HINSDALE, NH – BRATTLEBORO, VT – NH ROUTE 119 BRIDGE PROJECT

U.S. Department of Transportation
Better Utilizing Investments to Leverage Development

"BUILD 2019"

TRANSPORTATION DISCRETIONARY GRANTS APPLICATION

BENEFIT COST ANALYSIS

Project Name: Hinsdale, NH - Brattleboro, VT - NH Route 119 Bridge Project
Project Type: Bridge Replacement & Bridge Rehabilitation
Project Location: Rural, Hinsdale, New Hampshire and Brattleboro, Vermont
Project Website: https://www.nh.gov/dot/projects/hinsdalebrattleboro12210/index.htm
Funds Requested: $20,000,000 (40%)
Other State and Federal Funds
New Hampshire: $25,980,000 (52%)
Vermont: $4,020,000 (8%)
Total Construction Costs: $50,000,000 (100%)

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DUNS #: 80-859-1697

Anna Hunt Marsh Bridge

Charles Dana Bridge

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HINSDALE, NH – BRATTLEBORO, VT – NH ROUTE 119 BRIDGE PROJECT

1) Project Description

The Vermont Agency of Transportation (VTrans) and New Hampshire Department of Transportation (NHDOT) propose to construct a new bridge to bypass the Anna Hunt Marsh Bridge (NHDOT Bridge No. 041/040, CT. River Br. No.2) and the Charles Dana Bridge (NHDOT Bridge No. 042/044, CT. River Br. No. 1) which carry NH Route 119 over the Connecticut River between the rural Towns of Hinsdale, New Hampshire (Hinsdale) and Brattleboro, Vermont (Brattleboro). The historic Anna Marsh Bridge is a fracture-critical Parker Truss with a span length of 324 feet (') and is in poor condition (Note: the superstructure condition rating was reduced from a 5 (fair) to 4 (poor) as a result of a detailed hands-on fracture-critical inspection in June 2018). The structure has a roadway width of 20'4 inches (") (two 10'2" travel lanes and no shoulders). A 6' cantilevered sidewalk exists outside the upstream truss. The bridge is posted for a minimum vertical clearance of 11'4" which is below the minimum required vertical clearance of 16'6". The historic Charles Dana Bridge has a total length of 297' consisting of a 200' span fracture-critical Parker Truss and two steel girder approach spans and is now also in poor condition. The roadway and sidewalk configuration match those of the Anna Marsh Bridge mentioned above. The bridge is posted for a minimum vertical clearance of 11'10", also below the minimum required vertical clearance noted above. Both of the existing structures are structurally-deficient and functionally-obsolete due to the substandard roadway width and vertical clearance.

The proposed project includes construction of a new low-maintenance, aesthetically pleasing, single bridge structure on a new alignment approximately 1000' downstream of the existing structures as well as maintaining the existing historic structures for pedestrian and bicycle use. The new bridge will be an 8-span, 1,798' curved steel girder structure with a concrete deck and carry two 12' lanes, two 8' shoulders, one 5' sidewalk for a rail-to-rail width of 45'6". Based on recent large bridge construction projects in New Hampshire, it is assumed that the bridge will take three years to construct. It is anticipated that construction will begin in early 2020 and end in mid-2023. Therefore, all user cost benefits and proposed bridge operation and maintenance (O&M) disbenefits will begin in 2024. Additionally, the project includes the rehabilitation of the existing truss bridges for pedestrian and bicycle use in 2023 at the end of the proposed bridge construction when traffic is shifted onto the new structure. This rehabilitation work is assumed to take one year so all repurposed truss O&M disbenefits will begin in 2024.

This Benefit-Cost Analysis (BCA) was conducted to evaluate the new bridge compared to a baseline assumption, or "do minimal" alternative. The analysis considers some of the major societal benefits versus the net costs based upon criteria described in the U.S. Department of Transportation *Benefit-Cost Analysis Discretionary Grant Programs* dated December 2018 (BCA Guidance). The analysis presented herein computes the proposed project benefits from reduced O&M costs and avoided user costs including travel time savings and emissions reduction. Several additional benefits of the proposed project are difficult to quantify but are regionally significant including economic competitiveness, quality of life enhancements, safety due to elimination of the "at-grade" railroad crossing and a more reliable response time for emergency vehicles due to the rural location of the project.

a. Baseline

The baseline scenario for this BCA is the continued use and maintenance of the existing truss bridges which can be characterized as the "do minimal" alternative. These structures link southwestern New Hampshire and locally, Hinsdale, to the regional commerce center and Interstate highway system in Brattleboro, Vermont. Due to the significant Average Annual Daily Traffic (AADT) that utilizes the existing crossing it is assumed the bridges must remain serviceable for the entire duration of the analysis period. This is also consistent with the BCA Guidance as the baseline does not assume the same or similar project will occur within the analysis period. As a result, all costs associated with the ongoing O&M must be accounted for. Additionally, the existing truss bridges are in need of major rehabilitation due to the condition of the lower chords and gusset plates. If the proposed project was not considered, it is likely that the existing bridges will be rehabilitated over a two-year period starting in early 2020 and ending in late 2021 or early 2022.

The bridges are currently posted "E-2" which means that certified vehicles cannot use the structures. Certified vehicles are those with axle weights above the legal load limit. Further, the two existing steel truss bridges are nearly 100 years old and similar bridges of this age are routinely posted with more stringent weight restrictions. The baseline scenario assumes that the bridges will follow a similar deterioration curve as other structures in the region and will be down-posted further to a 20-ton load posting in 2037. The posting does not completely close the bridge to traffic, only to heavy trucks with a gross vehicle weight greater than 40,000 pounds. The spreadsheets and files pertinent to this BCA are referenced in the BCA and supporting spreadsheets and are included in the Appendices to this BCA narrative.

Table 1 – Executive Summary Matrix

Baseline	Proposed Project	Types of Impacts (Avoided Costs)
Continued operation and maintenance of the existing Anna Hunt Marsh and Charles Dana Bridges.	Construction of a new, low maintenance bridge downstream of the existing bridges.	• Increased O&M costs. • Increased VMT and emissions from detours and load postings. • Elimination of an at-grade railroad crossing. • Increased VHT and emissions from existing rail crossing.

2) General Principles

The BCA calculation is sensitive to many factors including but not limited to duration and discount factors. The following assumptions as stated in the BCA Guidance were used in the development of the BCA:

- The base year of analysis is 2020.
- All dollars are expressed in 2017 real dollars.

- A discount rate of 7% is used for the analysis with a 3% discount rate used for the sensitivity analysis.

a. Analysis Period

The selected analysis period for this project was set to the maximum recommended value of 30 years per the BCA Guidance. This duration was selected since bridges often require large up-front costs to construct while the true value of the benefits is only realized after a long period of compounding. Further, bridges are routinely designed for service lives exceeding 30 years. Therefore, there is extremely low probability that the proposed bridge will be replaced during the analysis period.

The beginning year of the analysis period is 2020 which coincides with the expected start of construction and the start of significant capital expenditures. Larger bridge projects, especially in environmentally or historically sensitive locations, are often characterized by long-term planning durations at relatively low capital expenditure levels prior to construction. Therefore, to begin the analysis at the onset of initial planning will limit the time horizon to realize the benefits of the proposed project. A 30-year analysis period beginning at the start of 2020 results in an end to the analysis period at year end 2049.

3) Benefits

a. Value of Travel Time Savings

The NH Route 119 bridges are the only crossing of the Connecticut River between the towns of Hinsdale, New Hampshire and Brattleboro, Vermont and the shortest route to Interstate 91 in Vermont. The next closest crossings for all vehicles are 16.9 miles to the north and 18.7 miles to the south through Massachusetts. The average alternate route is 17.5 miles to the north and utilizes a river crossing between Chesterfield, New Hampshire and Brattleboro. Posting the bridge to a 20-ton capacity will cause diversion of all heavy trucks travelling locally and regionally. So as not to over-exaggerate the cost of traffic diversion, heavy truck traffic volume was estimated. In the absence of measured project specific heavy vehicle traffic, the analysis calculated the ratio of qualifying Vehicle-Miles-Traveled (VMT) to the total VMT statewide as measured by the California Air Resources Board. This ratio is 1.6% and presumed to be less than the actual volume since NHDOT's 2015 traffic data measured 4% trucks for all truck types.

Contributing VMT is estimated to be 56,848,750 miles in 2020 due to a full bridge closure. This traffic detour pattern continues for nearly another two years as anticipated to complete a rehabilitation of the existing structures. For posting VMT calculations the analysis assumes 0.5% and 1.6% of the 8,900 AADT volume being detoured 17.5 miles to the next available river crossing. For successive years beyond 2020, traffic volume is increased using a modest traffic growth factor of 1% per year.

2020 VMT = Average Annualized Daily Traffic x Distance
= 8,900 x 365 days x 17.5 miles
= ***<u>56,848,750 VMT</u>***

Under the same detour condition, the total change in Vehicle-Hours-Traveled (VHT) was estimated at an increase of 2,576,996 hours in 2020. This increase in VHT is due to the extended travel time required by all vehicles being detoured 17.5 miles travelling at 30 miles per hour as a result of seeking the next nearest available crossing of the Connecticut River toward Interstate 91. Based upon speed limits on this alternate route, it is estimated that the detour will add an approximate 0.5833 hours or 35 minutes per trip. Again, for successive years beyond 2020, traffic volume is increased using a modest traffic growth factor of 1% per year. When all vehicles are being detoured a vehicle occupancy factor of 1.36 was used. All other years within the analysis use an occupancy factor of 1.0.

2020 VHT = Average Annualized Daily Traffic x Time per Trip
= 8,900 x 365 days x 0.5833 hours x 1.34
= ***2,539,099 VHT***

Avoided train conflict VHT analysis used information provided by Genesee & Wyoming, the parent company of the New England Central Railroad (NECR), who provided "at-grade" railroad crossing data. The daily gate down time exceeds 30 minutes with pre-emption. The Brattleboro Yard and Amtrak station stop is a busy location. In addition to NECR and Amtrak trains, Pan Am Southern also operates trains on this route. Rail traffic, depending on switching moves, is eight or more trains per day including two Amtrak trains stopping on the highway crossing daily. To estimate the time it takes to clear the traffic queues for a 3.75-minute gate-down situation in Vermont along Route 119, a basic Synchro traffic model was created. Using the hourly recorded traffic data from NHDOT offers a highly representative distribution of hourly volumes to enable prediction of the traffic delay at the crossing due to trains passing through the area. With the proximity of the railroad crossing to the eastern limit of the 5-way intersection queues longer than 100 feet can gridlock most movements.

Total delay, or train conflict VHT, is determined from a comparison of the existing traffic model to the model with an inserted intersection for trains. Train intersection input is provided by Genesee & Wyoming and provides past safety and traffic volume data along with an AADT of 11,100 vehicles per day (vpd) in 2016 crossing over the tracks. Subtracting the total delay determined in each model results in the resultant delay from the train intersection conflict, Appendix B – Traffic Data contains the Syncro model output for each scenario, train intersection data and volume calculations. Based on subtraction to total delay between Synchro analysis models, the train conflict delay = 6 hours per occurrence * 8 occurrences per day * 365 days per year = 17,520 hours per year.

The net changes in VHT per year were then multiplied by the hourly user costs of $16.10 for all vehicles and $28.60 for trucks to arrive at the yearly user costs. The annual travel time and avoided train conflict costs amount to a total monetized value of approximately $40.879 million and $282,072 in the year 2020 and 2022, respectively. The net present value of VHT is $98.551 million at the 3% discount rate and $83.742 million at the 7% discount rate.

b. Safety Benefits

The proposed project includes many safety benefits compared to the baseline scenario.
Although these safety benefits are not monetized for inclusion in the BCA, they are addressed in detail below.

In comparison to the existing bridges, the replacement bridge will improve safety for all users. Specifically, the existing 20'4" wide roadway will be widened to 46' (providing 12' lanes, 8' shoulders, and a 6' sidewalk), thereby, improving safety for motorists, bicyclists and pedestrians. With regard to freight, the limited minimum vertical clearance of 11'4" of the existing bridges causes issues for trucks forced to occupy the opposing lane along a curved approach geometry. The new bridge will allow for unlimited vertical clearance and sufficient width for two trucks to pass in either direction.

The existing bridge is the only connection between Hinsdale and Brattleboro. Brattleboro Memorial Hospital in Brattleboro is the nearest medical facility to several towns in western New Hampshire, as the next closest facility is the Cheshire Medical Center in Keene, New Hampshire, 20 miles further northeast. Under the baseline scenario, emergency vehicles may eventually be required to detour around the bridge to reach this facility from eastern Vermont towns. This would lead to an approximate 30-minute increase in emergency response time in each direction to the hospital. Although this impact cannot easily be monetized in the BCA, the increased emergency response time would have significant adverse effects related to medical issues where response time is critical.

The existing at-grade railroad crossing in Brattleboro presents an inherent collision risk due to the mixed-use involving trains, vehicles, bicyclists and pedestrians. Eight or more trains utilize the rail corridor at this location per day which presents increased risk for train collisions, loss of life and property damage as traffic volumes increase. Train frequency includes freight and two Amtrak trains stopping on the highway crossing daily for passenger boarding and disembarking at the Brattleboro station. The project will eliminate vehicle crossings of NH Route 119 and the railroad and reduce the number of pedestrians and bicyclists crossing the tracks, therefore, significantly reducing the probability of injury and possible fatality.

Bridge closure for rehabilitation or maintenance or additional weight limit restrictions will result in an increase in traffic on local roads. The associated cost of safety relative to any increase in accidents arising out of the diversion of traffic onto more local roadway facilities was not quantified and monetized in the BCA.

c. Emissions Reduction Benefits

The baseline alternative increases exhaust emissions due to the increase in VMT for all traffic required to utilize the alternative route due to bridge closures for rehabilitation and O&M as well as the E-2 and assumed 20-ton load posting of the bridge in 2037. The net emission savings have been calculated for Particulate Matter (PM), Carbon Dioxide (CO_2), and Nitrogen Oxides (NOx). These emissions factors were applied to the baseline alternative assuming that the bridge replacement alternative maintains a consistent level of emissions to the current condition with the existing bridge open to all traffic, including freight. Data is not available for Volatile Organic Compounds (VOC) or Sulfur Dioxide (SOx) emissions.

Based upon the annual VMT in year 2020, approximately 11.164 metric tons of NOx, 25,924 metric tons of CO_2, and 0.06631 metric tons of PM would result during the traffic detour necessary to rehabilitate the existing structures. These emissions amount to a total monetized value of approximately $146,184 in the year 2020 and $84,845 in the year 2049 due solely to the

20-ton posting that year. The net present value of air emissions costs is $1,047,362 at the 3% discount rate and $647,184 at the 7% discount rate.

d. Vehicle Hours Travel (VHT) Delay Avoidance

The benefits of avoided user costs are twofold. The baseline requires travelers to utilize a detour route during closure, future maintenance activities, and with E-2 and 20-ton load postings. Additionally, trains present daily conflicts that result in delay to the roadway network. The majority of avoided VHT are attributed to the annual costs during full closure required to rehabilitate the non-redundant member existing structures. In year 2020 VHT cost equals $40.880 million. The net present value for detouring traffic is $98.551 million at the 3% discount rate and $83.742 million at the 7% discount rate. Annually, train delay costs are approximately $0.282 million. The net present value for avoided train delay is $4.938 million at the 3% discount rate and $2.969 million at the 7% discount rate.

4) Costs

Various project costs necessary to achieve the benefits described in Section 3 of this report were developed for the proposed project. These include both the capital expenditures and O&M expenditures for the proposed alternative and baseline. As is indicated in the BCA Guidance, the O&M expenditures for the proposed bridge are accounted for as a “disbenefit” of the proposed project and the O&M and capital expenditures of the baseline are accounted for as “benefits” of the proposed project.

The total capital expenditures for the proposed project include engineering services, right-of-way acquisitions and estimated construction costs. The construction costs also include the proposed bridge and rehabilitation of the existing trusses for pedestrian use. Table 2 below shows the capital expenditure values including the assumed year of expenditure.

Table 2 – Capital Expenditures

Item	Capital Cost	Year(s) of Expenditure
Engineering	$1,085,000*	2016-2020
NH ROW	$270,000	2019
VT ROW	$8,080,000	2019
Proposed Bridge Construction	$42,000,000	2020-2023
Existing Truss Rehabilitation	$8,000,000	2023-2024
Total	**$59,435,000***	

* This cost is in nominal dollars. Refer to Appendix E7 for the calculation of 2017 real dollars.

a. Capital Expenditures

Per the BCA Guidance, the baseline scenario should not assume that the same or similar proposed project will be implemented later. The bridges are currently in need of a rehabilitation due to significant concern with the condition of the lower chords and gusset plates. Therefore, a rehabilitation cost along with an O&M schedule was developed based on NHDOT guidance such that the existing bridge may conceivably stay in-service during the entire analysis period.

It is anticipated that a rehabilitation will consist of, but is not limited to;

- Deck and floor system replacement
- Joint replacement
- Rocker bearing replacement
- Lateral bracing replacement
- Lower chord and gusset plate replacement
- Bridge rail replacement
- Complete bridge repainting

A square foot cost for this rehabilitation was developed based on a detailed cost estimate for a similar truss rehabilitation. The anticipated rehabilitation cost is assumed to be $12,600,000. See Appendix E3 for additional information.

b. Operating and Maintenance Expenditures

The baseline scenario assumes that the existing bridges will remain in service throughout the duration of the analysis period. This was assumed to be a more realistic scenario than complete bridge closure as the user costs associated with detouring 100% of vehicular traffic is significantly greater than periodic O&M. As such, an O&M schedule including task costs, task frequency, task duration and the anticipated impact to traffic, such as temporary lane closures or complete bridge closures, was developed. These costs are anticipated to continue to keep the existing bridges in a state of good repair and open to all but heavy trucks.

As discussed in Section 1a of this narrative, it is likely that these O&M activities will not indefinitely allow heavy freight traffic to continue to utilize the bridges based on the past history of similarly aged structures. Therefore, the user costs associated with freight detours are included in the analysis as benefits. The existing bridges have substandard travel way widths, and there is anecdotal evidence of vehicles waiting to cross the bridge until an oncoming truck has passed. Therefore, it is reasonable to assume that a truck detour will be in place even during lane closures for O&M tasks. See Section 3 of this narrative for more information on user costs. Baseline O&M tasks and costs are included in Appendix E6.

An O&M schedule was developed by the NHDOT design team in order to provide an estimated 120-year service life for the proposed structure. These tasks, including intervals and costs, are included in Appendix E9. The proposed bridge is assumed to have adequate bridge width such that all O&M tasks can be accomplished using phased construction. Therefore, user costs for vehicular and truck traffic are not considered since no detour will be required.

c. Residual Value and Remaining Service Life

The analysis duration selected for this BCA is 30 years, however, since bridges are routinely designed for a service life substantially longer than 30 years, residual value for the proposed project and the baseline should be taken into consideration when determining the total benefit.

Through design and proper O&M expenditures, the proposed bridge is expected to have a useful service life of 120 years. Assuming a three-year construction period, the proposed bridge will be 26 years old at the end of the 30-year analysis window (2049) and will, therefore, have 94 years of residual value remaining.

The existing truss bridges were constructed in 1920. As of 2019, the bridges are 99 years old and will be 138 years old at the end of the analysis period. Therefore, it is reasonable to assume that the existing trusses will have close to no residual value at the end of the analysis period for both the baseline and proposed project alternatives.

5) Comparing Benefits to Cost

The annual benefits and cost values were discounted at 3% and 7% over a 30-year period. Three percent is considered the more appropriate rate for this analysis as the new bridge is expected to have a long service life with well-defined O&M expenditures and consistent user cost benefits. In addition, an alternate use of the funds would be for public expenditure rather than private investment which may have higher yields. The full analysis can be found in the spreadsheets in the appendices to this narrative. A summary of the results of the analysis is shown in the Table 3.

Table 3 – BCA Summary

Criteria	3% Discount Rate	7% Discount Rate
Avoided Air Quality Impacts	$1,047,362	$647,184
Avoided VHT User Costs	$103,489,382	$86,710,530
Avoided Baseline O&M Costs	$16,337,570	$13,991,994
Total of Present Value Benefits	**$120,874,314**	**$101,349,708**
Total of Present Value Costs	**$45,298,134**	**$48,020,892**
Net Present Value (NPV)	$75,576,180	$53,328,816
Benefit-Cost Ratio (BCR)	***2.67***	***2.11***

The avoided user costs followed by the baseline rehabilitation and O&M costs represent the largest portion of the total annual benefits, and therefore, these represent the most significant factors influencing the value of the BCR. Other factors, such as air quality and O&M of the proposed bridge and repurposed pedestrian bridge have comparatively minimal influence on the overall value of the BCR. The proposed bridge and repurposed truss bridge O&M were conservatively included in the denominator of the BCR with the proposed project capital expenditures. This maintains the same net present value but reduces the overall BCR. Further, as discussed in Section 3 of this narrative, the proposed project includes many additional safety benefits which are not quantified in the BCR.

6) Appendices

a) **Project Alternatives Evaluation – Executive Summary from EA**
b) **Traffic Data**
   1) **MOE 2020 PM Peak Existing (With Train)**
   2) **MOE 2020 PM Peak Existing (Without Train)**
   3) **WBAPS Report**
   4) **Volume Calculations**
c) **Benefit-Cost Analysis (BCA) Guidance for Discretionary Grant Programs**
d) **BCA**
e) **BCA Worksheets**
   1) **Average Emissions Factors**
   2) **Emissions Reduction & VHT Worksheets**
   3) **Baseline Rehabilitation Costs**
   4) **US Route 2 Bridge Rehabilitation Estimate**
   5) **Existing Truss Painting Cost Estimate**
   6) **Baseline O&M Cost**
   7) **Proposed Project Capital Expenditures**
   8) **Proposed Project Preliminary Cost Estimate**
   9) **Proposed Bridge O&M Costs**
   10) **Proposed Project Residual Value Calculations**
   11) **Repurposed Truss Bridge O&M Costs**
f) **Bridge Inspection Reports**