

**NHDOT Bridge Program**  
**Recommended Network Funding**

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## 1 Executive Summary

The NHDOT Bridge Management Committee (BMC) has developed a protocol for calculating the level of funding needed to address the maintenance, preservation, rehabilitation, and replacement needs of New Hampshire bridges. Values are calculated on the global base cost for each type of work activity generally needed for each bridge type. An adjustment multiplier is then applied, based on the roadway tier of the bridge. These amounts represent the annualized bridge funding needed for a typical program year across the entire bridge network. However, they do not reflect the annual costs specific to any particular bridge.

The results provided through this effort are compiled into the Recommended Investment Strategy (RIS) for all five bridge types (Girder, Truss, Moveable, Timber, and Culvert). The RIS is then used as a basis for the distribution of funding that is available, so that work can be programmed for specific bridges in each program year, as presented in the Department's 10-Year Transportation Improvement Plan (10-Year Plan).

The goal of the Recommended Investment Strategy is determine the overall level of bridge investment that is necessary to keep bridges in a state of good repair for their safe use by the traveling public, while also, over time, reducing the Red List.

### 1.1 Base Costs for Work Activity by Bridge Type

| <u>Activity*</u>      |  | <u>Costs per Sq. Ft. for each Bridge Type</u> |              |                 |               |                |
|-----------------------|--|---|--------------|-----------------|---------------|----------------|
|                       |  | <u>Girder</u>                                 | <u>Truss</u> | <u>Moveable</u> | <u>Timber</u> | <u>Culvert</u> |
| <b>Maintenance</b>    | Clean and Seal Substructure  | \$0.10  | \$0.10       | \$0.10          | \$0.10        | \$0.10         |
| <b>Preservation</b>   | Crack Seal Pavement<br>(Highway Design task)                       | \$0.07  | \$0.07       | \$0.07          | \$0.07        | N/A            |
|                       | Pavement In-lay<br>(Highway Design task)                           | \$1.60  | \$1.60       | \$1.60          | N/A           | N/A            |
|                       | Install Concrete Invert (Culverts)                                 | N/A   | N/A          | N/A             | N/A           | \$50.00        |
|                       | Patch Deck, Replace Membrane &<br>Expansion Joints, Rehab Bearings | \$50.00                                       | \$100.00     | \$200.00        | \$50.00       | \$100.00       |
| <b>Rehabilitation</b> | Rehabilitate Bridge  | \$100.00                                      | \$250.00     | \$350.00        | \$100.00      | N/A            |
| <b>Replacement</b>    | Replace Complete Bridge or Bridge<br>Superstructure                | \$650.00                                      | \$750.00     | \$1,000.00      | \$500.00      | \$500.00       |

\* Specific work activity varies by bridge type. See details for each bridge type for more information.

### 1.2 Tier / Cost / Activity Multipliers by Bridge Type

| <u>Tier</u> | <u>Cost Multipliers based on Bridge Type</u> |           |           |              |           |           |                 |           |           |               |           |           |                |           |
|-------------|--|-----------|-----------|--------------|-----------|-----------|-----------------|-----------|-----------|---------------|-----------|-----------|----------------|-----------|
|             | <u>Girder</u>                                |           |           | <u>Truss</u> |           |           | <u>Moveable</u> |           |           | <u>Timber</u> |           |           | <u>Culvert</u> |           |
|             | <u>P</u>                                     | <u>Rh</u> | <u>Rp</u> | <u>P</u>     | <u>Rh</u> | <u>Rp</u> | <u>P</u>        | <u>Rh</u> | <u>Rp</u> | <u>P</u>      | <u>Rh</u> | <u>Rp</u> | <u>P</u>       | <u>Rp</u> |
| HIB         | 1.0  | 1.0       | 1.0       | 1.0          | 1.0       | 1.0       | 1.0             | 1.0       | 1.0       | N/A           | N/A       | N/A       | N/A            | N/A       |
| Tier 1      | 1.0  | 1.0       | 1.0       | 1.0          | 1.0       | 1.0       | N/A             |           |           | N/A           | N/A       | N/A       | 1.5 - 2.0      | 1.5 - 2.0 |
| Tier 2      | 2.0  | 1.5       | 1.4       | 2.0          | 1.2       | 1.3       | N/A             |           |           | N/A           | N/A       | N/A       | 2.0            | 2.0       |
| Tier 3      | 1.5  | 1.5       | 1.4       | 1.3          | 1.3       | 1.3       | N/A             |           |           | 1.1           | 1.1       | 1.1       | 1.8            | 1.8       |
| Tier 4      | 1.5  | 1.5       | 1.4       | 1.1          | 1.1       | 1.2       | N/A             |           |           | 1.0           | 1.0       | 1.0       | 1.2            | 1.2       |
| Tier 5      | 1.5  | 1.5       | 1.3       | 1.2          | 1.2       | 1.2       | N/A             |           |           | 1.1           | 1.1       | 1.1       | 1.0            | 1.0       |
| Tier 6      | 1.5  | 1.5       | 1.3       | 1.2          | 1.2       | 1.2       | N/A             |           |           | 1.1           | 1.1       | 1.1       | 1.1            | 1.1       |

P = Preservation; Rh = Rehabilitation; Rp = Replacement;

### 1.3 Recommended Annual Funding

The Recommend Annual Funding tables for State, Turnpike, and Municipal bridges are shown below, based on bridge inspection data and NHDOT cost data compiled through December 31, 2017. The Recommended Annual Funding values presented below do not include the cost of roadway preservation, such as Crack Sealing and Pavement Inlay. The funding also does not account for any bridge and roadway expansion during a bridge project that might be needed for capacity improvements. Instead, these values focus on the cost of maintaining the current system.

#### 1.3.1 State (Non-Turnpike) Bridges - Recommended Annual Funding

| State (non-Turnpike) | HIB                 | Tier 1              | Tier 2              | Tier 3              | Tier 4              | Tier 5      | Tier 6             | Totals               |
|----------------------|---------------------|---------------------|---------------------|---------------------|---------------------|-------------|--------------------|----------------------|
| Total Bridges        | 30                  | 400                 | 580                 | 510                 | 400                 | 0           | 70                 | 1,990                |
| Area (sq. ft.)       | 1,325,454           | 2,323,436           | 2,027,865           | 1,083,078           | 953,235             | 0           | 95,584             | 7,808,652            |
| Maintenance (\$)     | \$ 132,545          | \$ 232,344          | \$ 202,787          | \$ 108,308          | \$ 95,324           | \$ 0        | \$ 9,558           | \$ 780,866           |
| Preservation (\$)    | \$ 2,492,530        | \$ 4,887,210        | \$ 6,606,846        | \$ 3,340,166        | \$ 2,604,410        | \$ 0        | \$ 330,007         | \$ 20,261,169        |
| Rehabilitation (\$)  | \$ 1,428,476        | \$ 1,773,826        | \$ 2,224,594        | \$ 1,215,506        | \$ 1,097,098        | \$ 0        | \$ 181,818         | \$ 7,921,318         |
| Replacement (\$)     | \$ 7,736,300        | \$13,965,430        | \$17,003,736        | \$ 8,774,948        | \$ 7,312,031        | \$ 0        | \$ 805,023         | \$ 55,597,468        |
| <b>Totals:</b>       | <b>\$11,789,851</b> | <b>\$20,858,810</b> | <b>\$26,037,963</b> | <b>\$13,438,928</b> | <b>\$11,108,863</b> | <b>\$ 0</b> | <b>\$1,326,406</b> | <b>\$ 84,560,821</b> |

#### 1.3.2 Turnpike Bridges - Recommended Annual Funding

| State (Turnpike)    | HIB                 | Tier 1              | Tier 2              | Tier 3              | Tier 4              | Tier 5      | Tier 6            | Total                |
|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|-------------|-------------------|----------------------|
| Total Bridges       | 11                  | 109                 | 12                  | 12                  | 22                  | 0           | 5                 | 171                  |
| Area (sq. ft.)      | 654,990             | 1,075,039           | 169,576             | 156,076             | 209,391             | 0           | 67,592            | 2,332,664            |
| Maintenance (\$)    | \$ 65,499           | \$ 107,504          | \$ 16,958           | \$ 15,608           | \$ 20,939           | \$ 0        | \$ 6,759          | \$ 233,267           |
| Preservation (\$)   | \$ 1,185,356        | \$ 2,273,056        | \$ 423,939          | \$ 390,190          | \$ 523,477          | \$ 0        | \$ 222,332        | \$ 5,018,350         |
| Rehabilitation (\$) | \$ 662,958          | \$ 818,853          | \$ 211,969          | \$ 195,095          | \$ 261,739          | \$ 0        | \$ 169,367        | \$ 2,319,981         |
| Replacement (\$)    | \$ 3,694,277        | \$ 6,477,727        | \$ 1,285,948        | \$ 1,183,576        | \$ 1,587,881        | \$ 0        | \$ 570,944        | \$ 14,800,353        |
| <b>Totals:</b>      | <b>\$ 5,608,090</b> | <b>\$ 9,677,140</b> | <b>\$ 1,938,814</b> | <b>\$ 1,784,469</b> | <b>\$ 2,394,036</b> | <b>\$ 0</b> | <b>\$ 969,402</b> | <b>\$ 22,371,951</b> |

#### 1.3.3 Municipal (Other, Non-State) Bridges - Recommended Annual Funding

| Municipal (Other)   | HIB                 | Tier 1      | Tier 2      | Tier 3      | Tier 4      | Tier 5               | Tier 6      | Total                |
|---------------------|---------------------|-------------|-------------|-------------|-------------|----------------------|-------------|----------------------|
| Total Bridges       | 9                   | 0           | 0           | 0           | 0           | 1,679                | 0           | 1,688                |
| Area (sq. ft.)      | 442,313             | 0           | 0           | 0           | 0           | 2,124,186            | 0           | 2,566,499            |
| Maintenance (\$)    | \$ 44,231           | \$ 0        | \$ 0        | \$ 0        | \$ 0        | \$ 212,419           | \$ 0        | \$ 256,650           |
| Preservation (\$)   | \$ 830,327          | \$ 0        | \$ 0        | \$ 0        | \$ 0        | \$ 6,307,587         | \$ 0        | \$ 7,137,914         |
| Rehabilitation (\$) | \$ 485,018          | \$ 0        | \$ 0        | \$ 0        | \$ 0        | \$ 2,309,892         | \$ 0        | \$ 2,794,910         |
| Replacement (\$)    | \$ 2,541,391        | \$ 0        | \$ 0        | \$ 0        | \$ 0        | \$ 16,058,596        | \$ 0        | \$ 18,599,987        |
| <b>Totals:</b>      | <b>\$ 3,900,967</b> | <b>\$ 0</b> | <b>\$ 0</b> | <b>\$ 0</b> | <b>\$ 0</b> | <b>\$ 24,888,494</b> | <b>\$ 0</b> | <b>\$ 28,789,461</b> |

#### 1.3.4 Total Bridges - Recommended Annual Funding (All NH Bridges in Bridge Inventory)

| All Bridges         | HIB                 | Tier 1              | Tier 2              | Tier 3              | Tier 4              | Tier 5               | Tier 6             | Total                |
|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|----------------------|--------------------|----------------------|
| Total Bridges       | 50                  | 509                 | 592                 | 522                 | 422                 | 1,679                | 75                 | 3,849                |
| Area (sq. ft.)      | 2,422,757           | 3,398,475           | 2,197,441           | 1,239,154           | 1,162,626           | 2,124,186            | 163,176            | 12,707,814           |
| Maintenance (\$)    | \$ 242,276          | \$ 339,848          | \$ 219,744          | \$ 123,915          | \$ 116,263          | \$ 212,419           | \$ 16,318          | \$ 1,270,783         |
| Preservation (\$)   | \$ 4,508,213        | \$ 7,160,266        | \$ 7,030,785        | \$ 3,730,356        | \$ 3,127,887        | \$ 6,307,587         | \$ 552,339         | \$ 32,417,433        |
| Rehabilitation (\$) | \$ 2,576,452        | \$ 2,592,679        | \$ 2,436,563        | \$ 1,410,601        | \$ 1,358,837        | \$ 2,309,892         | \$ 351,185         | \$ 13,036,209        |
| Replacement (\$)    | \$13,971,968        | \$20,443,157        | \$18,289,684        | \$ 9,958,524        | \$ 8,899,912        | \$ 16,058,596        | \$1,375,967        | \$ 88,997,808        |
| <b>Totals:</b>      | <b>\$21,298,909</b> | <b>\$30,535,950</b> | <b>\$27,976,776</b> | <b>\$15,223,396</b> | <b>\$13,502,899</b> | <b>\$ 24,888,494</b> | <b>\$2,295,809</b> | <b>\$135,722,233</b> |

## 2 Definitions – Roadway Tiers and Tier Multipliers

### 2.1 Roadway Tiers

Each roadway is assigned a “Tier” number based on the relative “value” of the carried roadway to the overall transportation system, and a corresponding “Tier” number is assigned to each bridge on the roadway. If a bridge has a high value tier (greater importance = lower tier number) and has a long detour length, its closure will have a significantly greater impact on the operation of the overall transportation system, i.e., it will impact significantly more drivers, than a closed bridge having a lower value tier (lesser importance = higher tier number) that has a short detour. The roadway tiers as they apply to bridges are further defined below:

| <u>Roadway Tier</u> | <u>Roadway Tier Definitions - Bridges</u>   |
|---------------------|---|
| HIB                 | <u>High Investment Bridges</u> – Bridges in this group have a deck area of 30,000 sq. ft. or greater; or; a movable bridge, regardless of the type of roadway on which it is located.                                   |
| 1                   | <u>Interstates, Turnpikes, Divided Highways</u> – Multi-lane divided highways supporting the highest traffic volumes & speeds, and conveying the majority of commuter, tourist, & freight traffic.                      |
| 2                   | <u>Statewide Corridors</u> – State numbered routes with moderate to high traffic volumes and speeds, especially during commuter hours.  |
| 3                   | <u>Regional Transportation Corridors</u> – These roadways support travel within regions, access statewide corridors, and support moderate traffic volumes and speeds.   |
| 4                   | <u>Local Connectors</u> – These secondary roadways and unnumbered routes provide local connection between and within communities; usually support low volume and low speed traffic.                                     |
| 5                   | <u>Local Roads</u> – Locally owned roadways within town limits or city compact limits; provide local connections for travel between and within communities; support low volume and low speed traffic in most instances. |
| 6                   | <u>Off Network</u> – These are non-highway assets of the transportation network, e.g., Park ‘n’ Rides, pedestrian or railroad bridges, patrol sheds, and Rest Stops.  |

### 2.2 Tier Multipliers

Many factors can affect the cost of bridge work. For this reason, multipliers were developed to adjust estimated costs for the characteristics of each type of bridge and for the roadway tier on which it is located. Tasks for bridge maintenance, preservation, rehabilitation, or replacement will typically be more difficult to perform on bridges having a tier of greater importance and/or higher traffic volumes, i.e., a “lower” numbered tier, than performing the same tasks on bridges having a tier of lesser importance and/or lower traffic volumes, i.e., a “higher” numbered tier. When developing project cost estimates, it is necessary to adjust the average “per sq. ft.” costs to account for this relative difference in the difficulty of performing these tasks on different bridge types and different tiers. In this manner, it is possible to effectively estimate and compare the costs for similar work for bridges on different tiers.

It is also recognized that the size of a bridge can affect the “per sq. ft.” costs of the tasks being performed as well as the overall cost of the project. Bridges with a small deck area will have larger “per sq. ft.” costs since there is only a small quantity of work performed for each task, thus distributing all associated costs over the small deck area. Larger bridges will have lower “per sq. ft.” costs where all associated costs are distributed over a larger deck area, thus resulting in an “economy of scale” per sq. ft. for larger bridges, even though the total project cost will be larger.

Similar to the previous paragraph, traffic volumes can also affect construction costs. Bridges that carry high volumes of traffic have a lower tier number (higher importance) and will generally have higher traffic control costs due to the relative difficulty of safely performing construction activities with this traffic volume. Similarly, bridges that carry low volumes of traffic have a higher tier number (lower importance) and will generally have lower traffic control costs due to the relative ease of safely performing construction activities with this traffic volume.

Further, bridges with higher traffic volumes will have higher “per sq. ft.” costs since these more expensive traffic control costs are distributed over the entire deck area and are added to the “per sq. ft.” costs for all other bridge work. Correspondingly, bridges with lower traffic volumes will have lower “per sq. ft.” costs since these less expensive traffic control costs are distributed over the entire deck area and are added to the “per sq. ft.” costs for all other bridge work. For this reason, the traffic volumes associated with each roadway tier were considered when developing the multipliers assigned to each tier for projects to account for the different traffic volumes and their effect on the corresponding “per sq. ft.” cost estimates.

Records of current unit item costs for completed bridge projects were researched and evaluated, based on the roadway tier carried and the category of task being performed, e.g., maintenance, preservation, rehabilitation, or replacement. Using this data and the considerations noted above, multipliers were applied to the “per sq. ft.” costs when developing estimates to more accurately project the funding needs for specific projects and for the overall NHDOT Bridge Program. These multipliers are shown for each roadway tier, bridge type, and task performed.

As more experience is gained using these multipliers, and as costs change over time, the multipliers can be adjusted accordingly to also update the annual cost projections for the Bridge Program.

### 3 Girder Bridges

#### 3.1 Base Costs of Work Activity and Tier Multipliers for Girder Bridges

##### 3.1.1 Maintenance Efforts (Girder)

**Clean and Seal** – Utilizing the Bureau of Bridge Maintenance records, the base cost of cleaning and sealing the substructure, cleaning drainage ways, and controlling vegetation for a single bridge per year is estimated to be \$0.10 per square foot of bridge deck area. This work activity should be performed annually.

##### 3.1.2 Preservation Efforts (Girder)

**Crack Seal Pavement** – Utilizing the Pavement Section of the Bureau of Materials & Research records, the base cost of crack sealing the bridge pavement is estimated to be \$0.07 per square foot of bridge deck area when included as part of a corridor pavement preservation project. This work activity should be performed every 5 years over the projected 120-year life of the bridge and is coordinated with more extensive bridge rehabilitation or replacement efforts. (Highway Design task – not in Bridge Program.)

**Pavement In-lay** – Utilizing the Pavement Section of the Bureau of Materials & Research records, the base cost of performing a pavement in-lay on a bridge is estimated to be \$1.60 per square foot of bridge deck area. This work activity should be performed every 10 years over the projected 120-year life of the bridge and is coordinated with more extensive bridge rehabilitation or replacement efforts. (Highway Design task – not in Bridge Program.)

**Patch Deck; Replace Pavement, Membrane, & Expansion Joints; Rehabilitate Bearings** – Utilizing the Bureau of Bridge Design records, the base cost to remove all bridge pavement and membrane, perform full- and partial-depth patching of the concrete deck, replace the expansion joints, place new bridge membrane and pavement, and rehabilitate the bridge bearings is estimated to be \$50.00 per square foot of bridge deck area. This work activity should be performed every 20 years over the projected 120-year life of the bridge and is coordinated with more extensive bridge rehabilitation or replacement efforts.

The base cost to perform touch-up of the coating on painted bridges (no lead paint removal involved) is included in the above \$50.00 estimate. This is anticipated to be a limited (low) number of situations.

The base cost to perform touch-up of the coating on painted bridges (lead paint removal involved) is typically handled under a separate program and therefore is not included in the above \$50.00 per square foot estimate and is not included in the Recommended Network Funding for the NHDOT Bridge Program.

Replacement of the bridge bearings is not included in the above \$50.00 per square foot estimate and is not included in the Recommended Annual Funding.

**Roadway Tier Multipliers for Bridge Preservation Efforts (Girder)** - Utilizing records available in the Bureau of Bridge Design, multipliers were developed for each roadway tier, and then applied to the unit costs for girder bridge preservation tasks.

The multipliers and considerations for girder bridge preservation are outlined below.

| <b>Roadway Tier</b> | <b>Preservation Multiplier</b> | <b>Considerations for Girder Bridge Preservation Activities</b>                       |
|---------------------|--------------------------------|---|
| HIB                 | 1.00                           | Potentially heavy traffic volume; Economy of large bridge deck area;                  |
| Tier 1              | 1.00                           | Heavy traffic volume; Economy of large bridge deck area;                              |
| Tier 2              | 2.00                           | Large traffic volume; May or may not have economy of large bridge deck area;          |
| Tier 3              | 1.50                           | Medium traffic volume; Medium bridge deck area; Closure during construction unlikely; |
| Tier 4              | 1.50                           | Lower traffic volume; Potential economy if closure during construction is allowed;    |
| Tier 5              | 1.50                           | Mixture of traffic volumes and bridge deck areas;                                     |
| Tier 6              | 1.50                           | Low to very low traffic volumes; Range of deck areas;                                 |

### 3.1.3 Rehabilitation Efforts (Girder)

**Replace Bridge Deck** – Utilizing the Bureau of Bridge Design records, the base cost to replace the bridge pavement and membrane, replace the concrete deck, replace the bridge rail & bridge approach rail, replace the expansion joints, replace bridge bearings, and perform substructure patching/repair is estimated to be \$100.00 per square foot of bridge deck area. This work activity should be performed once at the mid-point (year 60) of the projected 120-year life of the bridge.

The base cost to prepare the bridge and apply a new paint coating (no lead paint removal involved) is included in the above \$100.00 estimate. This is anticipated to be a limited (low) number of situations.

The base cost to completely remove all lead based paint and to apply a new paint coating is typically handled under a separate program and therefore is not included in the above \$100.00 per square foot estimate and is not included in the Recommended Network Funding for the NHDOT Bridge Program.

**Roadway Tier Multipliers for Bridge Rehabilitation Efforts (Girder)** - Utilizing the limited records in the Bureau of Bridge Design, multipliers were developed for each roadway tier, and then applied to the unit costs for girder bridge rehabilitation tasks.

The multipliers and considerations for girder bridge rehabilitation are outlined below.

| <b>Roadway Tier</b> | <b>Rehabilitation Multiplier</b> | <b>Considerations for Girder Bridge Rehabilitation Activities</b>                         |
|---------------------|----------------------------------|---|
| HIB                 | 1.00                             | Potentially heavy traffic volume; Economy of large bridge deck area;                      |
| Tier 1              | 1.00                             | Heavy traffic volume; Economy of large bridge deck area;                                  |
| Tier 2              | 1.50                             | Large traffic volume; May or may not have economy of large bridge deck area;              |
| Tier 3              | 1.50                             | Medium traffic volume; Medium bridge deck area; Closure during construction unlikely;     |
| Tier 4              | 1.50                             | Lower traffic volume; Potential economy if bridge closure during construction is allowed; |
| Tier 5              | 1.50                             | Mixture of traffic volumes and bridge deck areas;   |
| Tier 6              | 1.50                             | Low to very low traffic volumes; Range of deck areas;                                     |



### 3.1.4 Replacement Efforts (Girder)

**Replace Superstructure** – Utilizing the Bureau of Bridge Design records, the base cost to replace the bridge superstructure, including the deck, girders, bridge & approach rail, bearings, expansion joints, and major substructure rehabilitation, is estimated to be \$650.00 per square foot of bridge deck area. (This \$650.00 estimated cost is an average of the costs to perform either superstructure replacement or complete bridge replacement.) This work activity would be performed once at the end of the projected 120-year life of the bridge. Depending on the overall condition of the entire bridge, the best solution may be to replace the entire bridge, instead of only replacing the superstructure.

**Replace Bridge** – Utilizing the Bureau of Bridge Design records, the base cost to completely remove the existing bridge and replace the entire bridge is estimated to be \$650.00 per square foot of bridge deck area. (This \$650.00 estimated cost is an average of the costs to perform either superstructure replacement or complete bridge replacement.) This work activity would be performed at the end of the projected 120-year life of the bridge. Depending on the overall condition of the entire bridge, the best solution may be to replace just the bridge superstructure as noted above, instead of replacing the entire bridge.

The \$650.00 per square foot estimated cost is an average of the costs to perform either superstructure replacement or complete replacement of a girder bridge. During development of the project the scope of work may change from a superstructure replacement to a complete bridge replacement, as the specific condition and needs of a deficient bridge are fully identified and quantified. Further, there may be roadway capacity needs to be addressed as well, which would require a larger bridge, thereby necessitating a complete bridge replacement. Using this averaged value for replacement actions provides the best estimate for planning purposes for the overall Bridge Program.

**Roadway Tier Multipliers for Bridge Replacement Efforts (Girder)** - Utilizing the limited records in the Bureau of Bridge Design, multipliers were developed for each roadway tier, which were then applied to the unit costs for all girder bridge replacement (superstructure or entire bridge) efforts.

The multipliers and considerations for girder bridge replacement are outlined below.

| <u>Roadway Tier</u> | <u>Replacement Multiplier</u> | <u>Considerations for Girder Bridge Replacement Activities</u>  |
|---------------------|-------------------------------|---|
| HIB                 | 1.00                          | Potentially heavy traffic volume; Economy of large bridge deck area; Low likelihood of needing to increase overall size of bridge;  |
| Tier 1              | 1.00                          | Heavy traffic volume; Economy of large bridge deck area; Low likelihood of needing to increase overall size of bridge;  |
| Tier 2              | 1.40                          | Large traffic volume; May or may not have economy of large bridge deck area; Likelihood of needing to increase overall size of bridge is greater than for HIBs and Tier 1, but less than for Tiers 3 & 4; |
| Tier 3              | 1.40                          | Medium traffic volume; Medium bridge deck area; Closure during construction unlikely; High likelihood of needing to increase overall size of bridge;  |
| Tier 4              | 1.40                          | Lower traffic volume; Potential economy if bridge closure during construction is allowed; High likelihood of needing to increase overall size of bridge;  |
| Tier 5              | 1.30                          | Mixture of traffic volumes and bridge deck areas; High likelihood of needing to increase overall size of bridge;  |
| Tier 6              | 1.30                          | Low to very low traffic volumes; Range of deck areas; High likelihood of needing to increase overall size of bridge;  |

## 4 Truss Bridges

### 4.1 Base Costs of Work Activity and Tier Multipliers for Truss Bridges

#### 4.1.1 Maintenance Efforts (Truss)

**Clean and Seal** – Utilizing the Bureau of Bridge Maintenance records, the base cost of cleaning and sealing the substructure, cleaning drainage ways, and controlling vegetation for a single bridge per year is estimated to be \$0.10 per square foot of bridge deck area. This work activity should be performed annually.

#### 4.1.2 Preservation Efforts (Truss)

**Crack Seal Pavement** – Utilizing the Pavement Section of the Bureau of Materials & Research records, the base cost of crack sealing the bridge pavement is estimated to be \$0.07 per square foot of bridge deck area. This work activity should be performed every 5 years over the projected 100-year life of the bridge and is coordinated with more extensive bridge rehabilitation or replacement efforts. (Highway Design task – not in Bridge Program.)

**Pavement In-lay** – Utilizing the Pavement Section of the Bureau of Materials & Research records, the base cost of performing a pavement in-lay on a bridge is estimated to be \$1.60 per square foot of bridge deck area. This work activity should be performed every 10 years over the projected 100-year life of the bridge and is coordinated with more extensive bridge rehabilitation or replacement efforts. (Highway Design task – not in Bridge Program.)

**Patch Deck; Replace Pavement, Membrane, & Expansion Joints; Rehabilitate Bearings** – Utilizing the Bureau of Bridge Design records, the base cost to remove all bridge pavement and membrane, perform full- and partial-depth patching of the concrete deck, replace the expansion joints, place new bridge membrane and pavement, and rehabilitate the bridge bearings is estimated to be \$100.00 per square foot of bridge deck area. This work activity should be performed every 20 years over the projected 100-year life of the bridge and is coordinated with more extensive bridge rehabilitation or replacement efforts.

The base cost to perform touch-up of the coating on painted bridges (no lead paint removal involved) is included in the above \$100.00 estimate. This is anticipated to be a limited (low) number of situations.

The base cost to perform touch-up of the coating on painted bridges (lead paint removal involved) is typically handled under a separate program and therefore is not included in the above \$100.00 per square foot estimate and is not included in the Recommended Network Funding for the NHDOT Bridge Program.

Replacement of the bridge bearings is not included in the above \$100.00 per square foot estimate and is not included in the Recommended Annual Funding.

**Roadway Tier Multipliers for Bridge Preservation Efforts (Truss)** - Utilizing the limited records in the Bureau of Bridge Design, multipliers were developed for each roadway tier, and then applied to the unit costs for truss bridge preservation tasks.

The multipliers and considerations for truss bridge preservation are outlined below.

| <b>Roadway Tier</b> | <b>Preservation Multiplier</b> | <b>Considerations for Truss Bridge Preservation Activities</b>                        |
|---------------------|--------------------------------|---|
| HIB                 | 1.00                           | Potentially heavy traffic volume; Economy of large bridge deck area;                  |
| Tier 1              | 1.00                           | Heavy traffic volume; Economy of large bridge deck area;                              |
| Tier 2              | 2.00                           | Large traffic volume; May or may not have economy of large bridge deck area;          |
| Tier 3              | 1.50                           | Medium traffic volume; Medium bridge deck area; Closure during construction unlikely; |
| Tier 4              | 1.20                           | Lower traffic volume; Potential economy if closure during construction is allowed;    |
| Tier 5              | 1.20                           | Mixture of traffic volumes and bridge deck areas;                                     |
| Tier 6              | 1.20                           | Low to very low traffic volumes; Range of deck areas;                                 |

#### 4.1.3 Rehabilitation Efforts (Truss)

**Replace Bridge Deck** – Utilizing the Bureau of Bridge Design records, the base cost to replace the bridge pavement and membrane, replace the concrete deck, replace the bridge rail & bridge approach rail, replace the expansion joints, replace bridge bearings, perform minor superstructure repairs, and perform substructure patching/repair is estimated to be \$250.00 per square foot of bridge deck area. This work activity should be performed at year 60 of the projected 100-year life of the bridge and is coordinated with more extensive bridge rehabilitation or replacement efforts. (NOTE: Since truss bridges are only projected to have a service life of 100 years, the deck replacement is performed at year 60, rather than the mid-point at year 50, to ensure that all deck deficiencies are addressed at least every 20 years.)

The base cost to prepare the bridge and apply a new paint coating (no lead paint removal involved) is included in the above \$250.00 estimate. This is anticipated to be a limited (low) number of situations.

The base cost to completely remove all lead based paint and to apply a new paint coating is typically handled under a separate program and therefore is not included in the above \$250.00 per square foot estimate and is not included in the Recommended Network Funding for the NHDOT Bridge Program.

The base cost does not include complete replacement of the floor system, but the cost to perform repairs to the floor system, including replacement of some individual structural members, is included in the above \$250.00 per square foot estimate.

**Roadway Tier Multipliers for Bridge Rehabilitation Efforts (Truss)** - Utilizing the limited records in the Bureau of Bridge Design, multipliers were developed for each roadway tier, and then applied to the unit costs for truss bridge rehabilitation tasks.

The multipliers and considerations for truss bridge rehabilitation are outlined below.

| <b>Roadway Tier</b> | <b>Rehabilitation Multiplier</b> | <b>Considerations for Truss Bridge Rehabilitation Activities</b>                          |
|---------------------|----------------------------------|---|
| HIB                 | 1.00                             | Potentially heavy traffic volume; Economy of large bridge deck area;                      |
| Tier 1              | 1.00                             | Heavy traffic volume; Economy of large bridge deck area;                                  |
| Tier 2              | 1.20                             | Large traffic volume; May or may not have economy of large bridge deck area;              |
| Tier 3              | 1.30                             | Medium traffic volume; Medium bridge deck area; Closure during construction unlikely;     |
| Tier 4              | 1.10                             | Lower traffic volume; Potential economy if bridge closure during construction is allowed; |
| Tier 5              | 1.20                             | Mixture of traffic volumes and bridge deck areas;   |
| Tier 6              | 1.20                             | Low to very low traffic volumes; Range of deck areas;                                     |

#### 4.1.4 Replacement Efforts (Truss)

**Replace Superstructure** – Utilizing the Bureau of Bridge Design records, the base cost to replace the bridge superstructure, including the deck, truss members (stringers, floorbeams, chords, diagonals, & verticals), bridge & approach rail, bearings, expansion joints, and major substructure rehabilitation, is estimated to be \$750.00 per square foot of bridge deck area. (This \$750.00 estimated cost is an average of the costs to perform either superstructure replacement or complete bridge replacement.) This work activity would be performed once at the end of the projected 100-year life of the bridge. Depending on the overall condition of the entire bridge, the best solution may be to replace the entire bridge, instead of only replacing the superstructure.

The \$750.00 per square foot estimated cost is an average of the costs to perform either superstructure replacement or complete replacement of a truss bridge. During development of the project the scope of work may change from a superstructure replacement to a complete bridge replacement, as the specific condition and needs of a deficient bridge are fully identified and quantified. Further, there may be roadway capacity needs to be addressed as well, which would require a larger bridge, thereby necessitating a complete bridge replacement. Using this averaged value for replacement actions provides the best estimate for planning purposes for the overall Bridge Program.

**Replace Bridge** – Utilizing the Bureau of Bridge Design records, the base cost to completely remove the existing bridge and replace the entire bridge is estimated to be \$750.00 per square foot of bridge deck area. (This \$750.00 estimated cost is an average of the costs to perform either superstructure replacement or complete bridge replacement.) This work activity would be performed at the end of the projected 100-year life of the bridge. Depending on the overall condition of the entire bridge, the best solution may be to replace just the bridge superstructure as noted above, instead of replacing the entire bridge.

**Roadway Tier Multipliers for Bridge Replacement Efforts (Truss)** - Utilizing the limited records in the Bureau of Bridge Design, multipliers were developed for each roadway tier, and then applied to the unit costs for truss bridge replacement tasks.

The multipliers and considerations for truss bridge replacement are outlined below.

| <b>Roadway Tier</b> | <b>Replacement Multiplier</b> | <b>Considerations for Truss Bridge Replacement Activities</b>   |
|---------------------|-------------------------------|---|
| HIB                 | 1.00                          | Potentially heavy traffic volume; Economy of large bridge deck area; Low likelihood of needing to increase overall size of bridge;  |
| Tier 1              | 1.00                          | Heavy traffic volume; Economy of large bridge deck area; Low likelihood of needing to increase overall size of bridge;  |
| Tier 2              | 1.30                          | Large traffic volume; May or may not have economy of large bridge deck area; Likelihood of needing to increase overall size of bridge is greater than for HIBs and Tier 1, but less than for Tiers 3 & 4; |
| Tier 3              | 1.30                          | Medium traffic volume; Medium bridge deck area; Closure during construction unlikely; High likelihood of needing to increase overall size of bridge;  |
| Tier 4              | 1.20                          | Lower traffic volume; Potential economy if bridge closure during construction is allowed; High likelihood of needing to increase overall size of bridge;  |
| Tier 5              | 1.20                          | Mixture of traffic volumes and bridge deck areas; High likelihood of needing to increase overall size of bridge;  |
| Tier 6              | 1.20                          | Low to very low traffic volumes; Range of deck areas; High likelihood of needing to increase overall size of bridge;  |

## 5 Moveable Bridges

### 5.1 Base Costs of Work Activity for Moveable Bridges

#### 5.1.1 Maintenance Efforts (Moveable)

**Clean and Seal** – Utilizing the Bureau of Bridge Maintenance records, the base cost of cleaning and sealing the substructure, cleaning drainage ways, and controlling vegetation for a single bridge per year is estimated to be \$0.10 per square foot of bridge deck area. This work activity should be performed annually.

**Perform Mechanical & Electrical Work** – Utilizing the Bureau of Bridge Maintenance records, the base cost of performing mechanical and electrical maintenance tasks is estimated to be \$ (TBD) per square foot of bridge deck area. Since New Hampshire only has 4 moveable bridges, this estimate was prepared using available cost records, and was then prorated into a cost per square foot of deck area, so that it could be compiled with other bridge costs for a composite total cost per square foot.

These costs include visual inspection of the electrical motors, switches, relays, controls, cameras, computer systems, etc., with replacements installed as needed. These tasks also include visual inspection and any adjustments to or lubrication of the mechanical gearing and drive system components, including all steel ropes/cables, which enable each bridge to move as required. These work activities should be performed annually to ensure safe and dependable operation of all moveable bridge systems.

These costs also include visual inspection and operational testing of all back-up power generators and alternative power sources and systems. This should be performed annually to ensure dependable operation of all back-up power systems.

#### 5.1.2 Preservation Efforts (Moveable)

**Crack Seal Pavement** – Utilizing the Pavement Section of the Bureau of Materials & Research records, the base cost of crack sealing the bridge pavement is estimated to be \$0.07 per square foot of bridge deck area. This work activity should be performed every 5 years over the projected 100-year life of the bridge and is coordinated with more extensive bridge rehabilitation or replacement efforts. (Highway Design task – not in Bridge Program.)

**Pavement In-lay** – Utilizing the Pavement Section of the Bureau of Materials & Research records, the base cost of performing a pavement in-lay on a bridge is estimated to be \$1.60 per square foot of bridge deck area. This work activity should be performed every 10 years over the projected 100-year life of the bridge and is coordinated with more extensive bridge rehabilitation or replacement efforts. (Highway Design task – not in Bridge Program.)

**Patch Deck, Replace Pavement, Membrane, & Expansion Joints; Rehabilitate Bearings** – Utilizing the Bureau of Bridge Design records, the base cost to remove all bridge pavement and membrane, perform full- and partial-depth patching of the concrete deck, replace the expansion joints, place new bridge membrane and pavement, and rehabilitate the bridge bearings is estimated to be \$200.00 per square foot of bridge deck area. This work activity

should be performed every 25 years over the projected 100-year life of the bridge and is coordinated with more extensive bridge rehabilitation or replacement efforts.

The base cost to perform touch-up of the coating on painted moveable bridges (no lead paint removal involved) is included in the above \$200.00 estimate.

The base cost to perform touch-up of the coating on painted bridges (lead paint removal involved) is typically handled under a separate program and therefore is not included in the above \$200.00 per square foot estimate and is not included in the Recommended Annual Funding.

Replacement of the bridge bearings is not included in the above \$200.00 per square foot estimate and is not included in the Recommended Network Funding for the NHDOT Bridge Program.

**Perform Mechanical & Electrical Work** - Utilizing records from the Bureaus of Bridge Maintenance and Bridge Design, the base cost of performing mechanical and electrical preservation tasks is estimated to be \$ (TBD) per square foot of bridge deck area. Since New Hampshire only has 4 moveable bridges, this estimate was prepared using available cost records, and was then pro-rated into a cost per square foot of deck area, so that it could be compiled with other bridge costs for a composite total cost per square foot.

These costs include performance inspection and testing of the electrical motors, switches, relays, controls, cameras, computer systems, etc., with replacement components installed as needed. These tasks also include full inspection and any repairs to or lubrication of the mechanical gearing and drive system components that enable each bridge to move as required. These tasks ensure the safe and dependable operation of all moveable bridge systems. They should be performed every 25 years over the projected 100-year life of the bridge.

These costs also include performance inspection and operational testing of all back-up power generators and alternative power sources and systems, with replacement components installed as needed. This should be performed every 25 years over the projected 100-year life of the bridge, to ensure dependable operation of all back-up power systems.

**Replace Steel Ropes (Vertical Lift Bridges)** - The base cost to replace all steel ropes/cables (operating & counterweight) on vertical lift bridges is estimated to be \$ (TBD). Since New Hampshire only has 4 moveable bridges, this estimate was prepared using available cost records, and was then pro-rated into a cost per square foot of deck area, so that it could be compiled with other bridge costs for a composite total cost per square foot. This work is typically accomplished through specific low-bid contracts and should be performed every 25 years over the projected 100-year life of the bridge.

### 5.1.3 Rehabilitation Efforts (Moveable)

**Replace Bridge Deck** – Utilizing the Bureau of Bridge Design records, the base cost to replace the bridge pavement and membrane, replace the concrete deck, replace the bridge rail & bridge approach rail, replace the expansion joints, replace bridge bearings, perform minor superstructure repairs, and perform substructure patching/repair, is estimated to be \$350.00 per square foot of bridge deck area. This work activity should be performed at the mid-point

(year 50) of the projected 100-year life of the bridge and is coordinated with more extensive bridge rehabilitation or replacement efforts.

The base cost to prepare the bridge and apply a new paint coating (no lead paint removal involved) is included in the above \$350.00 estimate.

The base cost to completely remove all lead based paint and to apply a new paint coating is typically handled under a separate program and therefore is not included in the above \$350.00 per square foot estimate and is not included in the Recommended Annual Funding.

The base cost does not include complete replacement of the floor system, but the cost to perform repairs to the floor system, including replacement of some individual structural members, is included in the above \$350.00 per square foot estimate.

**Replace Mechanical & Electrical Components** - Utilizing records from the Bureaus of Bridge Maintenance and Bridge Design, the base cost to rehabilitate the mechanical and electrical systems is estimated to be \$ (TBD) per square foot of bridge deck area. Since New Hampshire only has 4 moveable bridges, this estimate was prepared using available cost records, and was then pro-rated into a cost per square foot of deck area, so that it could be compiled with other bridge costs for a composite total cost per square foot.

These costs include replacement of the electrical motors, switches, relays, controls, cameras, computer systems, etc., with replacements installed as needed. These costs also include replacement/rehabilitation of any mechanical gearing and drive system components that enable each bridge to move as required. These tasks ensure the safe and dependable operation of all moveable bridge systems. They should be performed every 50 years over the projected 100-year life of the bridge.

**Replace Steel Ropes (Vertical Lift Bridges)** - The base cost to replace all steel ropes/cables (operating & counterweight) on vertical lift bridges is estimated to be \$ (TBD). Since New Hampshire only has 4 moveable bridges, this estimate was prepared using available cost records, and was then pro-rated into a cost per square foot of deck area, so that it could be compiled with other bridge costs for a composite total cost per square foot. This work is typically accomplished through specific low-bid contracts and should be performed every 20 years over the projected 100-year life of the bridge.

#### 5.1.4 Replacement Efforts (Moveable)

**Replace Superstructure** – Utilizing the Bureau of Bridge Design records, the base cost to replace the bridge superstructure, including the deck, girders, bridge & approach rail, bearings, expansion joints, all mechanical & electrical systems, and major substructure rehabilitation, is estimated to be \$1,000.00 per square foot of bridge deck area. (This \$1,000.00 estimated cost is an average of the costs to perform either superstructure replacement or complete bridge replacement.) This work activity would be performed once at the end of the projected 100-year life of the bridge. Depending on the overall condition of the entire bridge, the best solution may be to replace the entire bridge, instead of only replacing the superstructure.

The \$1,000.00 per square foot estimated cost is an average of the costs to perform either superstructure replacement or complete replacement of a moveable bridge. During development of the project the scope of work may change from a superstructure replacement to a complete bridge replacement, as the specific condition and needs of a deficient bridge are fully identified and quantified. Further, there may be roadway capacity needs to be addressed as well, which would require a larger bridge, thereby necessitating a complete bridge replacement. Using this averaged value for replacement actions provides the best estimate for planning purposes for the overall Bridge Program.

**Replace Bridge** – Utilizing the Bureau of Bridge Design records, the base cost to completely remove the existing bridge and replace the entire bridge with a completely new moveable structure is estimated to be \$1,000.00 per square foot of bridge deck area. (This \$1,000.00 estimated cost is an average of the costs to perform either superstructure replacement or complete bridge replacement.) This work activity would be performed at the end of the projected 100-year life of the bridge. Depending on the overall condition of the entire bridge, the best solution may be to replace just the bridge superstructure as noted above, instead of replacing the entire bridge.

5.2 **Tier Multipliers for Moveable Bridge Types**

**Roadway Tier Multipliers for Moveable Bridge Efforts** - Utilizing the limited records in the Bureau of Bridge Design, a multiplier was developed for the HIB roadway tier (only), and then applied to the unit costs for moveable bridge tasks.

The multipliers and considerations for all moveable bridge activities are outlined below.

| <b><u>Roadway Tier</u></b> | <b><u>Moveable Bridge Multiplier</u></b> | <b><u>Considerations for Moveable Bridge Activities</u></b>  |
|----------------------------|--|--|
| HIB                        | 1.00                                     | Potentially heavy traffic volume; Economy of large bridge deck area; Low likelihood of needing to increase overall size of bridge;   |
| Tier 1                     | N/A                                      | All Moveable Bridges are by definition HIBs and therefore do not have individual Tier Multipliers for the efforts associated with Preservation, Rehabilitation, and Replacement. |
| Tier 2                     | N/A                                      |  |
| Tier 3                     | N/A                                      |  |
| Tier 4                     | N/A                                      |  |
| Tier 5                     | N/A                                      |  |
| Tier 6                     | N/A                                      |  |



## 6 Timber Bridges

### 6.1 Base Costs of Work Activity and Tier Multipliers for Timber Bridges

As part of the inventory of timber bridges, there are 48 covered bridges in New Hampshire (7 state; 41 municipal), however, the activities and funds needed to address deficiencies in these historic structures present unique challenges as they are much more complex than other timber bridges. Although these challenges are not specifically noted in the costs and activities presented herein, consideration should be given to their uniqueness when preparing the scope of work and the cost estimates for projects involving covered bridges.

#### 6.1.1 Maintenance Efforts (Timber)

**Clean and Seal** – Utilizing the Bureau of Bridge Maintenance records, the base cost of cleaning and sealing the substructure, cleaning drainage ways, and controlling vegetation for a single bridge per year is estimated to be \$0.10 per square foot of bridge deck area. This work activity should be performed annually.

#### 6.1.2 Preservation Efforts (Timber)

**Crack Seal Pavement** – Utilizing the Pavement Section of the Bureau of Materials & Research records, the base cost of crack sealing the bridge pavement (if applicable) is estimated to be \$0.07 per square foot of bridge deck area. This work activity should be performed every 5 years over the projected 80-year life of the bridge. It is recognized that there are very few timber bridges with paved decks, however this information should be applied and included where appropriate. (Highway Design task – not in Bridge Program.)

**Pavement In-lay** – Utilizing the Pavement Section of the Bureau of Materials & Research records, the base cost of performing a pavement in-lay (if applicable) on a bridge is estimated to be \$1.60 per square foot of bridge deck area. This work activity should be performed every 10 years over the projected 80-year life of the bridge. It is recognized that there are very few timber bridges with paved decks, however this information should be applied and included where appropriate. (Highway Design task – not in Bridge Program.)

**Patch Deck, Replace Pavement, Membrane, & Expansion Joints; Rehabilitate Bearings** – Utilizing the Bureau of Bridge Design records, the base cost to remove all bridge pavement and membrane (if applicable), perform patching of the timber deck, replace the expansion joints, place new bridge membrane and pavement (if applicable), and rehabilitate the bridge bearings is estimated to be \$50.00 per square foot of bridge deck area. This work activity should be performed every 10 years over the projected 80-year life of the bridge and is coordinated with more extensive bridge rehabilitation or replacement efforts.

Replacement of the bridge bearings is not included in the above \$50.00 per square foot estimate and is not included in the Recommended Network Funding for the NHDOT Bridge Program.

**Roadway Tier Multipliers for Bridge Preservation Efforts (Timber)** - Utilizing the limited records in the Bureau of Bridge Design, multipliers were developed for each roadway tier, and then applied to the unit costs for timber bridge preservation tasks.

The multipliers and considerations for timber bridge preservation are outlined below.

| <u>Roadway Tier</u> | <u>Preservation Multiplier</u> | <u>Considerations for Timber Bridge Preservation Activities</u>                       |
|---------------------|--------------------------------|---|
| HIB                 | N/A                            | There are no timber bridges that are HIBs or on Tier 1 or 2 roadways.                 |
| Tier 1              | N/A                            |   |
| Tier 2              | N/A                            |   |
| Tier 3              | 1.10                           | Medium traffic volume; Medium bridge deck area; Closure during construction unlikely; |
| Tier 4              | 1.00                           | Lower traffic volume; Potential economy if closure during construction is allowed;    |
| Tier 5              | 1.10                           | Mixture of traffic volumes and bridge deck areas;                                     |
| Tier 6              | 1.10                           | Low to very low traffic volumes; Range of deck areas;                                 |

### 6.1.3 Rehabilitation Efforts (Timber)

**Replace Timber Bridge Deck** – Utilizing the Bureau of Bridge Design records, the base cost to replace the bridge pavement and membrane (if applicable), replace the timber deck, replace the bridge rail & bridge approach rail, replace the expansion joints, replace bridge bearings, and perform substructure patching/repair is estimated to be \$100.00 per square foot of bridge deck area. This work activity should be performed every 20 years over the projected 80-year life of the bridge.

**Roadway Tier Multipliers for Bridge Rehabilitation Efforts (Timber)** - Utilizing the limited records in the Bureau of Bridge Design, multipliers were developed for each roadway tier, and then applied to the unit costs for timber bridge rehabilitation tasks.

The multipliers and considerations for timber bridge rehabilitation are outlined below.

| <u>Roadway Tier</u> | <u>Rehabilitation Multiplier</u> | <u>Considerations for Timber Bridge Rehabilitation Activities</u>                         |
|---------------------|----------------------------------|---|
| HIB                 | N/A                              | There are no timber bridges that are HIBs or on Tier 1 or 2 roadways.                     |
| Tier 1              | N/A                              |   |
| Tier 2              | N/A                              |   |
| Tier 3              | 1.10                             | Medium traffic volume; Medium bridge deck area; Closure during construction unlikely;     |
| Tier 4              | 1.00                             | Lower traffic volume; Potential economy if bridge closure during construction is allowed; |
| Tier 5              | 1.10                             | Mixture of traffic volumes and bridge deck areas;   |
| Tier 6              | 1.10                             | Low to very low traffic volumes; Range of deck areas;                                     |

### 6.1.4 Replacement Efforts (Timber)

**Replace Superstructure** – Utilizing the Bureau of Bridge Design records, the base cost to replace the bridge superstructure, including the deck, girders, bridge & approach rail, bearings, expansion joints, and major substructure rehabilitation, is estimated to be \$500.00 per square foot of bridge deck area. (This \$500.00 estimated cost is an average of the costs to perform either superstructure replacement or complete bridge replacement.) This work activity would be performed once at the end of the projected 80-year life of the bridge. Depending on the overall condition of the entire bridge, the best solution may be to replace the entire bridge, instead of only replacing the superstructure.

The \$500.00 per square foot estimated cost is an average of the costs to perform either superstructure replacement or complete replacement of a timber bridge. During development of the project the scope of work may change from a superstructure replacement to a complete bridge replacement, as the specific condition and needs of a deficient bridge are fully identified and quantified. Further, there may be roadway capacity needs to be addressed as well, which would require a larger bridge, thereby necessitating a complete bridge replacement. Using this averaged value for replacement actions provides the best estimate for planning purposes for the overall Bridge Program.

**Replace Bridge** – Utilizing the Bureau of Bridge Design records, the base cost to completely remove the existing bridge and replace the entire bridge is estimated to be \$500.00 per square foot of bridge deck area. (This \$500.00 estimated cost is an average of the costs to perform either superstructure replacement or complete bridge replacement.) This work activity would be performed at the end of the projected 80-year life of the bridge. Depending on the overall condition of the entire bridge, the best solution may be to replace just the bridge superstructure as noted above, instead of replacing the entire bridge.

**Roadway Tier Multipliers for Bridge Replacement Efforts (Timber)** - Utilizing the limited records in the Bureau of Bridge Design, multipliers were developed for each roadway tier, and then applied to the unit costs for timber bridge replacement tasks.

The multipliers and considerations for timber bridge replacement are outlined below.

| <u>Roadway Tier</u> | <u>Replacement Multiplier</u> | <u>Considerations for Timber Bridge Replacement Activities</u>  |
|---------------------|-------------------------------|---|
| HIB                 | N/A                           | There are no timber bridges that are HIBs or on Tier 1 or 2 roadways.   |
| Tier 1              | N/A                           |   |
| Tier 2              | N/A                           |   |
| Tier 3              | 1.10                          | Medium traffic volume; Medium bridge deck area; Closure during construction unlikely; <b>High likelihood of needing to increase overall size of bridge;</b>     |
| Tier 4              | 1.00                          | Lower traffic volume; Potential economy if bridge closure during construction is allowed; <b>High likelihood of needing to increase overall size of bridge;</b> |
| Tier 5              | 1.10                          | Mixture of traffic volumes and bridge deck areas; <b>High likelihood of needing to increase overall size of bridge;</b>   |
| Tier 6              | 1.10                          | Low to very low traffic volumes; Range of deck areas; <b>High likelihood of needing to increase overall size of bridge;</b>                                     |

## 7 Culvert Bridges

### 7.1 Base Costs of Work Activity and Tier Multipliers for Culvert Bridges

#### 7.1.1 Maintenance Efforts (Culvert)

**Clean and Seal** – Utilizing the Bureau of Bridge Maintenance records, the base cost of cleaning and sealing the substructure, cleaning drainage ways, and controlling vegetation for a single bridge per year is estimated to be \$0.10 per square foot of bridge deck area. (For a culvert structure the deck area is taken as the total span of the culvert multiplied by the total length of the culvert.) This work activity should be performed annually.

#### 7.1.2 Preservation Efforts (Culvert)

**Crack Seal Pavement** – Utilizing the Pavement Section of the Bureau of Materials & Research records, the base cost of crack sealing the bridge pavement is estimated to be \$0.07 per square foot of bridge deck area. (For a culvert structure the deck area is taken as the total span of the culvert multiplied by the total length of the culvert.) This work activity should be performed every 5 years over the projected 60-year life of the bridge. It is recognized that this work effort would not apply to buried culvert structures. (Highway Design task – not in Bridge Program.)

**Pavement In-lay** – Utilizing the Pavement Section of the Bureau of Materials & Research records, the base cost of performing a pavement in-lay on a bridge is estimated to be \$1.60 per square foot of bridge deck area. (For a culvert structure the deck area is taken as the total span of the culvert multiplied by the total length of the culvert.) This work activity should be performed every 10 years over the projected 60-year life of the bridge. It is recognized that this work effort would not apply to buried culvert structures. (Highway Design task – not in Bridge Program.)

**Invert Repair** – Utilizing the Bureau of Bridge Maintenance records, adjusted for low-bid contracting, the base cost of repairing inverts of culverts is estimated to be \$50.00 per square foot of bridge deck area. (For culverts the deck area is taken as the total span of the culvert multiplied by the total length of the culvert.) It is estimated that 50% of the overall Culvert bridge inventory carries a waterway through it and therefore would require this effort. This work activity should be performed every 10 years over the projected 60-year life of the bridge.

**Concrete Patch** – Utilizing the Bureau of Bridge Maintenance records, adjusted for low-bid contracting, the base cost of patching of the concrete substructure is \$100.00 per square foot of bridge deck area. (For a culvert structure the deck area is taken as the total span of the culvert multiplied by the total length of the culvert.) This work activity should be performed every 20 years over the projected 60-year life of the bridge.

**Roadway Tier Multipliers for Bridge Preservation Efforts (Culvert)** - Utilizing the limited records in the Bureau of Bridge Design, multipliers were developed for each roadway tier, and then applied to the unit costs for culvert bridge preservation tasks.

The multipliers and considerations for culvert bridge preservation are outlined below.

| <b>Roadway Tier</b> | <b>Preservation Multiplier</b> | <b>Considerations for Culvert Bridge Preservation Activities</b>                      |
|---------------------|--------------------------------|---|
| HIB                 | N/A                            | There are no culvert bridges that are HIBs.   |
| Tier 1              | 1.50 to 2.00                   | Heavy traffic volume;   |
| Tier 2              | 2.00                           | Large traffic volume;   |
| Tier 3              | 1.80                           | Medium traffic volume; Medium bridge deck area; Closure during construction unlikely; |
| Tier 4              | 1.20                           | Lower traffic volume; Potential economy if closure during construction is allowed;    |
| Tier 5              | 1.00                           | Mixture of traffic volumes and bridge deck areas;                                     |
| Tier 6              | 1.10                           | Low to very low traffic volumes; Range of deck areas;                                 |

### 7.1.3 Replacement Efforts (Culvert)

**Replace Superstructure** – Utilizing the Bureau of Bridge Design records, the base cost to replace the bridge superstructure (concrete culverts/structures only), i.e., the top concrete slab often including the bridge & approach rail and possibly major substructure rehabilitation, is estimated to be \$500.00 per square foot of bridge deck area. (This \$500.00 estimated cost is an average of the costs to perform either superstructure replacement or complete bridge replacement.) This work activity would be performed once at the end of the projected 60-year to 80-year life of the bridge. Depending on the overall condition of the entire bridge, the best solution may be to replace the entire bridge, instead of only replacing the superstructure.

The \$500.00 per square foot estimated cost is an average of the costs to perform either superstructure replacement or complete replacement of a culvert bridge. During development of the project the scope of work may change from a superstructure replacement to a complete bridge replacement, as the specific condition and needs of a deficient bridge are fully identified and quantified. Further, there may be roadway capacity needs to be addressed as well, which would require a larger bridge, thereby necessitating a complete bridge replacement. Using this averaged value for replacement actions provides the best estimate for planning purposes for the overall Bridge Program.

**Replace Bridge** – Utilizing the Bureau of Bridge Design records, the base cost to completely remove the existing bridge and replace the entire bridge is estimated to be \$500.00 per square foot of bridge deck area. (This \$500.00 estimated cost is an average of the costs to perform either superstructure replacement or complete bridge replacement.) This work activity would be performed at the end of the projected 60-year life of the bridge. Depending on the overall condition of the entire bridge, the best solution may be to replace just the bridge superstructure as noted above, instead of replacing the entire bridge.

**Roadway Tier Multipliers for Bridge Replacement Efforts (Culvert)** - Utilizing the limited records in the Bureau of Bridge Design, multipliers were developed for each roadway tier, and then applied to the unit costs for culvert bridge replacement tasks.

The multipliers and considerations for culvert bridge replacement are outlined below.

| <b><u>Roadway Tier</u></b> | <b><u>Replacement Multiplier</u></b> | <b><u>Considerations for Culvert Bridge Replacement Activities</u></b>   |
|----------------------------|--------------------------------------|--|
| HIB                        | N/A                                  | There are no culvert bridges that are HIBs.  |
| Tier 1                     | 1.50 to 2.00                         | Heavy traffic volume;  |
| Tier 2                     | 2.00                                 | Large traffic volume; Likelihood of needing to increase overall size of bridge is greater than for HIBs and Tier 1, but less than for Tiers 3 & 4;       |
| Tier 3                     | 1.80                                 | Medium traffic volume; Medium bridge deck area; Closure during construction unlikely; High likelihood of needing to increase overall size of bridge;     |
| Tier 4                     | 1.20                                 | Lower traffic volume; Potential economy if bridge closure during construction is allowed; High likelihood of needing to increase overall size of bridge; |
| Tier 5                     | 1.00                                 | Mixture of traffic volumes and bridge deck areas; High likelihood of needing to increase overall size of bridge;   |
| Tier 6                     | 1.10                                 | Low to very low traffic volumes; Range of deck areas; High likelihood of needing to increase overall size of bridge;                                     |