SRF No. 0034846

MEMORANDUM

TO: Minnesota Department of Transportation

FROM: SRF Consulting Group, Inc.

DATE: April 16, 2004

SUBJECT: STILLWATER LIFT BRIDGE
DETERMINATION OF REPAIRS/REPLACEMENT REQUIREMENTS TO ALLOW CONTINUATION OF SERVICE FOR VEHICULAR TRAFFIC UNTIL 2055 AND BEYOND

This memorandum addresses SRF's assessment of the estimated requirements and cost for the Stillwater Lift Bridge to remain open to vehicular traffic to the year 2055 and beyond, and is a planning-level document to assist in the preparation of the DEIS.

All options under consideration and evaluation, except Alternate D, propose or include options for maintaining operation of the Stillwater Lift to either local vehicular traffic or as a Trunk Highway.

SRF's assumptions, determinations and some cost information have been made based on previous reports from HNTB and Lichtenstein as well as Mn/DOT Inspection Reports. The most recent and extensive report was the "Maintenance Projections and Annualized Costs Report of Finding – Stillwater Lift Bridge – August 6, 2003" was prepared by HNTB. This report assumes that the bridge would remain open to a reduced vehicular live load through the Year 2010 and pedestrian only through the Year 2055.

The following is a summary of our evaluation, assessment of required repairs and/or replacement and estimated costs.

BRIDGE HISTORY AND TYPE

The Stillwater Bridge is listed in the National Register of Historic Places. The bridge consists of one concrete-slab approach span on the east bank, six fracture critical fixed steel thru-trusses, one fracture critical vertical-lift span of the Waddell and Harrington type, and two concrete-slab approach spans on the west bank. The Stillwater Bridge has historical significance as a rare surviving example of vertical-lift highway bridge construction of the Waddell and Harrington type.

Each of the six fixed thru-truss spans are similar in size and configuration and approximately 140 feet in length. Each is a seven-panel, riveted, Through Parker Truss with top lateral and sway bracing. Each truss top chord consists of heavy paired channels tied with a cover plate above and X-bracing below. The bottom chord, diagonals and web members are back-to-back angles tied with V-bracing. The vertical-lift span is also a 140 foot, seven-panel, Parker Through Truss. The existing bridge has a 13-foot 2-inch vertical clearance, a 23-foot deck width and live load operating rating of HS20, inventory rating of HS13 and is posted for legal loads of 80,000 lbs.

DOCUMENTATION

The following inspections and reports were utilized to form the basis for our evaluation of extent and method of bridge repair and/or replacement requirements:

- **Mn/DOT Bridge Inspection Report 1991 and 1995**
  - The "pierwalls" have deterioration below the water surface. Underwater inspections found a one-foot band of scale (typically with exposed rebar, some 12-inch deep) at the waterline of each river pier.

- **Mn/DOT Bridge Inspection Report, 1994**
  - Due to the extensive structural deterioration, Mn/DOT posted the bridge with a load restriction of 28 tons (40 tons for truck/trailer combinations) – overweight permits are no longer being issued. Vertical signed clearance at 13 feet 2 inches – semi tractor-trailer should be restricted.

- **Mn/DOT Bridge Inspection Report, 1995**
  - Truss bottom chord/vertical member connection plates have severe pack rust (one-inch spread between plates) at many locations.

- **Mn/DOT Bridge Inspection Report, 1995**
  - Upper truss members have section loss, flaking and surface rust (bottom 10 feet).

- **Mn/DOT Bridge Inspection Report 2001**
  - Secondary Elements: East and west portal bracing replaced. Several sway bracing lower struts replaced. [1995] Bottom chord lateral bracing gusset plates have severe section loss (pitting and holes). [1997] Two lateral bracing hanger bars broken. Span 9: some top sway frame members bent, truck damage.

- **Mn/DOT Bridge Inspection Report 2003**
  - This Bridge needs structural analysis on all steel (severe section loss) before the new deck and repairs are started.

- **Mn/DOT Bridge Inspection Report 2003**
  - 30-inch deep floor beams (7 inch each span) – several holes found through the web.
- **HNTB Report – Maintenance Projections and Annualized Costs Report of Funding – Stillwater Lift Bridge – August 6, 2003.**
  - Report identifies that if the Stillwater Lift Bridge were to remain open to unrestricted vehicular traffic through 2055, the bridge would be unable to effectively serve meaningful transportation needs. The structure would require extensive structural preservation efforts and/or replacement of trusses in their entirety.
  - East Abutment has experienced settlement and rotation, estimated at several feet.
  - Substructure concrete: Repairs will tend to slow future deterioration. It is anticipated that the piers will be in need of substantial repair or replacement, if services continue beyond 2055 (however, this report was assuming the bridge would carry only pedestrian traffic beyond 2010).
  - Lower Chords: Repairs were made in three locations in 2003 with additional repairs proposed in the 2005 $5M repair project. However, isolated locations of corrosion will remain after the $5M repair project and failure of one of these lower chords would result in a sudden collapse of the truss.
  - Lower Chord Connections: If not maintained properly the pack rust is anticipated to continue forming, replacing the rivets with bolts will not address the main cause of the problem – the pack rust itself. This could render the connections to be structurally inadequate.

REQUIRED IMPROVEMENTS

Based on the condition of the bridge and the fracture critical nature of the structure combined with the possible use of the Stillwater Lift Bridge for unrestricted vehicular use, it is our assessment that major structural repair including replacement of individual truss members with in-kind members or total replacement of individual trusses will be required. Major repair to the trusses at a minimum may include:

- Total bottom chord replacement
- Strengthening of the top chord and diagonals
- Replacement of the mechanical and electrical components of the lift span
- Replacement of all rivets with round headed bolts
- Total replacement of all pack rust problem areas
- Bearing replacement
- Substructure rehabilitation or replacement, and
- Clean and re-paint truss

In addition to the repairs or truss replacement, continued maintenance will be required.

DEPARTMENT OF THE INTERIOR'S STANDARDS FOR REHABILITATION

Given that the bridge is listed on the National Register of Historic Places, federal and state regulations require that Department of Interior Standards for Rehabilitation be followed for any bridge repair.

The Standards include ten guidelines for preserving the physical integrity of historic structures. Particularly relevant to any future repairs of the Lift Bridge, Standard No. 6 states the following:

> 6. Deteriorated historic features shall be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature shall match the old in design, color, texture, and other visual qualities, and where possible, materials. Replacement of missing feature shall be substantiated by documentary, physical or pictorial evidence.

Accordingly, this report has been prepared to address both the repair and replacement options. The repair option assumes that bridge elements should be retained and repaired or where not feasible, replaced with new elements matching the old look as closely as possible. The replacement option examines the possibility that repair/partial replacement of bridge members may not be feasible from either a physical or a financial standpoint.

GEOMETRIC REQUIREMENTS

Due to the extensive amount of rehabilitation work that will be required to keep the Stillwater Lift Bridge in operation for vehicular traffic, a design exception or variance will be required for geometric deficiencies on the existing bridge.

The following is a summary of current conditions and required clearances for trunk highways and local roads.

	Vertical Clearance	**Bridge Width**
Existing Stillwater Lift Bridge Conditions	13'-2"	23'
Trunk Highway Minimum Requirements (Alternates "No Build" and "E")	*16'-4"	24'
State Aid (Local Road) Requirements (Alternates "B" and "C")	14'-6"	24'

* Mn/DOT Bridge Policy is to have 17-feet vertical clearance for Truss Type Bridges.

For the "No Build" and Alternate "E" option, the approval process will involve a "Design Exception" for the vertical clearance and deck width deficiencies. A design exception on a trunk highway facility requires the approval of the Mn/DOT Commissioner and FHWA. For Alternate "B" and "C," which utilizes the existing lift bridge for local traffic only, the approval process is different. A design variance will be required and is approved by a Mn/DOT Design committee.

REHABILITATION OPTION

Two alternative construction methods were considered for the truss rehabilitation option: 1) Member by member replacement with the trusses left in place during the rehabilitation or 2) Removal of the trusses span-by-span and complete necessary rehabilitation/member replacement work completed off site.

Due to the statically determinant nature of the structure, removal of any portion of the tension or compression chords makes the truss structurally unstable. Hence, in-place truss rehabilitation requires the truss to be temporarily supported, which is difficult and costly over water. Another option considered was the use of temporary top and bottom chords during truss rehabilitation. This method would also be costly and may affect the historic appearance of the structure.

Both alternatives would require the bridge to be closed during rehabilitation. Based on our engineering judgment, the rehabilitation work would be less disruptive and more cost effective by removing the trusses and performing the rehabilitation work on land next to the bridge. As many of the original parts as possible of the existing truss would be reused in order to retain the appearance of the original historic bridge.

Per the Mn/DOT "Bridge Preservation, Improvement, and Replacement Guidelines", the structure would need to be reconstructed to carry a minimum of HL-93 live loading. Increased capacity will be gained through the use of higher strength materials, strengthening/replacement of substructures and making a minor increase in member size where necessary.

Due to the removal of individual trusses, this method of rehabilitation does not allow the bridge to remain open while the time consuming reconstruction of the trusses off-site is taking place. Although span-by-span rehabilitation could be performed, it is estimated that the closure duration would be only slightly longer if a majority of the truss spans were removed at one time and rehabilitated. This method also would allow the vertical clearance to be adjusted slightly, if so desired. The estimated closure period to rehabilitate the majority of the trusses at one time is approximately two years.

The trusses will all be removed in one time frame and superstructure restoration would occur on land – the trusses would be dismantled and secondary members that are structurally sound would be reused. An engineering analysis would need to be performed to assess the limitations of where original members can be reused. All main members including but not limited to floor beams, stringers and fracture critical chords would be replaced with new steel.

The estimated cost for this option is approximately $26 million, and a detail cost estimate is included in Table A. The following assumptions were made in preparing the cost estimate:

- Rehabilitation work would begin at approximately 2020.
- The bridge will be fabricated to retain the appearance of the original trusses, round-headed bolts that look like rivets used.
- Higher strength steel and other improvements will be incorporated to increase the live load carrying capacity.

- East Abutment replaced with new piling and proper scour protection. The abutment aesthetics remaining as constructed in 1931.
- West Abutment rehabilitated with repairs to prevent future deterioration.
- Approach spans replaced on both ends of the bridge.
- Ornamental railing reused from the 2005 repair project.
- The six steel thru-trusses will be rehabilitated using as many of the existing parts as possible. Fabrication will occur on land with the fully erected truss put in place via barges.
- The vertical-lift span of the Waddell and Harrington type rehabilitated using as many of the existing members as possible. Fabrication will occur on land with the fully erected truss put in place via barges.
- The mechanical system replaced in-kind with the exception of reusing counterweights and other components where feasible. (Does not include mechanical work to be performed on 2005 Rehabilitation Project.)
- The electrical system replaced. (Does not include electrical work to be performed on 2005 Rehabilitation Project.)
- During subsequent inspections, a minimum of one of the piers will need replacing.
- The remaining five piers cleaned, reinforced and wrapped with a protective shell and the foundations shall be underpinned as necessary.
- All bearings replaced.
- The deck poured once the rehabilitated spans are set in-place.

Both of the proposed methods, Total Replacement or Rehabilitation, shall remain true to the original structure.

REPLACEMENT OPTION

This option would consist of replacing individual trusses with new fabricated trusses, and rehabilitating or reconstructing substructures as necessary. To minimize closure duration, SRF feels the best solution is to replace one truss span at a time. This option allows completing repairs over a period of 6 to 15 years. SRF estimates that the bridge would be closed about two months for each truss span removal and replacement. The duration of closure for the lift span, however, would be longer, approximately six months.

New trusses would be fabricated off-site while the bridge remains open to traffic. Removal of the existing trusses would be scheduled so that the necessary substructure work would be completed followed immediately by installation of the new truss span, thereby minimizing the closure duration.

The two lift-tower spans (Spans 3 and 5) and the lift-span (Span 4) would need to be replaced during the same closure period due to mechanical and electrical equipment. The two lift-tower spans must be compatible with each other for the lift-span to function properly. Structure replacement could allow for the new truss to be built with a 13-feet-6-inch clearance versus the existing 13-feet-2-inch clearance, thus removing the classification of "functionally obsolete".

The estimated cost for this option is approximately $26 million and a detail cost estimate is included in Table B. The follow assumptions were made in preparing the cost estimate:

- Bridge replacement work would begin at approximately 2020.
- The bridge will be fabricated to retain the appearance of the original trusses, round-headed bolts that look like rivets used.
- Higher strength steel and other improvements, such as minor modifications to member sizes, will be incorporated to increase the live load carrying capacity to today's standards.
- East Abutment replaced with new piling and proper scour protection. The abutment aesthetics will remain as constructed in 1931.
- West Abutment rehabilitated with repairs to prevent future deterioration.
- Approach spans replaced on both ends of the bridge.
- Ornamental railing reused from the 2005 repair project.
- The six steel thru-truss spans will be replaced in-kind. Fabrication will occur off site with the fully erected trusses put in place via barges.
- The vertical-lift span of the Waddell and Harrington type will be replaced in-kind. Fabrication will occur on land with the fully erected trusses put in place via barges.
- The mechanical system will be replaced in-kind with the exception of reusing counterweights and other components where feasible.
- The electrical system will be replaced.
- The remaining five Piers will be cleaned, reinforced and wrapped with a protective shell and foundations underpinned as necessary.
- All bearings will be replaced.
- The concrete deck will be installed prior to barging the new span to the site, thus minimize the time of closure of the bridge.

ESTIMATED OPERATING COSTS

The lift bridge operating costs and activities will not be substantially different from the costs necessary to operate the lift bridge today. These activities include bridge tenders to operate the lift bridge, utilities, administration costs, insurance and miscellaneous items. Therefore, the estimated operating costs will be similar to the previous HNTB cost estimate of approximately $105,000 per year.

ESTIMATED MAINTENANCE COSTS

Maintenance Costs will be reduced to the typical routine maintenance that is required to prolong the life of the lift bridge. Some of the ongoing maintenance activities include snow removal, deck cleaning, greasing and lubrication of the lift span mechanical systems, sweeping of the deck, annual inspections, lamp replacements, cleaning expansion joints and miscellaneous upkeep. The estimated "routine maintenance" will be similar to the previous HNTB estimate of $43,000 per year (2004 US dollars).

The bridge will need to be repainted at approximately 20-year intervals at an estimated cost of $1,500,000 (2004 US dollars) or an annualized cost of about $75,000.

Therefore, the annual maintenance cost of the new structure will be in the range of $120,000 per year, which assumes repainting every 20 years.

LAE/dcw

Attachments: Table A-Bridge Rehabilitation Cost Estimate
Table B-Bridge Replacement Cost Estimate

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Table A
ENGINEERS COST ESTIMATE
FOR
STILLWATER LIFT BRIDGE REHABILITATION
Mn/DOT BRIDGE NO. 4654
WisDOT BRIDGE NO. M-61

ITEM DESCRIPTION	UNIT	CONTRACT QUANTITY	UNIT COST	TOTAL PRICE
MOBILIZATION	LUMP SUM	1	750,000.00	750,000.00
SAVAGE ORNAMENTAL RAIL	LIN. FT.	2,000	50.00	100,000.00
BRIDGE SLAB CONCRETE (3Y36) - TRUSS SPANS	SQ. FT.	24,080	25.00	602,000.00
BRIDGE SLAB CONCRETE (3Y36) - APPROACH SPANS	SQ. FT.	1,528	40.00	61,110.00
PEDESTRIAN SLAB CONCRETE (3Y46)	SQ. FT.	7,128	25.00	178,200.00
RAILING CONCRETE (3Y46)	LIN. FT.	126	200.00	25,200.00
REMOVE ABUTMENT	EACH	1	50,000.00	50,000.00
REMOVE PIER 8	EACH	1	50,000.00	50,000.00
WEST ABUTMENT REHABILITATION	EACH	1	30,000.00	30,000.00
FOUNDATION PREPARATION, PIER 3	EACH	1	150,000.00	150,000.00
FOUNDATION PREPARATION, PIER 4	EACH	1	150,000.00	150,000.00
FOUNDATION PREPARATION, PIER 5	EACH	1	100,000.00	100,000.00
FOUNDATION PREPARATION, PIER 6	EACH	1	100,000.00	100,000.00
FOUNDATION PREPARATION, PIER 7	EACH	1	100,000.00	100,000.00
FOUNDATION PREPARATION, PIER 8	EACH	1	300,000.00	300,000.00
PIER 1 REHABILITATION	EACH	1	50,000.00	50,000.00
PIER 2 REHABILITATION	EACH	1	100,000.00	100,000.00
PIER 3 REHABILITATION	EACH	1	300,000.00	300,000.00
PIER 4 REHABILITATION	EACH	1	300,000.00	300,000.00
PIER 5 REHABILITATION	EACH	1	250,000.00	250,000.00
PIER 6 REHABILITATION	EACH	1	250,000.00	250,000.00
PIER 7 REHABILITATION	EACH	1	250,000.00	250,000.00
PIER 8 RECONSTRUCTION	EACH	1	400,000.00	400,000.00
EAST ABUTMENT RECONSTRUCTION	EACH	1	300,000.00	300,000.00
STRUCTURAL STEEL	POUND	1,065,750	5.50	5,861,625.00
CLEAN, REPAIR & REUSE EXISING STEEL	POUND	456,750	3.00	1,370,250.00
REMOVE TRUSS	EACH	7	150,000.00	1,050,000.00
OFF-SITE TRUSS DEMOLITION & SALVAGE	LUMP SUM	1	1,500,000.00	1,500,000.00
REINSTALL TRUSS	EACH	7	150,000.00	1,050,000.00
REINSTALL ORNAMENTAL RAILING	LIN. FT.	2,000	15.00	30,000.00
EXPANSION JOINT DEVICES TYPE 4	LIN. FT.	150	300.00	45,000.00
BEARING ASSEMBLY	EACH	28	5,000.00	140,000.00
REPLACE/REHABILITATE MECHANICAL SYSTEM	EACH	1	4,000,000.00	4,000,000.00
REPLACE ELECTRICAL SYSTEM	EACH	1	300,000.00	300,000.00
INORGANIC ZINC-RICH PAINT SYSTEM (FIELD)	LUMP SUM	1	1,600,000.00	1,600,000.00
TENDERS HOUSE - SALVAGE & REPLACE	LUMP SUM	1	50,000.00	50,000.00
LIGHTING	LUMP SUM	1	400,000.00	400,000.00
NAVIGATION GUIDANCE SYSTEM	LUMP SUM	1	25,000.00	25,000.00

SUBTOTAL	**$22,368,385.00**
15% Contingency	**$3,355,257.75**
TOTAL ESTIMATED BRIDGE COST	**$25,723,642.75**

Cost/SF Bridge Deck Area	**$1,004.52**
Cost/SF Total Deck Area	**$785.79**

Estimate Annual Operating Cost (base on previous reports)	**$105,000.00**
Estimate Annual Routine Maintenance Cost (base on previous reports)	**$43,000.00**

General Structure Information:

Truss Spans - Approximate Length	993 ft
Approach Spans - Length	63 ft
Total Length	1056 ft
Deck Width	24.25 ft
Sidewalk Width	6.75 ft
Bridge Deck Area - Truss	24080 sq. ft.
Bridge Deck Area - Slab Spans	1528 sq. ft.
Sidewalk	7128 sq. ft.
Total Deck Area	32736 sq. ft.

General Notes:

1. No Cost Escalation Included (2004 US Dollars)
2. Cost to Update Mechanical System to New Condition is based on HNTB 2005 Report's Rehabilitation Estimate multiplied times 2.
3. Does not Include Engineering & Construction Administration Fees
4. Rehabilitaion of Piers 2 thru 7 includes Chloride Extraction, Concrete Wrap & Underpinning of Foundations
5. East Abutment Reconstruction includes New Pile (100-ft length) End Span & Truss Span Support Stems
6. Truss Removal & Truss Installation via Barges.
7. Steel Quantity - 30% of Existing Steel to be Reused.

Table B
ENGINEERS COST ESTIMATE
FOR
STILLWATER LIFT BRIDGE REPLACEMENT
Mn/DOT BRIDGE NO. 4654
WisDOT BRIDGE NO. M-61

ITEM DESCRIPTION	UNIT	CONTRACT QUANTITY	UNIT COST	TOTAL PRICE
MOBILIZATION	LUMP SUM	1	1,500,000.00	1,500,000.00
SAVAGE ORNAMENTAL RAIL	LIN. FT.	2,000	50.00	100,000.00
BRIDGE SLAB CONCRETE (3Y36) - TRUSS SPANS	SQ. FT.	24,080	25.00	602,000.00
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FOUNDATION PREPARATION, PIER 6	EACH	1	100,000.00	100,000.00
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PIER 4 REHABILITATION	EACH	1	300,000.00	300,000.00
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PIER 6 REHABILITATION	EACH	1	250,000.00	250,000.00
PIER 7 REHABILITATION	EACH	1	250,000.00	250,000.00
PIER 8 RECONSTRUCTION	EACH	1	400,000.00	400,000.00
EAST ABUTMENT RECONSTRUCTION	EACH	1	300,000.00	300,000.00
STRUCTURAL STEEL	POUND	1,522,500	5.50	8,373,750.00
REMOVE TRUSS	EACH	7	100,000.00	700,000.00
REINSTALL TRUSS	EACH	7	150,000.00	1,050,000.00
REINSTALL ORNAMENTAL RAILING	LIN. FT.	2,000	15.00	30,000.00
EXPANSION JOINT DEVICES TYPE 4	LIN. FT.	150	300.00	45,000.00
BEARING ASSEMBLY	EACH	28	5,000.00	140,000.00
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REPLACE ELECTRICAL SYSTEM	EACH	1	300,000.00	300,000.00
INORGANIC ZINC-RICH PAINT SYSTEM (FIELD)	LUMP SUM	1	1,600,000.00	1,600,000.00
TENDERS HOUSE - SALVAGE & REPLACE	LUMP SUM	1	50,000.00	50,000.00
LIGHTING	LUMP SUM	1	400,000.00	400,000.00
NAVIGATION GUIDANCE SYSTEM	LUMP SUM	1	25,000.00	25,000.00
SUBTOTAL				**$22,410,260.00**
15% Contingency				**$3,361,539.00**
TOTAL ESTIMATED BRIDGE COST				**$25,771,799.00**

Cost/SF Bridge Deck Area **$1,006.40**
Cost/SF Bridge plus Sidewalk Deck Area **$787.26**

Estimate Annual Operating Cost (base on previous reports) **$105,000.00**
Estimate Annual Routine Maintenance Cost (base on previous reports) **$43,000.00**

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5. East Abutment Reconstruction includes New Pile (100-ft length) End Span & Truss Span Support Stems
6. Truss Removal & Truss Installation via Barges.
7. Steel Quantity estimated per Existing Bridge Plans