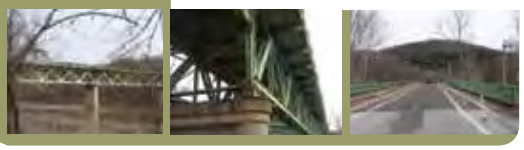
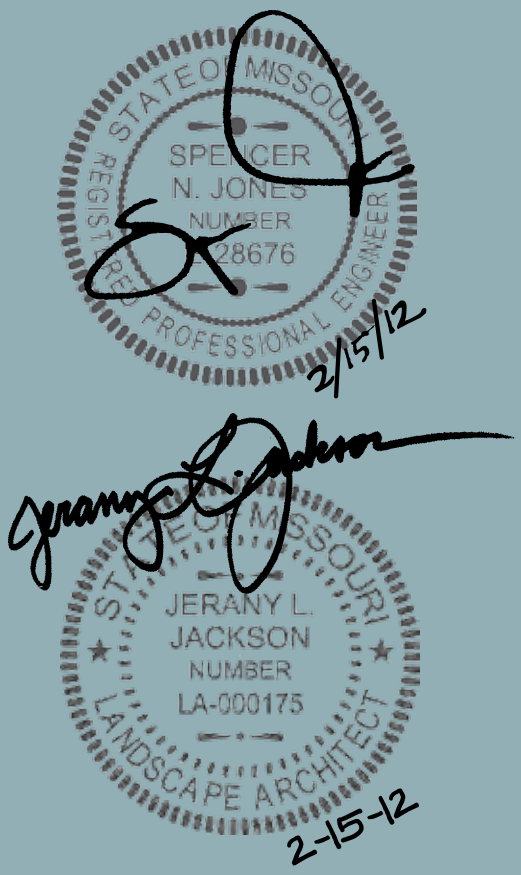
Meramec River U.S. 66 Bridge J-0421
Route 66 State Park, Missouri

Historic Structure Report





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November 2011

Prepared for:
Landmarks Association of St. Louis, Inc.

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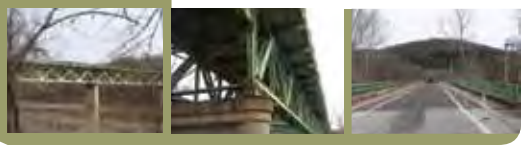
Volume 1 of 1



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Great River Associates, Inc.
November 2011

Foreword

We are honored to be part of the team of professionals preparing the Historic Structure Report (HSR) for the Meramec River U.S. 66 Bridge located near Eureka, in St. Louis County, Missouri. In the ongoing effort to provide comprehensive documentation for this historic bridge structure, the overall objective of the Report was to analyze the Bridge in an effort to preserve its structural and historic integrity and serviceability.

Writing this Report has been no small task. Collecting information, analyzing eighty year-old drawings, coordinating with over twenty Section 106 Consulting Parties and two state agencies in the development of the HSR for one of the most historically significant bridges in the state of Missouri and nationally significant as a U.S. Route 66 bridge as well, all on a tight timeframe has been a seemingly impossible task at times. It was necessary to act quickly as the Missouri Department of Transportation (MoDOT) closed the bridge in October of 2009 with the intent of tearing the bridge down in the summer 2012 if a new owner is not found beforehand. In addition to a new owner, MoDOT must have a "business plan" that sets forth the new owner's proposed future plan for the Meramec Bridge as well as identifying a potential time line for preservation activities. It is the hope of the Great River Associates Consulting Team that this Report will provide a new owner with as solid a base to build on as the Meramec River U.S. 66 Bridge itself.

The bridge, built in 1931, is 1,008 feet long and because of the age of the construction documents and the complexity of the design, the structural analysis was challenging. To meet the objective of preservation and serviceability as it relates to the original intent of the bridge, it was determined that we should follow the Secretary of the Interior's Standards for the Treatment of Historic Properties (Standards) [36 CFR Part 68], and their adaptation for historic bridges by the Virginia Transportation Research Council as Guidelines for Bridge Maintenance and Rehabilitation Based on the Secretary of the Interior's Standards (Guidelines).

The purpose of this document is to develop a plan for the U.S. Route 66 Bridge over the Meramec River. This Historic Structure Report will serve as an essential part of the master plan or as has been referred to in the development of this document, the business plan, the required long-range planning tool for the future use of the bridge and its surrounds, which are integral components of historic U. S. Route 66 in Missouri.

The HSR outlines the historical background and discusses the significance of the bridge. It examines the current condition of the bridge and analyzes the structural capacity for ways to stabilize the bridge, preserve it within its historic environs, and to provide public access to this

important component of U.S. Route 66. The HSR identifies a preferred alternative as well as other alternatives for consideration. The possibility of ownership transfer for the preservation of the bridge is outlined and the legalities of Right of Way (ROW) are presented.

The financial analysis portion of the Report examines the economic feasibility of preservation and rehabilitation costs. The new owner of the bridge will have to expend funds to either stabilize or rehabilitate the bridge; therefore, funding opportunities are presented. The importance of educating the public about the bridge as a historical resource is also recognized. Outreach programs are explored and avenues for gathering public input are identified, recognizing that it will likely be necessary to conduct a capital campaign in an effort to restore the bridge.

It is imperative that the public become educated about the Meramec River U.S. 66 Bridge and its significance to the history of U.S. Route 66, as well as its importance as an intrinsic resource to the State of Missouri's Route 66 Byway. The Missouri Highways and Transportation Commission Scenic Byway Program is authorized by the Missouri Revised Statutes Chapter 226, Section 226.797 to provide direction for the State Scenic Byways Program for purposes of protecting, preserving and enhancing scenic byways. The benefit in public education about the bridge is multi-faceted. Stimulation of community interest to take action on the preservation of this historic resource will serve as a vehicle with which to garner public opinion and support. Additionally, public interest and cooperation serves as an educational conduit to demonstrate the importance of preservation of community and national historic resources.

An overriding goal for the Report is to promote the responsible utilization of public and/or private funds and to find ways for historic bridge structures and properties to function and continue to benefit the public. We believe that the best way to preserve our historical treasures is to use them. It is through use that appreciation is built. As part of the road itself, the Meramec River U.S. 66 Bridge provides a tangible source of interpretation and historical documentation relating to Route 66. The preservation of the bridge would bring to fruition the ability to enhance, and utilize the bridge for current and future generations.

It is our hope that the Meramec River U.S. 66 Bridge Historic Structure Report will promote a greater understanding of the bridge, and that it will make a lasting and meaningful contribution to the work of its future caretakers.

Spencer Jones, P.E.
Principal Structural Engineer
Great River Associates

Jerany L. Jackson, ASLA, MBA
Department Head of Special Services
Great River Associates

Project Team

The development of this document, The Meramec River U.S. 66 Bridge Historic Structure Report, was undertaken as a result of the efforts of more than twenty Section 106 Consulting Parties for the Meramec River U.S. 66 Bridge. The Report was funded in part by the National Park Service Route 66 Corridor Preservation Program, in part by Great Rivers Greenway of St. Louis, Missouri and in part by Great River Associates of Springfield, Missouri.

The key to the success of the Meramec River U.S. 66 Bridge Historic Structure Report is the solid foundation of diverse professional team members and contributors. This combination of efforts offers the benefits of a multi-disciplinary professional team with planning and structural engineering experience and the broad-based knowledge of the stakeholders required to develop the Historic Structure Report for the Meramec River U.S. 66 Bridge. Great River Associates, the author of the document, appreciates the time that organizations and individuals took to share ideas, discuss their experiences, and review the pieces of this document. Many of the ideas raised by these stakeholders have been incorporated into this document.

Great River Associates (GRA) is the Project Consulting Firm for the Meramec River U.S. 66 Bridge project. GRA is a multi-disciplinary firm specializing in civil and structural engineering, landscape architecture, land surveying, Geographic Information Systems (GIS), graphic design, and comprehensive planning. GRA project team members were selectively chosen because they possess the experience and knowledge to complete a holistic and comprehensive plan for the Meramec River Bridge.

Great River Associates had the primary responsibility for developing the content and format of the document under the direction of Spencer Jones, P.E. and Jerany Jackson, ASLA, MBA. Great River assembled the teams of contributors and reviewers, and provided direction and untiring support as the project came to fruition. Spencer Jones and Jerany Jackson served as the principal writers and editors.

Mr. Spencer Jones, P.E. is a principal and structural engineer with Great River. Mr. Jones has extensive experience in the area of structural bridge design and engineering and in particular has worked on a number of historic bridge preservation projects. Most notably, he is

currently preparing plans for the rehabilitation of the Missouri Route 66 Devil's Elbow Bridge in Pulaski County and co-authored the recently completed Missouri Route 66 Corridor Management Plan. Mr. Jones served as the engineer of record on the engineering study and analysis as well as the quality control reviewer, the last stop before the report is complete.

Ms. Jerany Jackson, a Landscape Architect with Great River, served as the project manager for the project. Ms. Jackson has extensive experience in design and planning multi-modal transportation environments. Ms. Jackson has completed numerous historic downtown projects, landscape preservation projects and most recently served as the project manager and co-author of the recently completed Missouri Route 66 Corridor Management Plan. She was responsible for the coordination of the project with the project team, integrating the information generated by the various team members. She also served as author and editor.

Great River gratefully acknowledges the important contribution of their team of experts, who served as core technical advisors for this document. These individuals contributed a substantial amount of technical material and thoughtful comments on drafts and, most importantly, their considerable practical experience in the creation of a technical document. Great River would like to recognize the following staff for their particular contributions: James Ouellette, P.E.; Kathleen Giles, Planner; Ryan Evitts, ASLA, Landscape Architecture Staff and Keith Belt, Graphic Designer.

In addition to GRA, there are a number of team members, key stakeholders in the project, that bring an extensive degree of experience, public administration and funding to this project.

Landmarks Association of St. Louis, Inc. is a non-profit preservation advocate for the region's cultural resources (est. 1958 / incorporated 1959). Landmarks Association of St. Louis, Inc. is the non-profit agency serving as the fiscal agent until an owner can be found for the bridge. Ruth Keenoy and Ryan Reed (Preservation Specialists) are the primary contacts for Landmarks and have been actively involved in the project since its inception. Keenoy co-wrote the National Register nomination for the bridge and the Route 66 in Missouri Multiple Property Documentation Form (MPDF).

Great Rivers Greenway is the public organization leading the development of the River Ring, a region-wide system of interconnected greenways, parks and trails for the benefit of the St. Louis region residents, visitors and communities. Great Rivers Greenway provided part of the financial match for the Historic Structure Report. The lead agent for Great Rivers Greenway is Lonny Boring, Project Manager.

Scenic Missouri is a 501(c)(3) organization dedicated to the enhancement and preservation of Missouri's scenic landscapes and communities. It is through Scenic Missouri's leadership in the Scenic Byways program that the bridge was nominated for inclusion in Missouri Preservation's 2010 and 2011 Most Endangered List, as well as helping to bring together a large and diverse number of organizations in an effort to save this historic bridge. The lead agent for Scenic Missouri is John Regenbogen, Executive Director.

As part of the required Section 106 Process, agency officials must provide the public with information about a project and its potential effects on historic properties and seek public comment and input. In addition, certain individuals or organizations with "demonstrated interest" in a project may request, or be invited, to participate in project planning activities as consulting parties. Although consulting parties participate in project planning, they may or may not concur with project decisions or conclusions. The following groups and individuals are participating as consulting parties for the Meramec River U.S. 66 Bridge project:

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Glossary of Bridge and Preservation Terms

Appraisal ratings – Five National Bridge Inventory (NBI) inspection ratings (structural evaluation, deck geometry, under-clearances, waterway adequacy, and approach alignment, as defined below), collectively called appraisal ratings, are used to evaluate a bridge's overall structural condition and load-carrying capacity. The evaluated bridge is compared with a new bridge built to current design standards. Ratings range from a low of zero (0) (closed bridge) to a high of nine (9) (superior). Any appraisal item not applicable to a specific bridge is coded "N".

Approach alignment – One of five NBI inspection ratings. This rating appraises a bridge's functionality based on the alignment of its approaches. It incorporates a typical motorist's speed reduction because of the horizontal or vertical alignment of the approach.

Character-defining features – Prominent or distinctive aspects, qualities, or characteristics of a historic property that contribute significantly to its physical character. Features may include structural or decorative details and materials.

Condition rating – Level of deterioration of bridge components and elements expressed on a numerical scale according to the NBI system. Components include the substructure, superstructure, deck, channel, and culvert. Elements are subsets of components, e.g., piers and abutments are elements of the component substructure. The evaluated bridge is compared with a new bridge built to current design standards. Component ratings range from zero (0) (failure) to nine (9) (new).

Deck geometry – One of five NBI inspection ratings. This rating appraises the functionality of a bridge's roadway width and vertical clearance, taking into account the type of roadway, number of lanes, and Average Daily Traffic (ADT).

Deficiency – The inadequacy of a bridge in terms of structure, serviceability and/or function. Structural deficiency is determined through periodic inspections and is reflected in the ratings that are assigned to a bridge. Service deficiency is determined by comparing the facilities a bridge provides for vehicular, bicycle, and pedestrian traffic with those that are desired.

Functional deficiency is another term for functionally obsolete (see below). Remedial activities may be needed to address any or all of these deficiencies.

Deficiency rating – A nonnumeric code indicating a bridge's status as structurally deficient (SD) or functionally obsolete (FO). See below for the definitions of SD and FO. The deficiency rating status may be used as a basis for establishing a bridge's eligibility and priority for replacement or rehabilitation.

Design exception – A deviation from standard bridge design practices that takes into account environmental, scenic, aesthetic, historic, and community factors that may have bearing upon a transportation project. A design exception is used for federally funded projects where federal and state standards are not met. Approval requires appropriate justification and documentation that concerns for safety, durability, and economy of maintenance have been met.

Design load – The usable live-load capacity that a bridge was designed to carry, expressed in tons according to the allowable stress, load factor, or load resistance factor rating methods. An additional code was recently added to assess design load by a rating factor instead of tons. This code is used to determine if a bridge has sufficient strength to accommodate traffic demands. A bridge that is posted for load restrictions may not be adequate to accommodate present or expected truck traffic.

Fracture critical – Classification of a bridge having primary superstructure or substructure components subject to tension stresses which are non-redundant. A failure of one of these components could lead to collapse of a span or the bridge. Tension members of truss bridges are often fracture critical. The associated inspection date is a numerical code that includes frequency of inspection in months, followed by year, and month of last inspection.

Functionally obsolete (FO) – The Federal Highway Administration (FHWA) classification of a bridge that cannot meet current or projected traffic needs because of inadequate horizontal or vertical clearance, inadequate load-carrying capacity, and/or insufficient opening to accommodate water flow under the bridge.

Historic fabric – The material in a bridge that was part of original construction or a subsequent alteration within the historic period (e.g., more than 50 years old) that has

significance in and of itself. Historic fabric includes both character-defining and minor features. Minor features have less importance and may be replaced more readily.

Historic bridge – A bridge that is listed in, or eligible for listing in, the National Register of Historic Places.

Historic integrity – The authenticity of a bridge's historic identity, evidenced by the survival and/or restoration of physical characteristics that existed during the bridge's historic period. A bridge may have integrity of location, design, setting, materials, workmanship, feeling, and association.

Inspections – Periodic field assessments and subsequent consideration of the fitness of a structure and the associated approaches and amenities to continue to function safely.

Inventory rating – The load level a bridge can safely carry for an indefinite amount of time expressed in tons or by the rating factor described in design load (see above). Inventory rating values typically correspond to the original design load for a bridge without deterioration.

Maintenance – Work of a routine nature to prevent or control the process of deterioration of a bridge.

National Bridge Inventory (NBI) – Bridge inventory and appraisal data collected by the FHWA to fulfill the requirements of the National Bridge Inspection Standards (NBIS). Each state maintains an inventory of its bridges subject to NBIS and sends an annual update to the FHWA.

National Bridge Inspection Standards (NBIS) – Federal requirements for procedures and frequency of inspections, qualifications of personnel, inspection reports, and preparation and maintenance of state public bridge inventories. NBIS applies to bridges located on public roads.

National Register of Historic Places (NRHP)– The official inventory of districts, sites, buildings, structures, and objects significant in American history, architecture, archaeology, and culture, which is maintained by the Secretary of the Interior under the authority of the National Historic Preservation Act of 1966 (as amended).

Non-vehicular traffic – Pedestrians, non-motorized recreational vehicles, and small motorized recreational vehicles moving along a transportation route (includes bicycles).

Operating rating – Maximum permissible load level to which a bridge may be subjected based on a specific vehicle type, expressed in tons or by the rating factor described in design load (see above).

Posted load – Legal live-load capacity for a bridge usually associated with the operating or inventory ratings as determined by a state transportation agency. A bridge posted for load restrictions may be inadequate for truck traffic.

Preservation – Preservation, as used in this report, refers to historic preservation that is consistent with the Secretary of the Interior's *Standards for the Treatment of Historic Properties.* Historic preservation means saving from destruction or deterioration old and historic buildings, sites, structures, and objects, and providing for their continued use by means of restoration, rehabilitation, or adaptive reuse. It is the act or process of applying measures to sustain the existing form, integrity, and material of a historic building or structure, and its site and setting.

Preventive maintenance – The planned strategy of cost-effective treatments that preserve a bridge, slow down future deterioration, and maintain or improve its functional condition without increasing structural capacity.

Reconstruction – The act or process of depicting, by means of new construction, the form, features, and detailing of a non-surviving site, landscape, building, structure, or object for the purpose of replicating its appearance at a specific period of time and in its historic location. Activities should be consistent with the Secretary of the Interior's *Standards for the Treatment of Historic Properties.*

Rehabilitation – The act or process of returning a historic property to a state of utility through repair or alteration which makes possible an efficient contemporary use, while preserving those portions or features of the property that are significant to its historical, architectural, and cultural values. Historic rehabilitation, as used in this report, refers to implementing activities that are consistent with the Secretary of the Interior's *Standards for the Treatment of Historic Properties.* As such, rehabilitation retains historic fabric and is different from replacement.

Restoration – The act or process of accurately depicting the form, features, and character of a property as it appeared at a particular period of time. Activities should be consistent with the Secretary of the Interior's *Standards for the Treatment of Historic Properties.*

Scour – Removal of material from a river's bed or bank by flowing water, compromising the strength, stability, and serviceability of a bridge.

Scour critical rating – A measure of bridge's vulnerability to scour (see above), ranging from zero (0) (scour critical, failed, and closed to traffic) to nine (9) (foundations are on dry land well above flood water elevations). This code can also be expressed as "U" (unknown), "N" (bridge is not over a waterway).

Serviceability – Level of facilities a bridge provides for vehicular, bicycle, and pedestrian traffic, compared with current design standards.

Stabilization – The act or process of sustaining a bridge by means of making minor repairs until a more permanent repair or rehabilitation can be completed.

Structurally deficient (SD) – Classification indicating NBI condition rating of 4 or less for any of the following: deck condition, superstructure condition, substructure condition, or culvert condition. A structurally deficient bridge requires immediate rehabilitation to remain open to traffic; or requires maintenance, rehabilitation, or replacement.

Structural evaluation – Condition of a bridge designed to carry vehicular loads, expressed as a numeric value and based on the condition of the superstructure and substructure, the inventory load rating, and the ADT.

Substructure – The substructure includes those parts which transfer the loads from the bridge span down to the supporting ground. For a single-span structure, the substructure consists of two abutments, while for multi-span structures there are also one or more piers (or bents). The loads are applied to the substructure through the bearing plates and transmitted through the abutment walls or pier columns to the footings. If the soil is of adequate strength, the footings will distribute the loads over a sufficiently large area. If not, the footings themselves must be supported on pile foundations extended down to a firm underlying stratum.

Superstructure – The superstructure includes all those parts which are supported by the substructure, with the main part being the bridge spans. Vehicular loads are transmitted from the bridge deck, through the supporting girders or truss of the span, and into the substructure. On girder and truss bridges, the slab is supported on longitudinal members which, in turn, carry the load to the abutment or piers. Some superstructures consist of the deck, a floor system, and two or more main supporting members.

Sufficiency rating – Rating of a bridge's structural adequacy and safety for public use, and its serviceability and function, expressed on a numeric scale ranging from a low of zero (0) to a high of one hundred (100). It is a relative measure of a bridge's deterioration, load capacity deficiency, or functional obsolescence. This rating is used as the basis for establishing eligibility and priority for replacement or rehabilitation. Typically, bridges rated between fifty (50) and eighty (80) are eligible for rehabilitation and those rated fifty (50) and below are eligible for replacement.

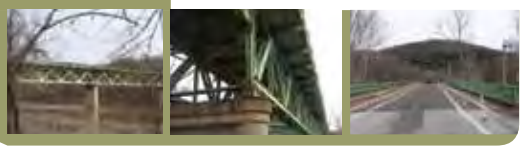
Under-clearances – One of five NBI inspection ratings. This rating appraises the suitability of the horizontal and vertical clearances of a grade-separation structure, taking into account whether traffic beneath the structure is one- or two-way.

Variance – A deviation from standard bridge design practices that takes into account environmental, scenic, aesthetic, historic, and community factors that may have bearing upon a transportation project. A design variance is used for projects using state aid funds. Approval requires appropriate justification and documentation that concerns for safety, durability and economy of maintenance have been met.

Vehicular traffic – The passage of automobiles and trucks along a transportation route.

Waterway adequacy – One of five NBI inspection ratings. This rating appraises a bridge's waterway opening and passage of flow through the bridge, frequency of roadway overtopping, and typical duration of an overtopping event.

Report Summary



Project Background
Project Data
- Location Data
- Related Studies
- Cultural Resource Data

Project Background

Located approximately two miles east of the City of Eureka in St. Louis County, Missouri, along the Historic U.S. Route 66 alignment, the Meramec River U.S. Route 66 Bridge is an example of a Warren deck truss. The Warren deck truss is a rare structural design in Missouri; only four examples remain standing and this bridge is the state's solitary three-span rigid deck truss structure.

Constructed in 1931-1932, the Meramec River U.S. Route 66 Bridge historically transported traffic across the Meramec River at a regionally significant river crossing associated with the original alignment of U.S. Route 66. The bridge connects two pieces of the Missouri Route 66 State Park and provides a critical link to the park's 250,000 annual visitors between the Route 66 Visitor Center (on the east side) and the 419-acre park (on the west side). The west side of the river was the entrance of the former Times Beach community. The park and visitor center are operated by the Missouri Department of Natural Resources (MoDNR).

Because the bridge was constructed to carry traffic on U.S. Route 66, a national historically significant highway, the connection is an important tie to not only Missouri's past, but also the nation's transportation history. The bridge is a critical part of the overall Route 66 experience for tourists and international travelers, as it connects to the only state park dedicated to Route 66 on the Route in the nation.

The bridge also serves as a significant bicycle and pedestrian link for the Meramec Greenway and the City of Eureka trail systems. This link provides a critical connection to thousands of acres of public open space acquired with millions of dollars, some from public funding and some from private fund raising.

MoDOT PROPOSED SCHEDULE

MoDOT reduced weight limit to 15 tons	2005
MoDOT crews made significant bridge repairs	2006
MoDOT reduced weight limit to 10 tons and restricted traffic to one lane	2007
MoDOT reduced weight limit to 5 tons	2009
MoDOT closed bridge completely due to extremely poor condition	October 2009
MoDOT met with consulting parties to try to find new owner	July 2010
MoDOT holds public meeting	September 2010
Add bridge demolition to state transportation improvement plan for July 2012 bid opening	February 2011
Complete another mussel survey (good for a year)	May 2011
Deadline for a new owner with a business plan to take over bridge	February 2012
Plans turned in for demolition	April 2012
Bid letting for demolition	June 2012
Notice to proceed	July 2012
Completion date for contractor to remove bridge	December 2012

Source: Missouri Department of Transportation's Proposed Schedule - July 2010

The Missouri Department of Transportation (MoDOT) owns the bridge, which, when it was open, carried about 2,640 cars a day between the Center and the Park. The Historic U.S. Route 66 Meramec River Bridge, listed on the National Register of Historic Places in 2009, has not experienced any major alterations over the years. However, time has taken its toll on the bridge, and MoDOT made the decision to close it to all traffic in 2009. MoDOT decided it could not invest the money needed to maintain the bridge, since many other major bridges around the region, with higher traffic volumes, continue to need maintenance. MoDOT maintains that if the bridge is not removed in the next several years, it could collapse under its own weight. The bridge is scheduled for demolition in summer of 2012 unless a new owner can be found, and support and monies are raised to show evidence of the public's need and interest in the bridge.

During the planning stages for projects involving federal action, a systematic process is undertaken to identify cultural resources within the project area, analyze the project's potential to impact them, and determine what action will be taken to eliminate or mitigate any identified impacts. This process is commonly referred to as "Section 106," after the portion of the National Historic Preservation Act (1966), which requires agencies to take into account the effects of their actions on historic properties.

Because this bridge is on the National Historic Register, MoDOT is mandated by law to go through the historic preservation process, referred to as the Section 106, to determine if another group or agency will be willing to accept the ownership, liability and costs for maintaining the Meramec River U.S. Route 66 Bridge. Figure 1 above shows the schedule MoDOT presented in July 2010 and has been following for the Section 106

process. Nearly twenty individuals or organizations indicated in writing that they have a demonstrated interest in the Section 106 undertaking, or concern regarding the undertaking's impact on the historic bridge. As defined in *The Regulations of the Advisory Council On Historic Preservation 36CFR Part 800*, the term "consulting party" identifies a person or organization that may become involved in the planning process of a federal undertaking. A federal undertaking can be a project that contains any type of federal involvement including assistance, permit or license.

According to MoDOT's website, "In addressing historic bridges in Missouri, the term "bridges" collectively refers to both public and privately owned highway, railroad, and pedestrian bridges, viaducts, and culverts. Historic bridges are listed in or eligible for listing in the National Register of Historic Places (NRHP). Because they are in the public right of way, MoDOT is responsible for identifying and managing historic bridges associated with highway projects.

In 1996, Missouri historic bridges were inventoried and evaluated statewide. The Surface Transportation and Uniform Relocation Assistance Act of 1987 (STURAA) directed all states to inventory their historic bridges. There are about 24,000 bridges in the State of Missouri (this includes state, county, and city-owned bridges). The 1996 Missouri Historic Bridge Inventory survey evaluated approximately 11,000 constructed prior to 1951. Of these, 399 were identified as listed in, or potentially eligible for listing in the NRHP. The results of the inventory, with some modifications, became what is known as the Missouri Historic Bridge List (MHB List). It contains about 25 types of structures including a variety of metal pony trusses and through trusses, wooden trusses, concrete arches and rigid frames, stone arches, etc. All were built between 1858 to 1954.

Bridges not on the MHB List are evaluated for NRHP eligibility in consultation with the State Historic Preservation Office (SHPO). Through the Section 106 process, a project can have "no effect", "no adverse effect" or an "adverse effect" on a historic bridge.

An adverse effect occurs when a project would harm a historic bridge's ability to convey its historic significance. Examples of adverse effects include demolition, removal from the original location, removal or alteration of original bridge parts, and introduction of new elements that diminish the bridge's significant historic features.

If a project is determined to have an adverse effect on an historic bridge, efforts must be made to minimize the effects through redesign of the project. If an adverse effect cannot be avoided, a Memorandum of Agreement is negotiated outlining measures to mitigate the effects of the project on the resource.

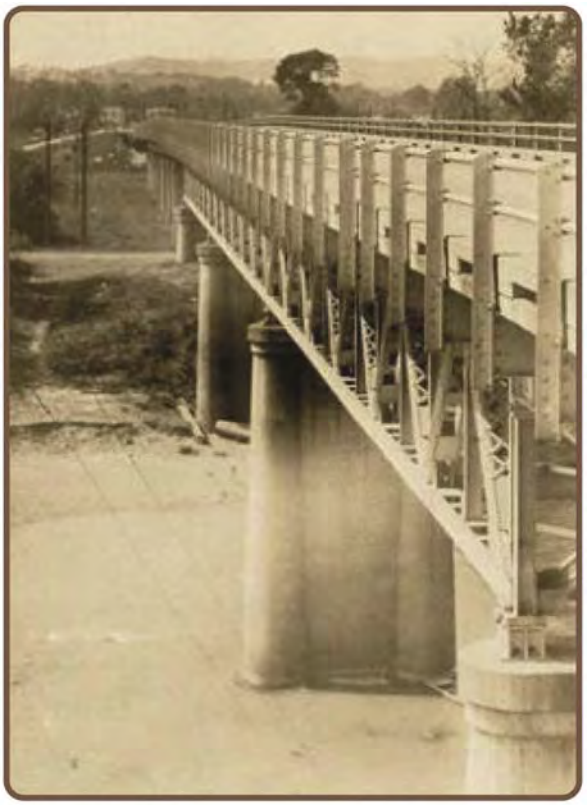
Mitigation typically includes archival photographs, and preparation of a thorough history and detailed written description, which are then archived at the state or national level depending upon the range of significance. Mitigation also may include marketing and advertisement for adaptive

reuse at the existing location or at a new location, dismantling and storing the bridge for future use on another site, salvaging important historical components of the bridge for reuse as educational or interpretive materials, or reusing salvaged components on similar historic bridges in need of rehabilitation.

Missouri Department of Natural Resources (MoDNR) State Parks Division owns and operates the Route 66 State Park and Visitors Center which is located on either end of the bridge. While MoDNR has indicated their support for the preservation of the bridge, the agency is reluctant to assume ownership citing a lack of expertise in bridges and decline in funds to care for state parks. MoDNR has participated in all of the Section 106 Consulting Party meetings and has written letters of support for the two sucessful grants received for bridge preservation efforts.

MoDOT and MoDNR, and the Section 106 Consulting Parties, as well as members of the public recognize the significant historical contribution that the Meramec River U.S. Route 66 Bridge makes to the State and Nation with regard to Route 66 history. The significance to the region in terms of the important connection over the river to the thousands of acres of public open space, and the regional multi-modal transportation network that serves locals as well as tourists is also apparent.

It is also recognized that the Warren deck truss bridge is a rare structural design in



Source: Joe Sonderman

Missouri. Out of the ten constructed in the state, only four examples remain standing. The Meramec River U.S. Route 66 Bridge is the state's solitary three-span rigid deck truss structure and the only Warren deck truss bridge left in the state that has not been rebuilt.

Many things are known about this bridge, what is not known is who will take temporary or permanent ownership to save this treasure or whether it will become a part of the past.

Project Data

Location Data

Bridge Name:
Meramec River U.S. 66 Bridge

Bridge Location:
Historic U.S. Route 66 (1932 alignment) spanning the Meramec River

MoDOT Bridge:
J-0421

Related Studies

Cassity, Michael. "Route 66 Corridor National Historic Context Study".

Foley, Terri and Keenoy, Ruth. *Route 66 in Missouri. National Register of Historic Places Multiple Property Documentation Form*. National Park Service. April 2008.

Jones, Spencer and Jackson, Jerany, "Missouri Route 66 Corridor Management Plan". January 2012.

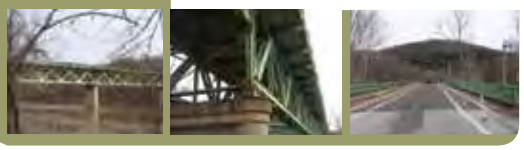
Snider, Ph.D., Becky L., and Debbie Sheals. *Route 66 In Missouri - Survey and National Register Project*. Rep. 2003. Print.

Cultural Resource Data

National Register of Historic Places: The Meramec River U.S. 66 Bridge was listed in the National Register of Historic Places on September 16, 2009.

Period of Significance: The Period of Significance for the Meramec River U.S. 66 Bridge begins in 1931 - 1956, when construction was completed. The Period of Significance relates to the bridge's era of construction and use as the sole Route 66 Meramec River crossing from 1931 to 1956. With regard to the National Register of Historic Places, the level of significance for the bridge is statewide in relation to its design, which is uncommon in Missouri and as an intrinsic resource to the state Byway. However, the bridge is significant to Route 66 as an intrinsic resource nation-wide in the greater context of Route 66 as it travels across the country and internationally with regard to its importance as an intrinsic resource to historical Route 66.

Part 1
Developmental History



Historical Background and Context
Evaluation of Significance
Physical Description
Description of Current Conditions
Structural Evaluation

Historical Background and Context

The historical background of the Meramec River U.S. 66 Bridge has been well documented in the National Register of Historic Places nomination form. A copy of the nomination form is included as an appendix to this report. This section does not repeat the entire history, but includes a summary of that work. Footnoting will not be provided for the following information.

Source: Missouri State Archives

The history of the Meramec River U.S. 66 Bridge is strongly associated with the development of modern highways and bridges in the United States. The state's bridge building history roughly parallels what occurred nationally. Historically, bridge builders adapted techniques used by earlier builders. Throughout the United States and Europe, modern bridge building was heavily influenced by 19th century railroad companies. Materials and design were crucial in developing early railroad bridges. In the United States, the most common building material for railroad bridges was wood. It was less expensive and more available than stone. Most American railroads continued to use wood even when iron became available. This was true in Missouri as well. Missouri did not begin using iron and steel until the late 19th century. This delay came in part from the fact that the Civil War began at about the same time as the state began to build railroads. The War caused many projects to be delayed and some were abandoned. Additionally, the state's two primary rivers – the Mississippi and the Missouri – required technological advances for bridges that did not occur until the mid-to-late 19th century.

The world's first railroad bridge – Causey Arch Bridge in County Durham, England – was constructed of stone in 1720 to support horse-drawn coal wagons. Later it supported steam locomotives and was the example that most subsequent bridge builders followed. In the 1820s, Stephenson, Brunel and Locke designed railroad bridges. The best known of these is the Royal Border Bridge – a stone viaduct across the River Tweed that

separates Scotland and England. That bridge (still standing) was completed in 1849. It is a semi-circular arched masonry and wood structure spanning approximately 2,162 feet. Railroad builders continued to use brick and stone for railroad bridges in Europe until the mid-19th century when cast-iron became available. Timber remained the primary choice for most American bridge builders until the late 19th century due to its abundance and affordability.

Cast-iron provided tension strength unmatched by timber – a critical factor in railroad bridges with long spans. The tension strength of wrought-iron was even greater than cast-iron. However, because wrought-iron was nearly twice as expensive as cast-iron, it was usually used in conjunction with other materials such as cast-iron and wood. Iron bridges began to appear in America after 1830 – although they had been successfully introduced by the 1780s. The world's first iron bridge was constructed in 1778 by Thomas Farnolls Pritchard across the River Severn in Shropshire County, England. The bridge remains standing today. The first iron bridge in the United States, Dunlap's Creek Bridge, was constructed in 1838 on the National Road in Brownsville, Pennsylvania. The designer, Richard Delafield, used iron because it was permanent (not wood) and was the most efficient in terms of cost and durability. The bridge still stands today.

Iron bridges relied on the use of pins and trusses, which made the bridges easier to assemble, were lighter than stone and wood, and were able to support heavier loads. In America, the most popular form of iron bridge was the truss bridge. Truss bridges are supported by triangular placement of beams which make the roadbed stiff and strong. Suspension bridges provide support from above the roadbed and arched bridges provide support from below the roadbed. Truss bridges, on the other hand, rely on a long, straight, horizontal chord at the top and bottom of the bridge. The chords are connected by a web of vertical posts and diagonals, serving to create the central part of the trusses. Support is also provided by abutments at either end of the bridge, and in some cases by central piers. Iron served extremely well in constructing truss bridges and thousands were constructed across the country during the mid-to-late 19th century. Less than 100 iron bridges remain standing in the United States today.

Source: Illustrated Pamplet of Wrought Iron Bridges, 1882

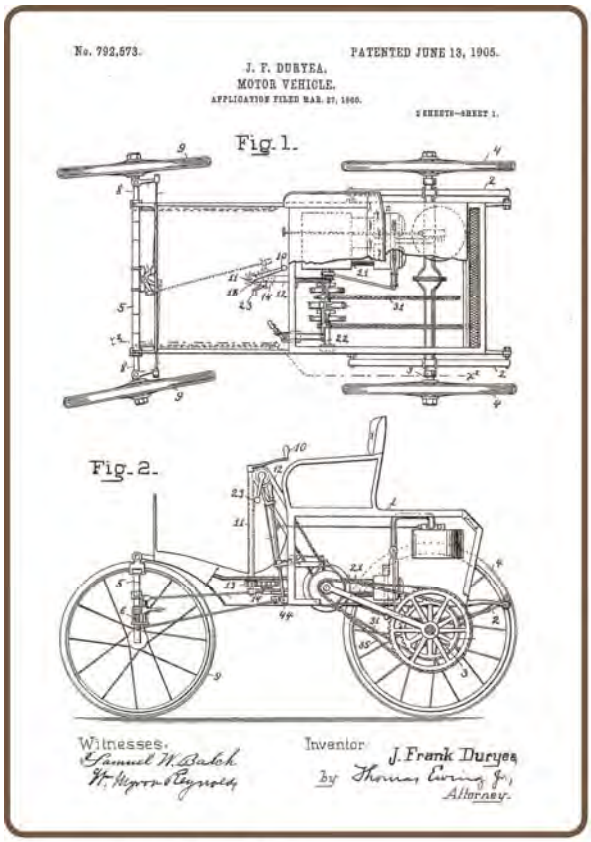
Advances in bridge designs during the 19th century most often focused on truss patterns. Truss patterns evolved rapidly after metal bridges came into fashion. Many designs were innovative and durable and worked well for railroad and automobile bridges.

Every builder tried to devise 'the' truss that would be economical, simple to construct and viable for longer lengths. The Civil War and the advent of railroads in Missouri had a far-reaching effect on the development of roads and bridges. Railroads became the leading factors in long distance travel, motivating bridge construction in Missouri. Railroads finally triggered the construction of bridges over the Mississippi and Missouri rivers – rivers that had previously limited travel in the state.

Missouri's landscape is largely dominated by its rivers. The nation's second largest river, the Mississippi, runs along the eastern edge of the state and extends some 2,300 miles in length from its headwaters in Minnesota to the Gulf of Mexico. The Mississippi is widest at its confluence with the Missouri River just north of St. Louis, Missouri. The size and flooding associated with the river system prevented bridge construction until well into the late 19th century. Few bridges constructed prior to 1850 still exist.

The first Mississippi River railroad bridge was completed in 1854, linking Rock Island, Illinois and Davenport, Iowa. A number of other projects were constructed on the Mississippi – completed after the Civil War. One of Missouri's earliest railroad bridges on the Mississippi was constructed in 1868-71 at Hannibal. A number of other bridges were constructed across the Mississippi by 1874. The nation's first "all-steel bridge" was constructed in 1879 in Glasgow, Missouri, across the Missouri River. Steel had several important advantages over iron. Steel could be shaped in any way without reducing its strength and it was much lighter than iron, which made it adaptable to nearly every design. By the beginning of the twentieth century, steel had become the material of choice for bridge construction.

The advent of the automobile in Missouri (and the nation) began the change from railroad construction to the construction of roads and bridges aimed to serve the automobile. Until the advent of the


No. 792,573. PATENTED JUNE 13, 1905.
J. F. DURYEA.
MOTOR VEHICLE.
APPLICATION FILED MAR. 27, 1900.
2 SHEETS—SHEET 1.
Fig. 1.
Fig. 2.
Witnesses:
Inventor
J. Frank Duryea
by Thomas Ewing Jr.
Attorney.

Source: Missouri State Archives

automobile, few improvements were made to the state's roads and bridges, except for those serving the railroad. This was due largely to the shortage of funds for these improvements. Local governments were primarily responsible for the construction and maintenance of roads and bridges. This began to change with the nation's Good Roads Movement, sparked by automobile and bicycle enthusiasts during the late 19th century. Missouri's Good Road advocates were instrumental in gaining political support for laws that improved the state's funding for road and highway bridge construction.

Automobiles were introduced to Missouri around the turn of the century. St. Louis was one of the nation's few cities that had a network of paved roads, which made the state an early center of automobile development. Missouri's roads were improved after 1900, but by 1920 less than ten percent were paved. Changes in the states legislation during the early 1900s slowly switched the funding responsibility for building roads solely from the local communities to the state.

The Federal government also began planning a transportation network that would link states via existing and new roads. The Federal Highways Act of 1916 was the first legislation to provide federal assistance for interstate roads. Missouri's Hawes Act of 1917 assisted the federal funding. Missouri was therefore able to modernize existing roads, survey new routes and standardize highways. This included permanent road and bridge work and the implementation of new bridge design.

Through the state and federal funds received for roads during the 1920s, Missouri was able to create a network of state roads and support one of the most important national highways, U.S. Route 66. Designated as a federal highway in 1926, Route 66 in Missouri was possible in large part because of the state's modern bridges that linked the road across the state.

The Meramec River U.S. 66 Bridge – J-0421 was constructed in 1931-32 to serve the needs of Route 66. The structure spans a large body of water that although secondary in size to the Mississippi and Missouri Rivers, was no less problematic for bridge builders. Earlier bridges had been constructed across the Meramec near Eureka prior to 1931; but the Meramec River Bridge was the first specifically designed for automobiles.

U.S. Route 66 was heavily promoted as a tourist attraction. However, the lower Meramec River was already a well-known resort area with established hotels and commercial activities attracting visitors from the St. Louis area and beyond – originally by train and later by automobile. The area, specifically the community of Times Beach, grew into a permanent community when the improvements of roads and cars made commuting more practical combined with a shortage of housing in St. Louis. Route 66 and the Meramec River Bridge enhanced the growth of the area.

The Meramec River U.S. 66 Bridge was constructed by the Frazier-Davis Construction Company which was established in 1917 by Adrian W. Frazier and Edward C. Davis. The firm specialized in heavy industrial construction work, with projects in many parts of the United States. The Illinois Steel Company of Chicago produced the steel components used in assembling the bridge.

The bridge incorporates a rigid-connected Warren truss deck design. Deck trusses like that used in the Meramec River Bridge were infrequently used in Missouri because the state's waterways are flat and often do not provide sufficient clearance for water traffic below the deck trusses. In Missouri, most deck truss bridges were constructed during the 1920s and early 1930's. All were designed by the state highway department and only where under-truss clearance was not an issue. Out of the ten originally constructed, only four rigid connected Warren deck truss bridges still exist in Missouri and the Meramec is the only one that has not been reconstructed. The Meramec River Bridge is the only three-span deck truss in the state.

Source: Joe Sonderman

In 1956, the state initiated construction on Interstate-44 (I-44), which currently passes south of the 1931 Meramec River Bridge. Route 66 reached its zenith during the early 1950s. By this time, state and federal agencies had identified the road as extremely dangerous due to its narrow width, lack of federal safety standards and rapid deterioration due to constant and heavy traffic. By the late 1960s, I-44 was nearly complete in Missouri, and the state began to decommission sections of Route 66 as the interstate opened. In 1956 new lanes were constructed to carry eastbound traffic. The bridge continued to carry west bound traffic until 1970 when new westbound lanes for I-44 were completed. Nationally, Route 66 was officially decommissioned in 1985; local sections were often decommissioned

incrementally as sections of I-44 opened. The bridge remained open and in use for local traffic serving the community of Times Beach, accessible via an interchange linking Route 66 with I-44. According to Karen L. Daniels in the document she prepared for MoDOT, "Historic Documentation, Bridge J-0421, Meramec River Bridge", May 2011, it served that purpose until 1983 when the community was declared a hazardous waste site and quarantined for cleanup." Today, the bridge is closed to all traffic, but remains within the boundaries of Route 66 State Park, which opened in 1999. The park on the west side of the river is located on land which was previously occupied by the community of Times Beach, a town destroyed by an environmental hazard, which was purchased by the state, completely removed and cleaned of hazardous waste.

The Meramec River separates the state park visitor center, located on the east side of the bridge, from the bulk of the park, which borders the western side of the bridge. The 419 acre-park interprets and showcases the surrounding environment and portions of Route 66 within its boundaries, including the bridge one of only three Route 66 artifacts left in the park. The state park is the only state park on the entire national road named for Route 66. Attendance at the Route 66 State Park is approximately 250,000 visitors annually. The Meramec River Bridge is an exemplary component of Route 66 and one of the state's best examples of its unique deck truss design.

On October 29, 2009, the Meramec River U.S. 66 Bridge was closed to all traffic by MoDOT due to safety considerations that the agency had. MoDOT made the decision that the department could not invest the money needed to maintain the bridge, as many other major bridges around the region, with higher traffic volumes, continue to need routine maintenance and repairs, and that this route did not provide system connectivity with the highway network.

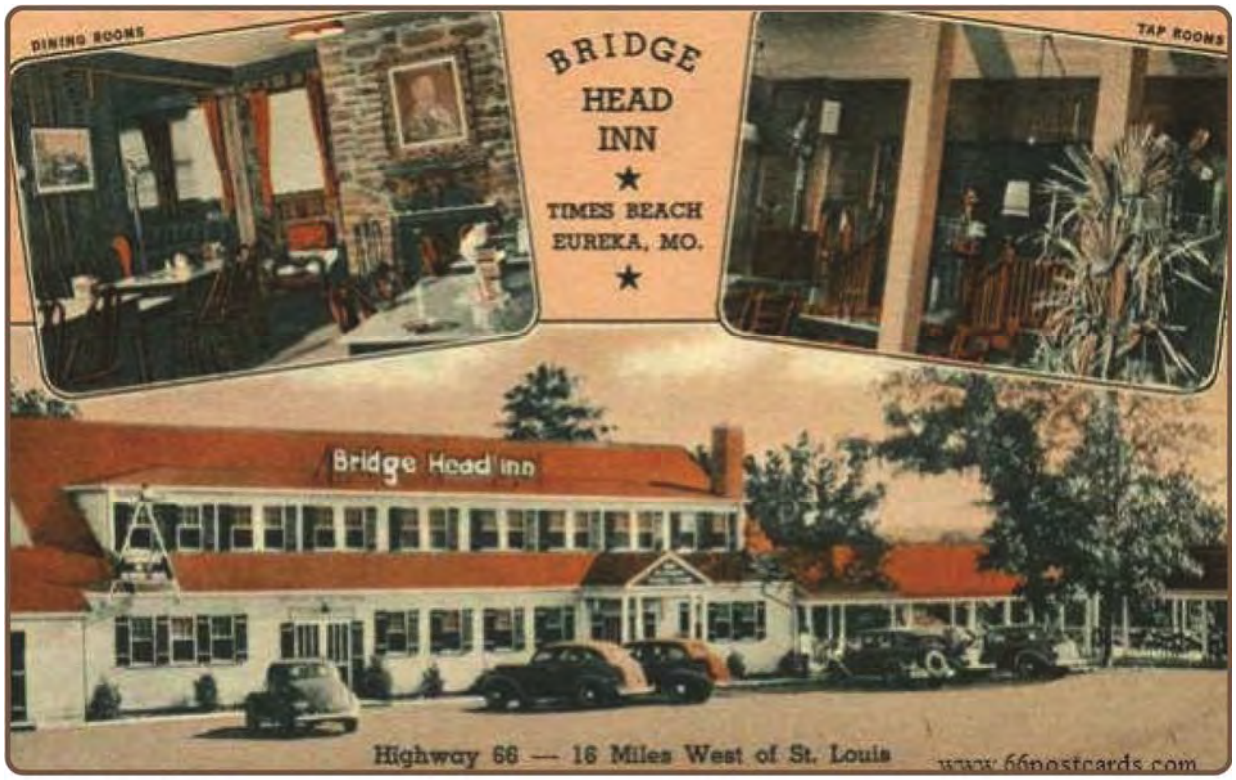
Evaluation of Significance

The Meramec River U.S. Route 66 Bridge was listed on the National Register of Historic Places in 2009. The bridge serves as a key feature in the history of Route 66 nationally, although its significance relating to the National Register nomination is identified as being of statewide significance. The bridge was nominated under the Multiple Property Documentation Form (MPDF) entitled "Route 66 in Missouri." Ruth Keenoy, a Landmarks of St. Louis staff member and key project team member, co-wrote the National Register nomination for the bridge and the Route 66 MPDF (Missouri) along with Terri Foley, a historic preservation consultant.

The Missouri State Historic Preservation Office has been involved in identifying the bridge as a significant historical property for years. Mark Miles, Director, supervised the identification and nomination of the bridge to the National Register of Historic Places, and the resource was identified in a 1996 statewide bridge inventory as eligible for the National Register. The bridge's significance relates to its design and construction (Criterion C of the National Register of Historic Places). It is a rare property type in Missouri with only ten rigid-constructed Warren deck truss bridges constructed statewide. Only four extant examples are still standing, including the Meramec River U.S. Route 66 Bridge. Additionally, the bridge's significance relates to Route 66 (Criterion A of the National Register of Historic Places). It was the first automobile bridge to span the Meramec River in Missouri and it was designed specifically for the highway which served as a federal transportation route prior to the interstate system.

U.S. Route 66 in Missouri passed through portions of St. Louis, Franklin, Crawford, Phelps, Pulaski, Laclede, Webster, Greene, Lawrence, and Jasper Counties (northeast to southwest), roughly following the Old Wire Road and the St. Louis-San Francisco

Railroad. The Old Wire Road was designated as a "preliminary" national highway as early as 1916 in relation to the Federal-Aid Road Act in which Congress appropriated $75 million per year for federal road construction/improvements. By 1921, U.S. Route 66 was paved in St. Louis and Franklin Counties. Further west, U.S. Route 66 from Springfield to Joplin was paved early on with concrete (by 1922) and considered one of the best sections of the road. In early 1928, Rolla and Springfield newspapers indicated that plans were underway to pave all of U.S. Route 66 (in Missouri) with concrete by 1930. Culmination of the completion of U.S. Route 66 in Missouri is closely tied to the construction of the bridge spanning the Meramec River. The road's final paved section was completed in 1931 – 72 miles between Rolla and Springfield. The Meramec River U.S. Route 66 Bridge was under construction in that year and was completed in 1932.



Source: Joe Sonderman

Physical Description

The Meramec River Bridge is a steel rigid-connected Warren deck truss bridge resting on reinforced concrete abutments and reinforced concrete piers/bents. The bridge is 1008 feet in length and consists of three 130-foot truss spans. The Warren truss design features vertical web members that create equilateral triangles. The bridge's diagonal truss members create a series of alternating "V" and "A" shapes that extend the length of the truss. The bridge is reinforced with concrete abutments, wingwalls, and piers with bullnosed cutwaters. Automobiles travel along the roadbed extending above the deck truss that is additionally supported by the bridge's horizontal chords.

Superstructure

The Meramec River Bridge superstructure is comprised of the components that span the Meramec River. This segment of the bridge carries the traffic load and distributes the load to the substructure. The superstructure of the Meramec River Bridge includes the following components:

Bridge deck – the roadway section of the Meramec River Bridge is 30 feet wide including shoulders. The bridge deck is constructed of reinforced concrete (concrete with steel bars for increased tensile strength). The bridge deck conforms to the grade of the approach roadway, so there was no bump or dip as traffic passed on and off of the bridge. Its total length is 1008 feet.

Structural members – for the approach spans, the bridge deck is supported by steel plate girders (beams aligned with the length of the spans that support the deck). For the main spans, the bridge is supported by steel deck trusses. A truss is a frame of members that creates tension (pulling force which tends to lengthen a member) and compression (pushing force which tends to shorten a member) that support the bridge load. Used in the same way as a beam, consisting of several smaller members that can be constructed longer and/or deeper than beams or girders.

Railing – these are the steel bridge angle pipe guardrails and pipe handrails. Total footage of handrails and railings for the Meramec River Bridge was 4,052 feet.

Substructure

The substructure of the Meramec River Bridge includes the abutments, piers, and footings that support the superstructure. The bridge's substructure has concrete bents (a traverse frame designed to support either vertical or horizontal loads) on piling and concrete piers.

Abutments – the element of the bridge supports the extreme ends of the Meramec River Bridge and restricts the approach embankment, thus permitting the embankment to be built up to grade with the bridge deck. The Meramec River Bridge features concrete abutments.

Piers – the Meramec River Bridge is supported by concrete piers. The piers are located between abutments to support the ends of the multi-span superstructure.

Bents – the concrete bents of the Meramec River Bridge comprise a frame made of reinforced concrete that supports the vertical load and is placed transverse to the length of the bridge structure. The bents are used to carry the load of the beams and girders.

Piling or Pile – the bridge has concrete pilings, a long column driven deep into the ground to form a component of the foundation or substructure. The bent is located at the top of the piling.

Footing – the Meramec River Bridge has concrete footings that rest directly on the soil and bedrock; usually footings are located below grade and are not visible.

Wingwalls – the concrete wingwalls of the Meramec River Bridge were designed to be an extension of the abutment and are used to contain the fill of the approach embankment.

The Meramec River U.S. 66 Bridge is well preserved and has not experienced any alterations, although it has fallen into disrepair. The bridge is a rare and intact example of the rigid-connected Warren Deck Truss and one of the four that remain in Missouri. All of the structural elements and features specific to this design exist in the Meramec River Bridge and are unchanged. The bridge retains its distinctive truss configuration and all of its vital components of design, workmanship and materials. It appears substantially as it did when it was completed in 1932, when it served as an important Meramec River crossing for U.S. Route 66.

Description of Current Conditions

General Structure Information

Owner:	MoDOT
Bridge Name:	Meramec River U.S. 66 Bridge
Bridge Location:	Route 66 State Park, Eureka, Missouri
Bridge #:	J-0421
Construction Date:	1931
On the NBIS:	Yes
Feature Crossed:	Meramec River
Facility Carried:	Outer Road of Route 44 E
Length:	1,008 feet
Number of Spans:	12
Main Structure Type:	Truss-Deck
Maximum Span Length:	131 feet
Deck Width:	Curb-Curb: 29 feet, 10 inches Out-Out: 31 feet, 5 inches
Structure Status:	Closed
Sufficiency Rating:	36.6
Load Posting:	NA (Closed)
Deficiency Rating:	Structural
Appraisal Rating:	
Structural Evaluation	0
Approach Road	7
Deck Geometry	4
Underclearance	N
Waterway Adequacy	8
Scour Assessment	3
Condition Rating Information:	
Deck Condition	5
Superstructure	3
Substructure	3
Channel	5
Date of last Inspection:	July 2009

- Definitions for some of the terminology can be found in the Glossary.

Modifications and Dates

No significant modifications have been made to the Meramec River U.S. 66 Bridge since construction was completed in 1931. Repairs have been made to the substructure, and some modifications to the floor beams due to deterioration.

Current Conditions

Available information was reviewed prior to assessing the options for preservation of the Meramec River U.S. 66 Bridge and visiting the bridge site. Available information, cited in the Project Introduction section of this Report was reviewed to develop a baseline for analysis. Additionally, a site visit was conducted to observe the following:

1. General condition of structural members

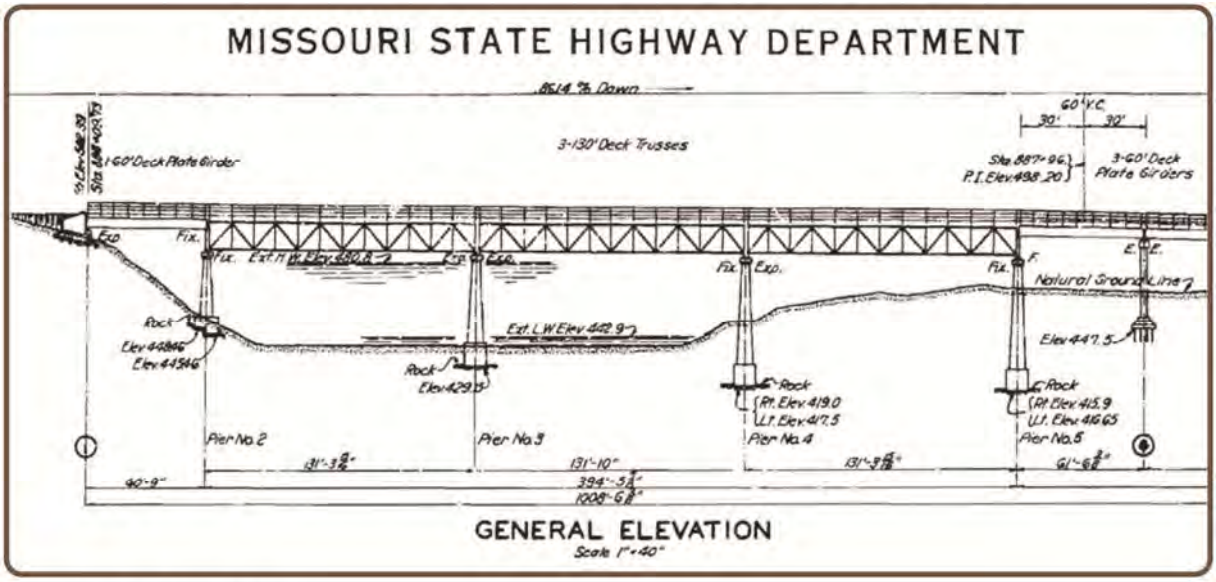
2. Conformity of structure to available plans

3. Roadway geometry and alignment

4. Bridge geometry

Review of Inspection Data

The bridge consists of 12 spans with the eastern approach being a two girder system. The main superstructure is a three span continuous deck truss, with the west approach being a series of eight, two girder system. With the two girder system and the truss system, the bridge is considered a fracture critical structure. The bridge has received numerous inspections by its current owner, the Missouri Department of



Source: MoDOT Bridge Division

Transportation (MoDOT), and during these inspections, the condition of the bridge was determined to be deteriorated to a point that the bridge was closed in the fall of 2009.

After the collapse of the I-35 Bridge in Minneapolis in August of 2007, specific attention was given to the inspection of gusset plates for truss bridges. The Meramec River Bridge received a Comprehensive and Fracture Critical Bridge Inspection by MoDOT from July 29 to August 12, 2009. This inspection was an all inclusive inspection that included a general inspection, a fracture critical inspection and an in-depth inspection, and a gusset plate inventory inspection. The inspection procedures involved performing ground level and roadway level visual observations, soundings of the substructure and the utilization of a snooper truck to access the areas not accessible from the ground. The soundings of the substructure units were to record the extent of delimitation and potential repairs. A log sheet was kept to quantify these repairs. The fracture critical members were inspected at "arms length" for the total surface of each member. Cracks or section loss were noted as observed. Additionally, the gusset plates were measured to verify thickness and document section loss. At these locations, a minimum of four measurements were taken with an ultrasonic type device. When section loss was encountered, additional readings were required to be taken to adequately document the amount of section loss. Likewise, section losses in fracture critical members were also verified by ultrasonic means. Portions of this inspection are summarized below.

General Inspection Findings (from MoDOT's inspection log)**:**

Superstructure:

Deck - Heavy spalling at the underside of the deck joints is common at most bents and piers along the floor beams. There is extensive exposure of the reinforcing steel at these locations. The deck is delaminated and general water saturation is evident throughout.

Span 1 (Plate girder system) - No deficiencies were noted on the two girder system. The first four or five floor beams are twisted on the outside. Three or four floor beams were found to have cracks in the top of the floor beams, where the knee braces are located above the girder.

Span 2, 3, and 4 (Deck Truss):

The main observation in the truss members is the section loss that was primarily located at the ends of the truss. The section loss averages between 35% and 45% at these locations. It was also noted that the gusset plates at the lower chord interface showed some section loss as well. The vertical end posts have holes either at the top or bottom of the post. Heavy rusting and section loss was observed at the lateral bracing at the deck truss ends. Other random areas with much less section loss occurs in other areas of the lower chord.

Spans 5 thru 12 (Plate girder system)

The western span's conditions were similar to the eastern approach. No deficiencies were noted on the two girder system. The issue, again, was the condition of the floor beams.

Bearings:

The bearings for the truss and some of the plate girder bearings are in need of maintenance and repairs.

Substructure:

The east abutment and the main river piers were found to be in sound condition, with random cracks. The Pier 2 footing is exposed at the ground line and would need protection measures against scour. The western intermediate bents and abutment have the greatest amount of deterioration. Many of these have had repair work in the past. Column deterioration is now the predominate deterioration. Some of these locations have exposed reinforcing steel which show signs of corrosion.

Bank and Channel:

An underwater inspection of the footings was conducted in July 2006. No significant findings were noted. Due to the Pier 2 footing being on rock and exposed, the pier requires field review after extreme flood conditions to ensure that undermining has not occurred. No undermining has been reported to date at the Pier. As additional information regarding bridge scour, the U.S. Geological Survey conducted a Level II

Bridge Scour Analysis for the Meramec River U.S. 66 Bridge in 2002. From this analysis, it was computed that the 100-year storm event would cause moderate exposure of the bent and footing piers.

Expansion Devices:

The expansion devices and open joints in the deck are in poor condition and are in need of repair and/or replacement.

Paint Condition:

The paint is chalking and fading throughout, and there is widespread peeling of the topcoat. There are also areas of paint failure down to bare steel. While some areas are experiencing heavy rusting, the average degree of rust places it in "fair" condition.

Bridge Railing:

The bridge railing consists of a double steel pipe system. The pipe rail is disengaged at span 3 on the left side.

Conclusion

Over the years, constant use and inconsistent maintenance have left the Meramec River U.S. 66 Bridge in need of repair. In general, the main deficiencies noted are primarily the result of water damage, corrosion of steel members. Also of general note, the lack of protective coating, paint, is both a real and a perceived deficiency, more so than the other elements, primarily as the result of lack of maintenance.

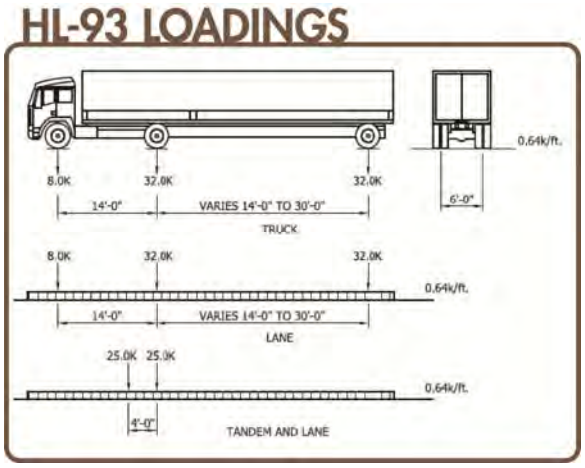
The purpose and goal of this Historic Structure Report is the preservation and maintenance of the Meramec River U.S. 66 Bridge. The best solution to address routine maintenance issues, and the more critical deficiencies is by following the guidelines developed by the Secretary of the Interior Standards included in Appendix A. And, the main issues identified here have been appropriately addressed through preservation recommendations made by the Great River Association Consultant Team in the Alternatives Section of this document. The outline below provides an overview of the step taken to get to this point, and the order by which the remaining task will be accomplished.

Historic Bridge Task List

STEP	ACTION
1	**Develop statement of historic significance**
2	**The Bridge Team will review available construction plans and review records**
3	**Perform structural analysis for intended use**
4	**Perform a site visit to confirm or establish the following:** • Confirm condition of structural members • Take photographs as needed • Assess safety, geometry and clearances
5	**Preliminary cost estimates for preservation options**
6	**Prepare a report on findings** • Statement of historic significance • Preservation options • Cost estimates • Funding options

Structural Evaluation

In an effort to determine the structural performance of the Meramec River U.S. Route 66 Bridge, the decision was made to analyze the structure in accordance with today's design standards. This approach would take advantage of the present methodology in bridge design, and therefore, could be used to assess its capacity in regards to current and anticipated future loading conditions. This is the customary standard of practice to which new bridges are designed. The computational data presented in this report was prepared by analyzing the Meramec River U.S. Route 66 Bridge superstructure against the modern American Association State Highway Transportation Officials (AASHTO) Load Resistance Factor Design (LRFD) Bridge Design Specifications. This design reviewed a vehicle loading of HL-93. HL-93 loading is a notional representation of shear and moment produced by a group of above-legal limit vehicles routinely permitted on the highways in various states. It is called notional because it is not intended to represent any particular truck, but produces the same extreme load effects as the above-legal limit vehicles.



Furthermore, the LRFD design approach uses this notional traffic loading in combination with other load effects each of which are factored (either up or down) according to likelihood of simultaneous occurrence and their relative variability. This produces various loading combinations which recognize that the maximum effects of all transient loads considered will not be observed at any given moment, while maintaining a uniform reliability.

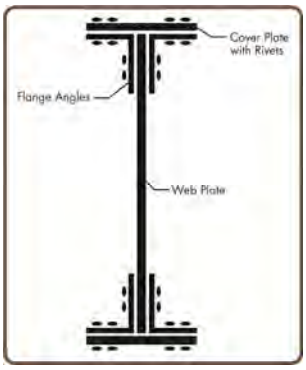
Similarly, the theoretical ability of members to resist the design load effects is factored (always reduced) to account for unavoidable variations in materials, design equations, fabrication, and erection. The degree of the reduction factor is dependent upon variability in testing data.

The load and resistance factors have been calibrated by trial designs to provide a high, uniform level of safety in new bridges, expressed by a reliability index. LRFD

provides a reliability index of about 3.5 for different types and for different configurations of bridges. This ensures that only 2 out of 10,000 design elements or components will have the sum of the factored loads greater than the factored resistance during the design life of the structure. Using this standard to evaluate historic bridges can be challenging.

One of the challenges was interpreting of the available construction documents. Digital scans rendered from microfiche images of the original hand drafted contract plans proved to be difficult to read in some instances, particularly with regard to reading fractional dimensions. Scans of the shop drawings provided a second source of information, but presented similar interpretation difficulties. In order to obtain the most accurate information possible, three experienced professionals performed independent reviews of both sets of documents to extract the information for use in the analysis.

A second challenge commonly encountered with the analysis of historic bridges is in the application of the AASHTO Specifications to the bridge. The construction techniques, materials, and configurations used on the Meramec River Bridge vary significantly from today's modern bridges. As a result, in some instances, the LRFD specifications contain provisions which are not directly applicable to the existing bridge. In order to complete the analysis, it was necessary to adapt the application of those provisions using professional judgment and experience.



A notable example would be the Section 6.10 provisions (I-Section Flexural Members). This section of the modern code assumes that plate girders will consist of a top and bottom plate continuously welded to a web plate. The plate girders for the Meramec River U.S. Route 66 Bridge however, consist of multiple top and bottom plates attached to angles which are in turn attached to the web plate. All attachments use rivets in various patterns in lieu of the continuous welding. The plate girders and the truss members where constructed from multiple steel shapes. Due to this multiple component configuration, custom spreadsheets were developed to allow the data to be computed into a format that could be utilized by current modeling software. To assist with the computations, a three dimensional analysis program called RISA 3D was used.

Methodology:

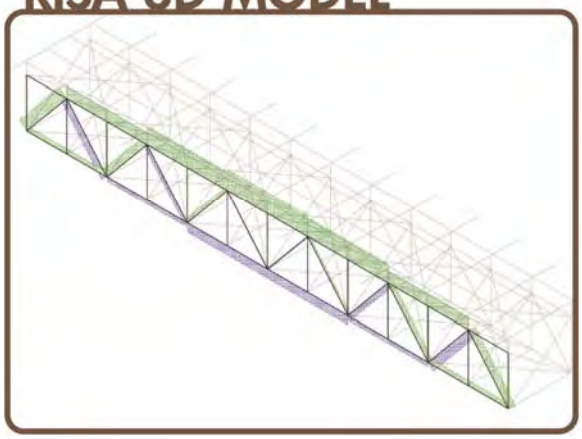
The following approach was used for both the plate girder and truss member analysis.

The first step was to determine the principal structural properties of each built up and

historic member section i.e. strong and weak axis moments of inertia, section modulus, compressive areas etc. This was achieved by a combination of researching historical member property tables and analysis spreadsheets customized for the purpose.

Once the properties were known, a three dimensional model of the various bridge spans was constructed utilizing the RISA 3D program. Within the RISA 3D program, general members were defined by assigning their computed properties. The bridge

RISA 3D MODEL



elements were then assigned dead and live loading in accordance with the AASHTO Specifications. Factored load combinations were developed to determine the response of the bridge span members to the various possible combinations of design lane and design truck/tandem moving loads and pedestrian loads for the Strength I limit state. Other limit states such as Strength III incorporating wind loading, Service I for comparison with deflection criteria, and Fatigue may also be appropriate, but are not covered in the scope of this report.

The applicable maximum resultant forces for each member under each load combination, was computed. The maximum load effects were then input into a custom spreadsheet. The spreadsheet applies applicable effect modifiers for the number of design lanes considered as well as the Average Daily Truck Traffic (ADTT) and then determines what the governing (ultimate) load effect(s) are for all loading conditions considered. Each of the individual bridge members is to be considered in this analysis.

The final step of the analysis process involves using two more customized spreadsheets. One was developed specifically for determining the flexural and shear capacities of the plate girder configurations using the provisions of AASHTO Specification Section 6.10 adapted for the historical member configurations. The other was developed specifically for determining the axial capacities of the truss members using the provisions of AASHTO Specification Sections 6.8 and 6.9. These two spreadsheets also incorporated various general dimension and detail requirement checks as outlined in AASHTO Specification Section 6.7.

Once the ultimate loads and factored resistance for each member is determined, a comparison is made to assess if there is sufficient capacity in the member to resist the applied load. To assist in the evaluation, a safety factor against code minimums is calculated by taking the ratio of resistance capacity to ultimate load for each failure mode considered. Safety factors less than 1.0 would indicate the member does not meet the minimum degree of safety required by code under HL-93 design loading. These Safety Factors are also useful in determining how much deficiency (section loss) can be accepted before failure. A member with a factor of safety of 2.0 can theoretically have a 50% reduction in section before failure is eminent. This conclusion however must be tempered with engineering judgment when determining what the actual acceptable section loss may be.

Summary of Results:

Analysis of As-built Condition:

The results of the analysis performed indicate that the primary superstructure members would perform relatively well under HL-93 loading for Strength I load combinations, provided all deficiencies were fully restored.

In the case of the built up plate girders, shear capacities were found to be adequate, with factors of safety ranging from 1.10 to 2.77. Likewise, flexural capacities of the girders were found to be adequate. The compression flanges were found to perform with a factor of safety ranging from 1.20 to 2.80. The tension flanges were found to perform with a factor of safety ranging from 1.22 to 3.02 for gross section analysis.

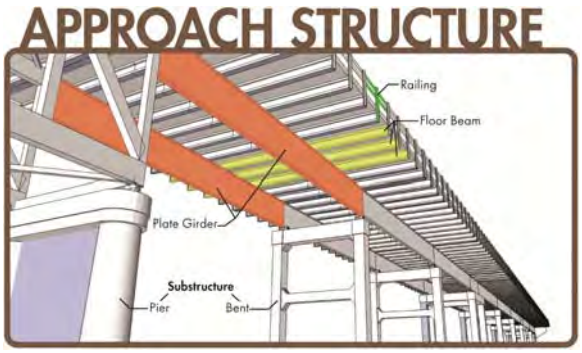
When the tension flanges are analyzed for fracture at the net section, however, two girder sections were found to be inadequate by a small margin. It should be noted that insufficient information about the number, diameters, and spacing of the rivets which attach the flange plates to the girder section is provided in the documentation available. To complete this analysis, several, what are believed to be conservative assumptions were used. Field verification of assumptions used may yield more favorable analysis results.

It should also be noted that all girder sections fail to meet the Web Proportion

limit given in section 6.10.2.1, although the margin is small (4% typically). The AASHTO commentary for this requirement indicates that the requirement was previously not applicable to girders with transverse stiffeners, but is now included so that the requirement in previous Specifications to provide additional transverse stiffeners for handling in girders with more slender webs, beyond those required for shear, is eliminated. Although not investigated, it may be possible to use older AASHTO Specifications to show that the transverse stiffeners provided are sufficient to pass the web slenderness requirements. This finding should not be considered to be significant from an analysis standpoint as the provision is for erect ability only, not for strength.

All other Cross Sectional Proportion Limits required in section 6.10.2 are passed by all girders with one exception. The compression and tension flange proportions required in section 6.10.2.2, equation 1 are exceeded by 3% for the 20 foot span girder section. The AASHTO commentary for this requirement indicates that the purpose for this limit is to ensure that the flange will not distort excessively when welded to the web. As the girder sections are built up using rivet connections, this requirement is not applicable to this bridge.

Similarly, the axial capacities for the main truss members were generally found to be adequate. The margin, however, was small in some instances. Analysis of the compression members indicates performance with factors of safety ranging from 1.01 to 23.89. Most compression members have factors of safety ranging from near 1.10 to 2.00.



Tension member analysis yielded slightly more favorable results. Members were found to have factors of safety ranging from 1.41 to 26.72 with most members performing at a factor of safety between 2.0 and 4.0.

It should be noted that traditional analysis for the truss members was performed considering axial only loads and the member's capacity to resist those loads. The connection detailing used to construct these trusses, will in actuality, induce some fixity into the connections. This in turn will cause the members to have some bending moment in addition to the axial loading. A more detailed final design analysis will be required to determine the extent of this effect and the implications to member capacities to resist the combined effects. However, it is reasonable to infer that those

members having factors of safety near 1.0 for axial effects alone will be shown to be insufficient for the combined effects under the same HL-93 loading. Questionable members could be supplemented with reinforcing to achieve sufficient capacities.

Evaluation of Current Conditions:

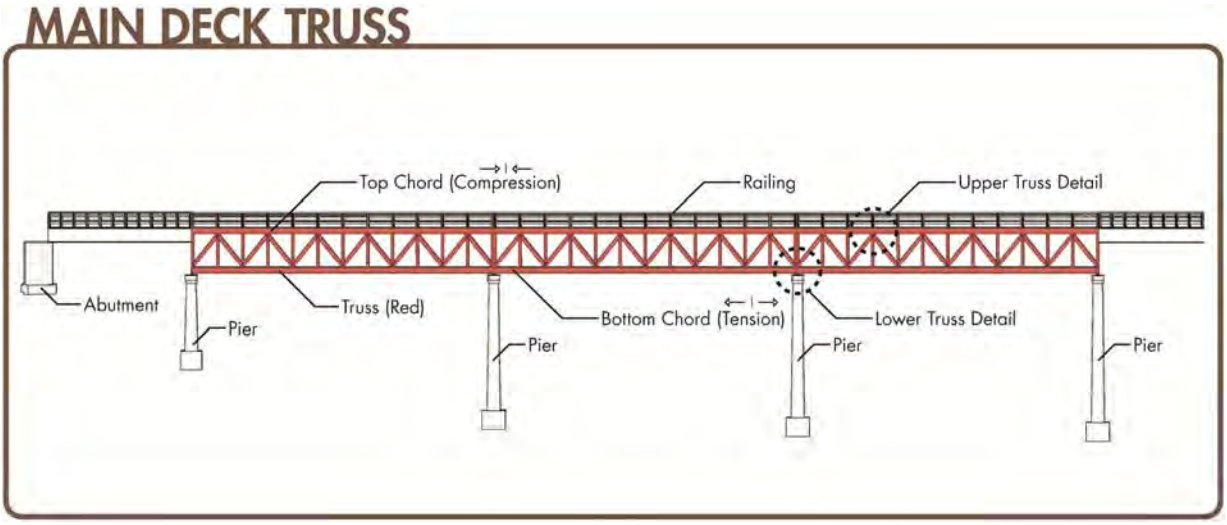
Based upon the information derived from the As-built Condition Model, the current ability of the bridge to support the design loads can be assessed by taking into consideration the effect of section loss and deterioration of the structural elements of the bridge.

Critical members were identified from the As-built Model and the effects of assumed section loss of these members evaluated. Also, the members which had experienced the most significant section loss as identified in the MoDOT inspection reports were also considered.

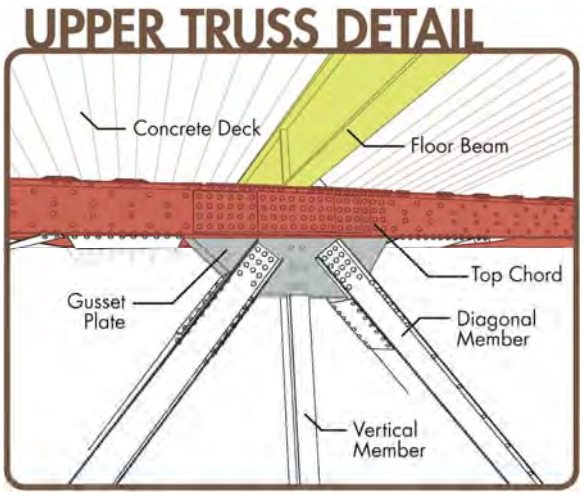
Analysis of the top (compression) chord of a typical truss span, revealed that the critical section would have a theoretical axial compressive capacity of 1046 kips, assuming no deficiencies. The required axial load at this critical member under the AASHTO HL-93 design live load and self weight of the bridge structure itself was found to be 1037 kips (Factor of Safety = 1.01).

If the assumption is made that current and anticipated future deficiencies results in a 10% section loss in this critical section, the available axial compressive capacity drops to 941 kips, while the required axial load remains 1037 kips (Factor of Safety = 0.91). Therefore, this number would need special consideration for the rehabilitation of the bridge.

Alternately, analysis of the bottom (tension) chord of a typical truss span, revealed that the critical section would have a theoretical axial tensile capacity of 1532 kips, assuming no deficiencies. The required axial load at



this critical member was found to be 530 kips (Factor of Safety = 2.89).



If the assumption is made that current and anticipated future deficiencies results in a 45% section loss in this critical section, the available axial tensile capacity drops to 842 kips, while the required axial load remains 530 kips (Factor of Safety = 1.58). This means that in this deteriorated state there is still sufficient capacity to resist the full HL-93 design loading.

Evaluation of the Gusset Plates:

In addition to the primary member analysis of the main deck truss, two gusset plate connections were chosen for an in-depth evaluation. These two connections were selected on the basis of maximum loads in both the webbing and chord members.

To assist in the evaluation, a spreadsheet developed by the Michigan Department of Transportation "Gusset Plate LRFR Analysis V2.2" was used. This spreadsheet is based upon Federal Highway Administration Guidance Documents and AASHTO LRFD Bridge Design Specifications. The spreadsheet performs several checks including resistance of fasteners, gross section yielding, net section fracture, and block shear rupture. A rating factor based upon the AASHTO Strength I load combination is determined for each check. This rating factor compares the capacity of the connection to resist loads to the loads applied. Rating factors of 1 or greater are considered satisfactory.

The geometry input for the spreadsheet is extensive. To achieve the best accuracy the gusset plate connections were recreated in AutoCAD, a computer assisted drafting software, based upon information in the steel shop drawings. From these recreated details, precise dimensions can be determined directly. One half inch was used as the gusset plate thickness and is considered to be generally conservative based upon MoDOT inspection reports.

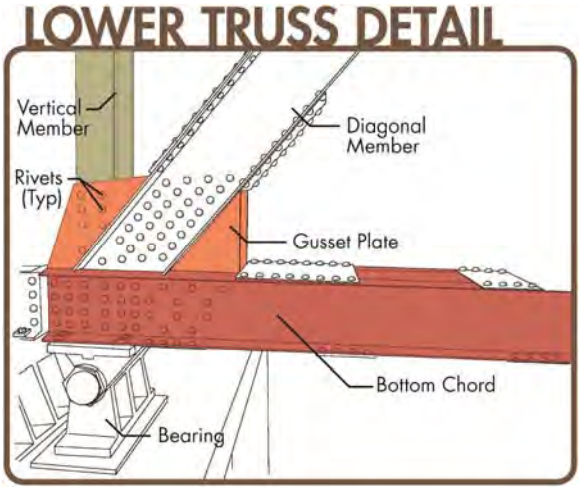
The spreadsheet factors loads internally, so new load combinations were created within the RISA model to determine unfactored member loads with adjustments for multiple presence and impact only. All live loading combinations were ran to determine which load combination would result in the maximum load effect in each member of

both gusset plate connections considered. Each of those combinations was then run in turn and all individual connection member forces recorded for each instance.

With the governing load combinations and respective member forces determined, each connection was then evaluated in the spreadsheet. Effectively, this checked each connection for each maximum member load condition. The lowest reported rating factor reported governs for the connection.

The first connection considered performed well. This connection is located along the bottom chord of the truss, two panels in from the bearing. It was selected for evaluation because of the high axial loads in the truss web members. Rating factors reported ranged from 1.45 to 1.16.

The second connection analyzed is located along the top chord of the truss, five panels in from the end. It was selected for evaluation because of the high axial loads in the chord members. Rating factors reported ranged from 1.26 to 0.85. However, it should be noted that the governing check in this example (Resistance of Section-Based Checks: Combined Axial and Bending Forces/Edge Buckling) is a very conservative check. Furthermore, Section 3.4 of the FHWA Guidance Document specifically states that "the application of flexural theory to the analysis of gusset plates is questionable and not required in this Guidance". In discussing the subject with a MoDOT representative, it was



determined that MoDOT policy is not to complete this check for gusset plate analysis. Disregarding this check, the resulting rating factors would range from 1.26 to 0.96.

Evaluation of gusset plate capacities is an extensive task. The two joints judged to be most likely to be problematic for this bridge were selected for purpose of this report; however, each truss connection should be evaluated in a similar fashion to determine its sufficiency. Connections with ratings below 1 may be strengthened on an individual basis. Options may include additional angle reinforcement and/or replacing the gusset plate and rivets with new higher strength materials.

Evaluation of a Pedestrian/Bicycle only use Scenario:

Strictly speaking, the AASHTO Specifications require bridges that are for

pedestrian use only, to be designed considering a 85 psf uniform loading (as opposed to a 75 psf pedestrian load in combination with the vehicular traffic loading, a 65 psf lane load) Accordingly, consideration of the full design pedestrian load over the entire area of the bridge will result in considerably more load requirement than any previous analysis. This analysis is not deemed necessary; however, as this full pedestrian load scenario is not likely to occur at any point. There are no other provisions in the AASHTO Specifications to address pedestrian only bridge loading, but the following, more likely scenario is investigated for the reader's consideration.

In the event that the bridge is closed to vehicular traffic, and the pedestrian traffic is limited to the exterior 6 feet of bridge deck surface, the critical top chord member in a typical truss span is found to have a design force effect of 709 kips of axial compression. With no deficiencies, this member would have a capacity of 1046 kips and perform at a factor of safety of 1.48. At 10% deficiency, it would have a capacity of 941 kips and perform at a factor of safety of 1.33.
Similarly, under this proposed scenario, the critical bottom chord member would have a design force of 345 kips tension and even considering a 45% section loss, would have ample capacity at 843 kips and perform at a factor of safety of 2.44.

Evaluation of Stabilized Structure (without deck):

An important observation made during the investigation of the truss members was that the bulk of the real stresses (unfactored loads) induced in the truss members are contributed by the weight of the concrete deck. In fact, an 82% reduction in real stresses is achieved when considering the weight of the existing concrete deck removed from the truss system (no live load considered). Thus, if the concrete deck is removed, this approach would increase the life of the structure and permit time for further evaluation and funding for rehabilitation.

This analysis also highlights benefits of reducing dead load. By doing so there is an opportunity to increase the ability of the bridge to accept additional live load. Therefore, investigation of a light weight alternative decking system is strongly recommended.

There are several light weight deck alternatives that may be considered for this purpose. A cost to benefit investigation will determine if sufficient reserve capacity can be achieved economically when compared to a standard cast in place deck and steel member reinforcing.

Conclusion:

The Structural Evaluation has evaluated several scenarios from vehicular and pedestrian loading to pedestrian only to stabilization by removing the deck.

Utilizing the current design approach for new bridges, it has been demonstrated that with rehabilitation efforts focusing on replacing some of the floor beams, strengthening the lower chord members near the ends of the truss and replacing the deck the bridge could carry vehicular and pedestrian traffic. More discussion on the rehabilitation is included in the Alternatives Section of this HSR.