Grand Trunk Trail & Riverlands Revitalization: Trail & Pedestrian Bridge Design

A Technical Memorandum Submitted to the Town of Sturbridge

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Trail Design

Project Summary

The goal of this project was to design a trail system connecting the Sturbridge Commercial Tourist District to the existing local trails network in the Riverlands area to encourage residents and visitors to engage in outdoor recreation in Sturbridge, MA. This will promote tourism and a more active lifestyle among the community and visitors. The final recommendation presents a full trail design, including delineation, materials, steep slope management, stormwater management, cross sections, cost analysis, and a maintenance plan.

Site Evaluation and Data Collection

In order to identify restricting factors, the GIS data and town maps were compiled using MassGIS files and data provided by the Town. After organizing these maps in ArcMap, state contour data and wetlands data were added. Using ArcMap's import to CAD function, the file was converted to a drawing file. This data was not detailed enough to make and analyze a surface in AutoCAD Civil 3D, so data was collected manually as well. During the site visits a GPS, the Garmin eTrex 20x, was used to collect elevation and coordinate data while walking through the area. In addition to elevation data, potential construction obstacles and areas of drainage concern were marked as waypoints with a corresponding description. All data collected was used to create a surface in Civil 3D.

Delineations

Multiple delineations (shown in Figure A) were created based on the surface in Civil 3D and the contour maps from the Town. Factors that limited alternate trail locations included existing grades, property boundaries, and environmental concerns. Once potential delineations were chosen, site visits verified that the options were free of large obstacles or drainage concerns.

Figure A: Delineation Options

Considering the importance of sustainability and minimizing environmental impact, it was decided that option four would be best, due to having the least interaction with stormwater and wetland areas, as well as providing hikers with a pleasant aesthetic view of the forest.

Materials

In consideration of material types, information was gathered on three materials including paved asphalt, compacted aggregate, and woodchips. Using the collected material design specifications and an estimated trail length, required material quantities were calculated. The material quantities were multiplied by material prices in dollars obtained from local suppliers to calculate material costs. Labor and equipment costs were found using the 2009 edition of RSMeans Heavy Construction Cost Data, then calculated for each step and totaled. The labor and equipment costs were adjusted using a price index to better reflect today's prices, accounting for inflation.

The recommended material for the trail tread was the Aggregate: ½" stone compacted to 6" with a 2" surfacing of compacted stone dust. The cross section for the trail bed is shown in Figure B. Overall, 57,000 ft^3 of ½" stone and 19,000 ft^3 of stone dust are required. Other costs include labor and construction costs. The total cost of construction for this project is roughly $93,800.

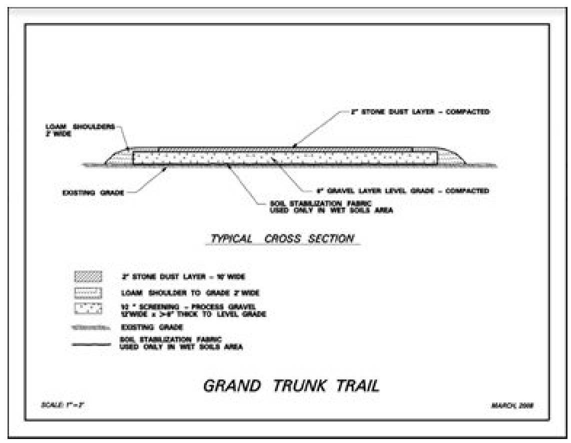

Figure B: Trail Bed Material Cross Section

Steep Slope Solutions

Based on the existing steep slopes in some small areas, which pose potential risks to accessibility, the NH Trail Construction and Maintenance Manual was consulted for solutions. It was determined that climbing turns were an effective way to solve slope issues. It is the least expensive ADA-accessible option, and the slopes aren't steep enough to require switchbacks. The environmental impact of climbing turns is less than either re-grading or switchbacks due to less excavation of the land. There is ample room in the area to make climbing turns with large radii for ease of construction. Figure C displays the finalized 1.2 mile delineation after implementing the climbing turns. The original delineation was a length of roughly 0.8 miles, with 0.4 miles added by the climbing turns.

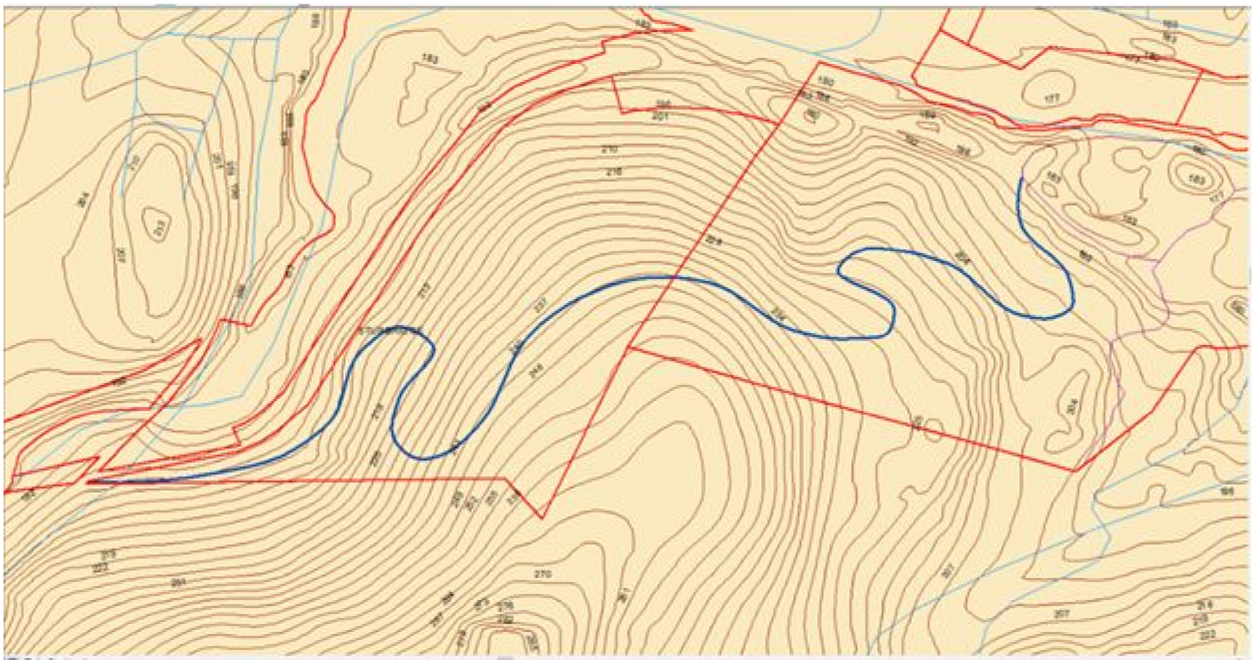

Figure C: Delineation Incorporating Climbing Turns

Stormwater Management

Using regional rainfall data (Massachusetts Department of Environmental Protection) and the GIS data for the Riverlands, swales were designed for stormwater management. Contours and surface data were used to draw flow lines throughout the area to represent the paths the water takes, which were then used to divide the area into multiple catchment areas. Those smaller sections were then further divided based upon what section of trail the water would flow across, giving eight sections. The volume of water is relatively evenly distributed, and it was determined that the best management practice would be swales running along the side of the trail. Four of these sections were identified as needing larger stormwater swales. Figure D shows the eight sections with green representing the areas that need larger swales. Blue represents the areas that need smaller swales. Figure E shows the typical cross section, featuring the smaller swale size.

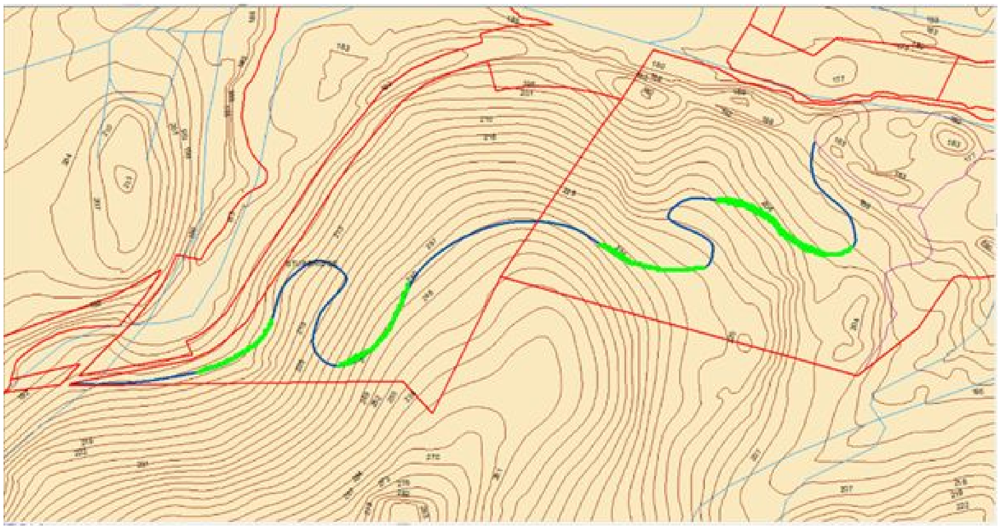

Figure D: Delineation Incorporating Swales

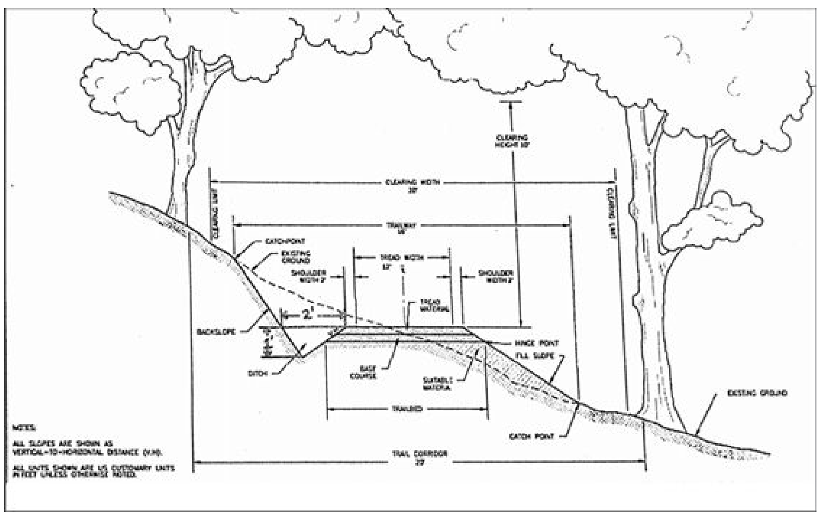

Figure E: Typical Cross Section

Maintenance Plan

After construction, trail maintenance is essential for the sustainability of the trail. Performing regular trail inspections will identify maintenance concerns before they become more problematic. It is a best practice to have at least three of these inspections each year: the first being before Memorial Day, the next in the middle of the summer, and a final inspection during the fall before the winter season. Additional trail inspections should be performed after heavy storms that occur during the time that the trail is being used (North Country Trail Handbook, 2019).

Pedestrian Bridge Design

Project Summary

The goal of this project was to design a pedestrian bridge to cross the Quinebaug River, connecting the commercial district to the recreational trail system in Sturbridge, Massachusetts. First, the team developed design criteria, selected a location for the proposed bridge, and produced preliminary bridge designs. The final recommendation for this project was to build a partially-covered, truss bridge that spans the river. A full structural analysis and design were performed and a final cost estimate was prepared.

Ranked Design Criteria

We established two sets of design criteria for the proposed bridge: one for the location of the bridge and a second for the bridge type. These criteria, that can found in Table 1, were based on the goals outlined in the Town of Sturbridge's *Recreational Trails Master Plan,* feedback from our stakeholders, and other engineering design resources, such as the *LRFD Guide Specifications for the Design of Pedestrian Bridges*, and accessibility requirements specified by the *Americans with Disabilities Act* (ADA).

Location Selection Criteria

1. Constructability
2. Environmental Impacts
3. Accessibility and Proximity to the Commercial District
4. Site Conditions

Bridge Design Criteria

1. Constructability
2. Environmental Impacts
3. Cost
4. Aesthetics

Location Study

Utilizing the Location Selection Criteria above, we analyzed 8 potential locations for the pedestrian bridge shown in Figure F. Due to site constraints, including existing utilities, elevation differences between each side of the river, low elevation with flooding concerns, long spans, and poor accessibility, locations 1, 2 and 5 were analyzed further using quantitative decision matrices. Location 5 ranked highest, as it is central to the commercial district, has a short 80-foot span, and can maintain ADA compliance with a maximum slope of 5% across the river. This location also lies within a town-owned portion of land near a recently acquired parcel to be used for parking.

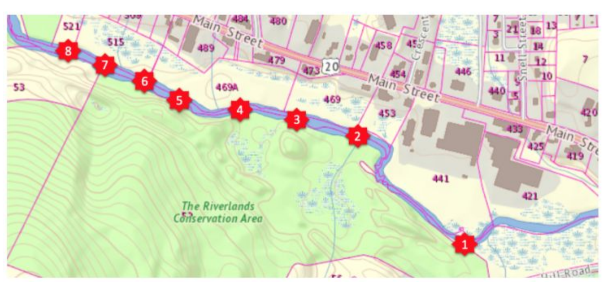

Figure F: Eight Potential Bridge Locations

Bridge Type Selection

Following the location selection, seven bridge alternatives were explored. Immediately, we eliminated the cable-stayed, suspension, and cantilever bridge types due to complexity, cost, and environmental impacts caused by supports located within the river. Inverset bridge sections, retained by the Town of Sturbridge, were also eliminated due to aesthetics and insufficient length. Three preliminary designs were produced for a beam, truss, and arch bridge. After receiving feedback from the Town of Sturbridge, we proceeded with the truss bridge design, as it fit the local aesthetics of the Town and historic rail beds, could span the necessary width of the river, and was relatively cost effective.

Superstructure & Finishes

The superstructure design consists of a truss on either side of the bridge, concrete deck as a walking surface, floor and roof beams to support the deck and resist horizontal wind loads, a roof truss system to cover the bridge's users, and a wooden siding to maintain the aesthetic of the Town's historic environment. A rendering of this design can be seen in Figure G. The trusses were designed using steel tube sections to resist loads specified in the *LRFD Guide Specifications for the Design of Pedestrian Bridges.* A prestressed, precast deck system is used in the design to carry the pedestrians that will be using the bridge. The deck system will be placed on floor beams that are also designed as steel tube sections, and will carry the load of the deck and pedestrians on the bridge. The floor and roof beams were designed to resist horizontal wind loads and will limit the horizontal deflection of the bridge in extreme wind situations. The roof truss system was designed to resist expected snow loads and will protect the bridge users from the elements. The roof consists of a wooden truss to be placed along the top chords of the bridge and consists of an asphalt shingle finish. The siding along the outside consists of reclaimed barn lumber. The use of reclaimed lumber is beneficial for the environment as it reduces the consumption of new timber and reduces landfill waste, while complementing the historic aesthetic of the Sturbridge area. Connections for the superstructure were also designed to hold together all of its components.

Figure G: Three-Dimensional Rendering of Pedestrian Bridge

Abutments

The abutments were designed to withstand the bridge load and avoid soil failure. The abutments consist of reinforced concrete, in the form of a wall that carries the load into a spread footing located below the frost depth. The wall design was used to transfer the load while minimizing the volume of necessary concrete. The wall is 10’ long, 8” wide, and 3’4” tall and the spread footing beneath the wall is 10’ long, 3’ wide, and 8” tall.

Cost Analysis

The cost analysis was completed using *R.S. Means Heavy Construction Cost Data 2009,* which we converted to current dollars, and *R.S. Means Online 2020*. The final cost estimate for the bridge totaled $91,000 including a location factor where applicable. This includes the cost of materials, labor, equipment, overhead and profit, and mobilization for the superstructure, substructure, and sitework for the project. The condensed cost analysis is shown in Table 1.

Table 1: Condensed Final Cost Analysis

Item	Total Current Dollars
Superstructure	**$37,390**
Decking	**$9,090**
Abutments	**$1,860**
Coverings	**$10,160**
Railings	**$30,120**
Excavation	**$1,220**
Mobilization/Demobilization	**$1,180**
Total	**$91,000**

Recommendations & Next Steps

We recommend that boring samples be taken in the location of the proposed bridge because we used an assumption for soil bearing capacity based on information from MassGIS Oliver. This value should be confirmed to verify adequate footing dimensions. We also recommend that the Town of Sturbridge look into ways to obtain reclaimed lumber. Reclaimed lumber fits well with the historical Sturbridge aesthetic and is beneficial for the environment; however it is not readily available. Perhaps stakeholders may know of a building that is being taken down in town so that the lumber can be reused as an aesthetic cover for the bridge. Lastly, we recommend that the Trails Committee look into developing a path to access the bridge from Route 20.