FUSS & O'NEILL

MEMORANDUM

TO: Rebekah Cornell, South Hadley

FROM: Lara Sup, PE, Fuss & O'Neill
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DATE: March 20, 2023

RE: Culvert Replacement Summary Memorandum
Pearl Street/Elmer Brook, South Hadley, MA

Fuss & O'Neill has developed a concept design for the replacement of the existing Pearl Street culvert crossing of Elmer Brook in South Hadley, Massachusetts. The crossing was designed based on Massachusetts Department of Transportation (MassDOT) Chapter 85 bridge replacement standards and Massachusetts Stream Crossing Standards while also addressing future climate conditions using the guidelines created by the Resilient Massachusetts Action Team (RMAT). The crossing has been identified as among the top 5% of crossings prioritized for replacement by the Mass Wildlife Climate Action Tool and is located along a stream that is mapped as a coldwater fishery resource. Further, due to the observed field conditions, the limited hydraulic capacity of the culvert, and a known history of flooding at this location, the crossing was identified as a top 10 priority crossing for the Town during their FY21 MVP Action Grant to assess and prioritize culverts for replacement Town-wide. The existing 6' culvert severely constricts the stream and has a cascade/free fall condition at the outlet. These conditions have resulted in the formation of a large scour pool approximately 40 feet across and 4-6 feet deep downstream of the culvert.

The proposed replacement crossing is a 16-foot span by 6-foot rise open-bottom corrugated metal arch structure designed to meet 1.2 bankfull widths and accommodate predicted climatic condition peak flows for the 2070 50-year design storm.

The open bottom culvert will be set at the approximate invert elevations of the existing channel to keep the stream's longitudinal profile. The estimated total project cost is $675,000, which includes design, permitting, and construction.

Resource Area Description

Fuss & O'Neill Inc. performed a wetland resource area field inspection and delineation of the project area on September 8th, 2022. There were three inland wetland resource areas identified and delineated at the Site during the field investigation: Bordering Vegetated Wetland (BVW), Bank, Land Under Water Bodies, and Waterways (LUWW). There are five other state-regulated wetland resource areas present at the site: Bordering Land Subject to Flooding (BLSF), Buffer Zone, Riverfront Area, Priority Habitats of Rare Species, and Estimated Habitats of Rare Wildlife. These sites were determined from MassGIS and Fuss & O'Neill's modeling of the site and its associated hydrology.

In addition to the field delineation of resource areas, an inspection of Elmer Brook and the surrounding

habitats was conducted. Elmer Brook is a mapped, perennial watercourse that flows in a southerly direction through the project area. It then joins Bachelor Brook 0.9± miles south of the Site, which flows westerly to the Connecticut River (in addition, it has been identified as a Coldwater Fishery Resource by the Massachusetts Department of Fish and Wildlife). It is possible that the brook was straightened or otherwise altered due to the history of surrounding agricultural land use. A representative bankfull width of the stream was determined to be 13' based on upstream and downstream bankfull measurements outside the influence of the existing culvert. Green frogs and small fish measuring about two inches in length, presumably a species of dace (Rhinichthys sp.), were observed throughout the inspected reach of Elmer Brook. Several species of birds common to riparian areas were also observed, including mallard duck, northern flicker, downy woodpecker, crested nuthatch, blue jay, cardinal, red-tail hawk, and turkey vulture. Tracks of raccoon and beaver chew (2+ years old) were seen sporadically along the brook. Adjacent to the river-left bank, the floodplain is dominated by fields managed for hay or pasture. Upstream of Pearl Street, the river-right bank is adjacent to wooded and scrub-shrub BVW; below Pearl Street is a broad floodplain which is currently a meadow but was likely an agricultural field in the recent past. The riparian corridor connects habitats at the Site to a relatively large and diverse assemblage of wetland and terrestrial habitats located to the north and south.

Hydrology

The Site is located within the local drainage basin of Elmer Brook, a perennial stream that joins Bachelor Brook 0.9± miles downstream (to the south) in Hadley and eventually the Connecticut River. The Elmer Brook watershed at Pearl Street has approximately 3.7 square miles of contributing area.

Unit hydrographs for the 2-, 5-, 10-, 25-, 50-, and 100-year storm events were calculated using a GeoHEC-HMS hydrologic model with precipitation values obtained from NOAA Atlas 14 for the 24-hour storm event. Both present and future climatic conditions were considered in this analysis. The crossing was classified as Tier 2 based on the RMAT Climate Resilience Design Standards Tool, therefore the NOAA Atlas 14 data was scaled by a 27% increase for the 100-year storm event and a 20% increase for more frequent design storms.

Hydraulic Analysis

To analyze the stream crossing of Elmer Brook at Pearl Street, a 1-dimensional (1D) HEC-RAS hydraulic model was developed. The model's terrain was created from LIDAR data obtained from NOAA Coastal Data Viewer, a survey of Pearl Street and existing culverts completed in September 2022, and field data collected by Fuss & O'Neill staff in September 2022.

Pearl Street is classified as an urban local road; MassDOT Chapter 85 guidelines, therefore, require that the design flood frequency be based on the 10-year storm, with the design scour frequency based on the 25-year storm, and the check scour frequency based on the 50-year storm. The RMAT guidelines are more stringent in this case. Based on the level of criticality and an expected useful life of more than 50 years, it was determined that this culvert should be sized based on Tier 2 RMAT rainfall recommendations. The 50-year storm was used for the design storm plus a 20% magnification for additional capacity to accommodate predicted climatic condition peak flows.

The culvert size was optimized to meet all design criteria and maintain or lower WSEL (water surface elevations) along Pearl Street in the current climate. Future climate conditions show decreases in WSEL as a

result of the proposed culvert as well. This design also fulfills the requirement of 2 feet of freeboard above the future projected 10-year WSEL to the low chord of the culvert. The proposed culvert will not raise WSEL downstream of the project or significantly alter WSEL under current climate conditions. Table 1 below compares the water surface elevation for the different design storms (existing, proposed, and proposed future climatic conditions) at Pearl Street.

The project site is located in Zone B, according to its FEMA FIRM map. The WSEL shown on the FIRM is at elevation 121, but this elevation is derived solely from the Connecticut River tailwater. The proposed WSEL from the hydraulic modeling shows a higher value.

Table 1: Pearl Street WSEL Comparison

Design Storm	Existing Conditions WSEL	Proposed Conditions WSEL (2022)	Proposed Conditions WSEL (2070)
2-year	121.30	119.84	120.53
5-year	122.85	120.98	121.67
10-year	124.60	121.69	122.20
50-year	128.05	122.58	123.12
100-year	128.24	122.94	123.98

Recommended Replacement Structure

The choice of structure type generally depends on cost considerations, site limitations and access, foundations, and geotechnical requirements, geographical location, geometric considerations, and aesthetic or historic requirements. At this location, the primary considerations were overall cost, constructability, and geotechnical requirements.

Two structure types were considered for the culvert construction at this site, with the primary design considerations being the overall span length, scour depth and structure height. In addition, it was decided that only open-bottom structures would be considered to provide for a full-depth natural streambed. The structure types evaluated were a single-radius aluminum arch on concrete pedestals, and a precast concrete rigid frame – both on cast-in-place concrete spread footings.

- Cost Considerations – Overall cost of the proposed replacement structure was one of the most significant factors in selecting a replacement structure type at this location. Between the two structure types, the aluminum arch was far less expensive in terms of material cost. In addition, this structure does not require cranes or heavy machinery to install, so construction costs will be less. Finally, use of this structure allows for aluminum plate wingwalls and headwalls instead of concrete, providing further potential cost savings.

- Hydraulic Considerations – A rectangular concrete rigid frame will provide substantially more hydraulic area over the same span/height due to the arch's circular shape. However, this was found to be of limited benefit at the site due to bankfull width (not hydraulic area) controlling the sizing of the structure.

- Site Considerations – Common site considerations that affect the selection of structure type include available roadway cover, vehicular traffic, utilities, and environmental resources. There are more limitations to be considered with the use of an aluminum arch, including cover requirements and utility attachments. However, the site requirements at this location can accommodate those parameters.

- Geotechnical Considerations – Common geotechnical considerations include the foundation design based on structure size and existing soil conditions, as well as scour and embankment stability. The scour depth at the structure location is 5.5 feet, which is reasonable for use of a spread footing. Most of the material above this depth is organic and will need to be removed, and the varved clay on which the structure will be founded can provide the required bearing resistances.

The recommended structure type for this location is an aluminum arch on concrete pedestals. The 16' open-bottom arch will have an approximate height (rise) of 6 feet and be founded on concrete pedestals which will extend down to the buried spread footings.

This structure provides for all site and hydraulic project requirements and is very cost-effective, with the possibility for additional cost savings through the use of aluminum plate headwalls and/or wingwalls. The use of aluminum provides significant corrosion protection over the structural steel plate structures which were historically used.

Relative Opinion of Cost

We have developed an order of magnitude opinion of cost based on the review of construction costs for similar items in past projects, applicable reference cost data, and design and construction costs from the recent similar stream-crossing replacement projects in Massachusetts. The total project cost is estimated to be $675,000.

The total project cost assumes road closure and an off-site detour, which is generally the most convenient and least costly alternative for traffic control from a construction perspective. An off-site detour generally allows for a simpler, less expensive, and faster construction process as compared to stage construction or a temporary on-site detour bridge and bypass road. This option is feasible and acceptable to the Town at this location as alternate routes are available.

Permitting Requirements

The following permits and approvals are anticipated to be required for this project:

- MassDEP Wetlands Protection Act Notice of Intent
- USACE Self-Verification Notification
- MESA Project Review
- MassDOT Chapter 85 Bridge Review