enter the WSE from the table and populate the respective field in GIS.
4. Extract the ground elevation from the LiDAR and assign to the asset.
5. Calculate the depth of flooding for each scenario using the WSE – Ground Elevation.

Summary

This memo summarizes the GIS approach to establishing the flooding risk to transportation assets in the Tier 1, Tier 2, and Coastal Areas as part of this study. The resulting WSE information was used as an indicator to determine if the transportation asset was sensitive due to flooding, which impacts the vulnerability rating.