West Montrose Covered Bridge

Preservation Plan

Submitted to The Regional Municipality of Waterloo
by IBI Group

April 2014

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1 EXECUTIVE SUMMARY

The West Montrose Covered Bridge is a heritage structure designated by the Township of Woolwich under the Ontario Heritage Act, is ranked as one of the top ten most historically significant bridges in Waterloo Region, and is the last remaining covered bridge in Ontario. It is highly valued as a tourist attraction, a local community access route, a convenient route for horse-drawn buggies, and as part of a unique cultural heritage landscape.

In April of 2013, a report was submitted (Region of Waterloo Planning and Works Committee (E-13-054)), which recommended a number of short term preservation measures be undertaken at the West Montrose Covered Bridge, as well as the creation of a longer term bridge preservation plan. The recommended measures and their current status are as follows:

RECOMMENDATION	CURRENT STATUS
Installation of additional load restriction signs, including signs specifically restricting tractors, buses, trucks and limousines from using the bridge.	Installation complete. In conjunction with the early warning signs, alterations to these signs will take place in the Spring, 2014
Installation of early warning signs on routes that lead to the bridge. Each sign will provide advanced warning of the load restriction, and display details on alternate routes. Locations are being finalized, please see Attachment 1 for Aerial view of area and potential sign locations.	Initial installation complete. After a review of usage patterns, a second iteration of signage will be installed by the Spring, 2014
Replacement of the roof ridge cap.	Complete
Installation of additional survey points for twice-yearly field surveying of the bridge superstructure.	To be undertaken in 2014.
Upgrading of specific tongue and groove wood panels to facilitate annual engineering inspection of the internal bailey truss.	Complete.
Delivery of post cards to homes, farms and businesses in Woolwich Township with notification of the load limit.	Complete.
Notification of the load limit to commercial vehicle operators (limousines, bus, delivery companies, couriers).	Complete.
Installation of a heritage recognition plaque at the bridge.	To be undertaken in 2014.
Pruned trees from north (village) end of bridge.	Complete.
Updating electronic media and maps, including making information available to map providers such as Google, to indicate bridge restrictions.	Complete.
Improve lighting inside the bridge.	To be undertaken in 2015.

In addition to the short term preservation measures listed above, the April 2013 report recommended the creation of longer term bridge preservation plan for the bridge. The objective of the bridge preservation plan (the Plan) is to identify a proactive sustainable program for the preservation of the covered bridge for the enjoyment of generations to come.

The Plan developed identifies the principals to be followed in the ongoing management of the structure. For example, should the structure be strengthened to permit unrestricted use, what level of intrusive measures are acceptable, is visual monitoring of the site desirable, and the establishment of ongoing annual maintenance measures and budgets.

Development of the Plan has included input from all stakeholders and interested parties gathered at a number of meetings in the latter part of 2013. Specifically, the following groups were consulted during the preparation of the Plan:

- Region of Waterloo Heritage Planning Advisory Committee (HPAC)
- Township of Woolwich
- The BridgeKeepers (West Montrose Residents Association Inc.)
- Region of Waterloo staff from the Planning, Housing, and Community Services, as well as the Transportation and Environmental Services departments

The Plan identified both major and minor risks to the covered bridge, and provided potential mitigation measures for each risk. The risks were then evaluated and a list of recommended capital and maintenance works was created as a result. The identified risks include:

RISK GROUP	DESCRIPTION OF RISK
Geometrics and Alignment	Risks include: Bridge Sag; Distortion of the bridge portal frames; Bracing systems
Loading	Risk of vehicles heavier than the current 3 tonne load posting crossing the bridge
Oversized Vehicles	Risk of a vehicle that is oversized (by height or by width) striking the bridge
Fire	Fire is a risk at this location, due to the timber members of the bridge.
Vandalism	All remote areas are subject to risk through vandalism.
Illumination	Updating of the lighting system will increase safety and be a deterrent to vandalism.
Signage and Operational Issue	A mix of advisory and regulatory signage is expected to assist in deterring overweight and oversized vehicles from crossing the bridge.

RISK GROUP	DESCRIPTION OF RISK
Approach Safety	The current guide-cable system at the bridge does not provide adequate protection to errant vehicles.
Natural Hazards	Risks include: Lightning Flood Snow Ice (jamming) Animal waste (risk to the structural integrity of wooden members due to animal waste in areas of the bridge not regularly accessed by humans).

For each of the risks identified above, a series of mitigation options are, along with estimated costs for each measure.

The risks, with their associated mitigation measures are then evaluated. When prioritizing the implementation of mitigation measures, the objective is to eliminate/reduce the most significant risks sequentially with the overall risk to the structure being reduced to an acceptable level over a time line compatible with funding availability. That is:

- Assess the current highest risk;
- Reduce the highest risk by implementing the first mitigation measure;
- Re-review and assess the new highest risk;
- Apply first mitigation to this item and ;
- Continue this process until risk levels for all items are reduced to an acceptable level.

This permits proactive resolution of issues within a programmed budget on a predetermined time base.

OUTCOMES

Capital Plan

Based on the discussion above, and in line with the need for a proactive management plan for the West Montrose Covered Bridge, a suggested 10 year capital program for improvements and risk mitigation is provided. The capital plan includes:

CAPITAL PLAN	
Capital Improvements (Risk Reducing Elements)	• Fire Alarm System • Lightning Arrestor • Regulatory and Advisory Signage improvements • Approach barrier upgrades • Bracing restoration • Climate Studies

CAPITAL PLAN	
	• Installation of a sprinkler system (dry sprinkler first, then upgrading to automated sprinklers) • Illumination Upgrades • General strengthening (twinning of the bailey system) • Floor beam Strengthening
Mandatory Capital Maintenance	• Survey sensor installation • Painting – interior • Painting – exterior • Roof Re-shingling

The total risk mitigation capital needs for the West Montrose Covered Bridge require funding of $1,010,000 over the next 10 years. The full 10 year capital and maintenance plan is included as part of the preservation plan.

Maintenance Program

The maintenance program should be a proactive process to both maintain the structure in its current condition and to prevent further degradation where possible. The program should include:

- Systematic cleaning and general maintenance should be a part of any asset management plan including removal of feces from behind the interior board works.
- Annual review of structural systems,
- Tightening bracing and hanger rods
- Deflection and translation monitoring,
- Fire systems testing
- Annual review of roadway surface through the bridge with repair/replacement as required
- Tree pruning at portals

The estimated cost for the maintenance items is approximately $15,000 annually.

The full 10 year capital and maintenance plan is included as part of the preservation plan.

2 INTRODUCTION / OBJECTIVES

The West Montrose Covered Bridge is a significant heritage resource under the jurisdiction of the Region of Waterloo. It is the intent of this study to identify a proactive sustainable program for the preservation of the Covered bridge for the enjoyment of generations to come.

The plan developed identifies the principals to be followed in the ongoing management of the structure. For example should the structure be strengthened to permit unrestricted use, what level of intrusive measures are acceptable, which of the foregoing risk mitigation measures are desirable, establishment of ongoing annual maintenance measures and budgets, is visual monitoring of the site desirable etc.

Development of the preservation Plan has included input from all stake holders and interested parties gathered at a number of meetings held over the last year.

3 HISTORY

3.1 Historical Background

Throughout the 19th century the construction of covered timber truss bridges proliferated in North America. In the period from the construction of the first recorded bridge at the turn of the 19th century (by Timothy Palmer in Philadelphia) to shortly after the American Civil War it is estimated 10,000 to 12,000 such bridges were erected in the USA alone

Neglect, fire, flood and progress have sadly depleted that number significantly. In 1983 Adams recorded 1300 authentic covered bridges remaining in the U.S.A. In 1965, Petersen reported 1154, and in 1977, McKee reported only 844. Similarly, for the same reasons, and in spite of many such bridges being constructed in New Brunswick in the twentieth century, numbers in Canada dwindled from a recorded 425 in 1965 (Petersen) to less than half that number in 1997.

The Harringtons (1975) record seven historic covered bridges built in Ontario; West Montrose, Frankford, Nappanee, Peterborough, Trenton, Williamstown and Martintown. To these should be added the crossing at Shingle Bridge (Blair) on the Huron Road. West Montrose's Kissing Bridge represents the sole survivor of these. (It is noted one other covered timber truss bridge was constructed in 1992 in Guelph, Ontario for pedestrians and other small reproductions exist elsewhere in Ontario).

The West Montrose Covered Bridge represents the only authentic vehicular covered bridge in Ontario, the 8th oldest covered bridge in Canada, and probably the longest Queen Post variant bridge in North America. Only 65 to 70 Queen truss variants of this vintage or older remain in North America.

The bridge is an integral component of the cultural fabric of the local community and as such has been designated under Township of Woolwich by-Law Number 60-2007 to be of cultural heritage value or interest pursuant to the provisions of section 29 of the Ontario Heritage Act, R.S.O. 1990, Chapter O.18.

Attributes identified in the By-Law which must be retained in any works (rehabilitation, restoration or modification) include:

- The original location of the bridge
- The original dimensions of the bridge
- The original truss configuration
- The central pier
- The exterior sheathing and interior paneling and louvered window openings
- The shingle gable roof
- The system of illumination by 'decorative' electric interior lamps
- Views to and into the bridge from the north and south banks of the Grand River

The fore going items must be inherent in the preservation planning.

3.2 Structure History

The structure is located on a township road off Waterloo Regional Road 86 over the Grand River in Lot 71, Township of Woolwich, in the Regional Municipality of Waterloo. The Township road formerly formed part of Regional Road 86.

Following its design in 1880:

"The covered bridge at West Montrose was built for Woolwich Township, Waterloo County, by the Bear (or Baer) brothers Sam and John in 1881, at a cost of $3179.50. The finest pine timbers some of them 9" X 18" X 50' were cut and hauled from Doon. Their finished bridge measured 196.5 feet across the Grand River with an additional 6-foot overhang at each portal. The bridge was 17 feet wide inside with a 13-foot clearance, and consisted of two equal spans resting on cedar cribs, now replaced by concrete (wing) abutments and a stone centre pier. The louvered window openings admitted air and light while keeping out snow and rain. The 3-inch oak planking was laid transversely and not nailed down" (Harrington, 1975)

At this time (or possibly later) much of the exterior sheeting of the west wall and part of the east wall was replaced. It is noted the original sheeting is tongue and groove battens between boards while the 'new' is butting barn boards with a batten covering the joints.

A major rehabilitation of the structure was carried out by the Ontario Department of Highways in 1950 when the original flooring was replaced with a laminated deck (2" x 4" laminations). The 2" x 4" spruce timber deck is covered with 1"± asphalt and is supported on a mixture of 5" x 10" No.1 White Pine (original) and 6" x 12" No. 1 Douglas Fir (new) stringers at 18"± centres. It is also recorded that approach modifications, installation of electric lighting and rebuilding of the centre pier (top?) was also included in the work. Highway 86 was re-routed north of the existing road (and the Village of West Montrose) in 1950.

As a result of concerns over the structural integrity of the bridge, the Ministry reinforced the bridge by the introduction of Bailey Panel Trusses placed adjacent to the existing timber trusses. The original internal paneling (to protect the lower 5' - 0" of the timber truss) was removed to place the Bailey Trusses. After installation, new tongue & groove paneling was added to enclose the Bailey resulting in a sympathetic reinforcement of the structure retaining the visual characteristics of the original, the Bailey trusses being completely hidden.

The original roofing fabric (No. 1 shingles, 5 inches to the weather) was replaced in 1987.

The superstructure is now supported on concrete abutments and a masonry pier. The date of replacement of the original timber crib abutments is unknown, however it is believed the pier was replaced in 1900 and assumed the abutments were replaced shortly thereafter.

The bridge provides a roadway width of approximately 15' between timber curbs and accommodates a single lane of vehicular traffic.

A chronological record of construction/maintenance of the bridge is included in Appendix 1 of this report. The summary is based on Ministry of Transportation Records, newspaper reports, literature reviews and reports from historical documents in the care of the Waterloo Historical Society.

3.3 Structural Systems

The trusses of the West Montrose Bridge are commonly referred to in literature as Queen Post Trusses. However their configuration does not truly represent a Queen Post and is probably more correctly described as a hybrid Howe configuration. The confusion probably arises from the unusual (if not unique) top chord configuration which gives the impression of two superimposed Queen Posts with a King Post at mid-span (see Appendix 2, Sheet 3). A true Queen Post includes two or three verticals, single uniform top chord and inclined end members (i.e. no interior diagonals). Queen Posts were entirely of heavy timber construction.

Cross bracing in the form of iron rods is included below the bottom chord level to transfer lateral wind loads to the support points. The cross bracing was supplemented by the Ministry with longitudinal chord reinforcing rods in 1959 as a strengthening.

The enclosure is simple post and beam construction typical of framed buildings of the time. However the system providing lateral stability of the frame is rare. Lateral stability is provided by the extension of alternate floor beams (needle beams) beyond the trusses to accommodate an inclined exterior rod brace. The system has been more recently supplemented by steel ships knees and cable bracing.

Few examples of this form of bracing have been found in the literature and those found incorporate enclosures around the brace/needle beam to prevent the deterioration observed at West Montrose. (Protection of some kind was an original intent at West Montrose, although it is not known if it was included in the original construction.)

Although added at a later date and of secondary interest, the Bailey system is of some historical significance. The system was developed by Donald Bailey of the Experimental Bridging Establishment in 1941 for the use of Allied Forces. Full scale production started in July 1941 with almost 700,000 panels being produced over final war years. The panels included in the West Montrose Bridge are part of this number being date marked 1944 and including the steel mill designated Frodingham.

> *"The Bailey Panel, BB.1, is a welded fabrication comprising two chord members interconnected by vertical and diagonal bracing. These members are made from special high tensile steel. At one end of the panel both chords terminate in male lugs and at the other end in female jaws. Panels are connected together end-to-end by engaging these lugs and jaws and inserting panel pins through the pin-holes."*

Further details of the existing structure can be found in the MTO Report ' Structural Evaluation of West Montrose Covered Bridge, MTO Site 33-58, 1997, prepared prior to transfer of ownership to the Region attached as Appendix 5.

3.4 MTO Ownership

The Ontario ministry assumed ownership of the bridge in 1937 and which they 'semi-retired' in 1959 with the construction of the Hwy 86 bridge over the River.

Under provincial stewardship major repairs to the bridge were carried out including replacement of the deck with a laminated timber deck, needle beam repairs and re-roofing.

In the 1950s, in response to structural concerns Bailey Truss lines were installed within the structure to supplement /replace the load carrying elements of the timber truss. The existing interior paneling was relocated, marginally reducing the road way width, in order to screen the bailey trusses and maintain the aesthetic of the interior

It is also noted that electrical illumination was added to the interior of the bridge in 1950

3.5 Regional Maintenance History

As a result of realignment of ownership of Provincial infrastructure the Region of Waterloo acquired ownership and responsibility for the Covered Bridge in 1998. Following the acquisition major rehabilitation works were carried out in 1999/2000 By Theo Vandenberk Contracting (see Appendix 2). In addition to significant replacement of deteriorated sections of the primary truss members, the work included temporary support of the superstructure to facilitate replacement of Bailey panels at the pier location to address local shear deficiencies and permit realignment of the Bailey Truss bearings. In particular the realignments included levelling of the north-west bearing through bearing seat reconstruction. Retainer pins were also installed to prevent lateral translation of the timber truss bolsters.

Circa 2003 repointing of the pier masonry was carried out.

In February 2011 during routine biannual bridge inspections a failure of the north-west bearing seat was identified and the seat reconstructed including the replacement of the original.

In September 2012 a passing canoeist reported observation of a significant crack in a primary floor beam. On investigation it was determined that failure of the beam could be attributed to passage of a significantly overweight vehicle. After a short period of closure the floor beam was replaced in kind.

Areas of deterioration were identified in the shingle roof and Fall 2013 saw limited repairs carried out to shingle roof with full replacement scheduled for a later date. Repairs included replacement of shingles in local areas of deterioration and full replacement of the ridge cap.

3.6 Community Involvement

The West Montrose residents association, known as the bridge Keepers is non-profit group of citizens *“committed to preserving the heritage, culture, quality of life and unique appeal of this special place: and protect it and its people from misuse or exploitation”*.

The bridge has been a focus for many community events including the annual Carol Sing. In a similar vein to the public adoption of sections of Regional roads the group has performed on going regular cleaning, graffiti removal and interior painting for the benefit of the community.

Similarly, recognizing the value of the crossing to their community the Mennonite Community volunteered to provide labour to remove the deteriorating deck and replace in kind. This work was completed in three and one half days under the supervision of the Region, with the provision of all materials by the Region.

This community involvement is to be encouraged but it is recognized that the involvement may be more limited in the future due to liability issues.

4 CURRENT CONDITIONS

4.1 General

In October 2012 during the replacement of the damaged floor beam, a visual inspection of accessible bridge components, in particular, west and east Bailey trusses, was carried out. The Bailey trusses were examined at abutments, pier, and at the location of the floor beam replacement to assess the general condition of the Bailey trusses and conditions within the enclosure.

In addition any horizontal deflection of Bailey truss top chord with respect to the bottom chord (i.e. out of plumb of the truss) was measured at these locations. The results varied from a low value of 1 mm to a high 60 mm (Fig.1). Almost all showed the top chord movement to be in the easterly direction.

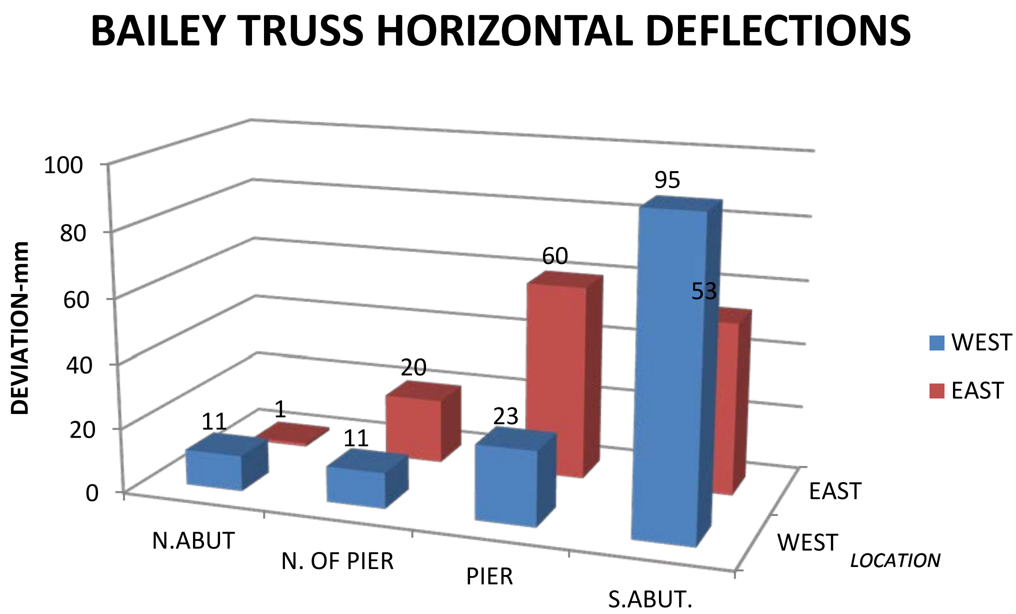


Figure 1 Horizontal Deflection of Bailey Truss's Top Chord

4.2 Vertical Deflections

A survey to measure vertical deflection of the Bailey truss along the spans was carried out in October 2012 and compared to a similar survey carried out in 2005. Deflection measurements indicate increased vertical deflection of the Bailey trusses in both the West and East trusses of less than 20 mm (Fig.2). This increase in vertical deflection is attributed to the transfer of additional load to the Bailey system from the timber truss systems (and minor measurement tolerance issues).

The vertical deflection curve of the West Bailey truss is uniform and considered reasonable. However discontinuities were noted in the deflection curve of the east Bailey truss. Therefore the east bailey was exposed at the apparent discontinuity and inspected for any pin/weld failure. No significant problems were detected in the Bailey truss assembly.

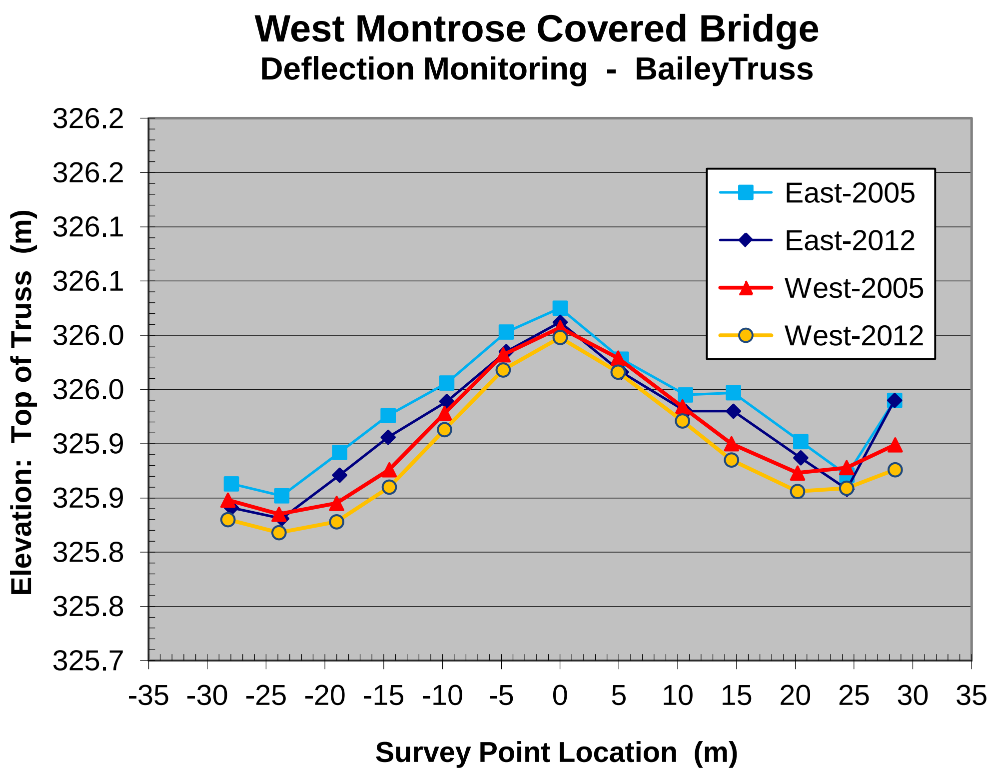


Figure 2 West and East Bailey Trusses Deflection in 2005 and 2012

4.3 Load Sharing

Based upon the theoretical deflection curves for the Bailey Trusses compared to observed vertical deflections it is concluded that the west Bailey Truss system is now carrying the total dead load of the structure with little contribution from the original west timber truss systems. The east load distribution is less distinct due to apparent anomalies in the deflection curves. Deflections should be monitored on a regular basis until the anomalies have been rationalised. The current observations were also compared with the assessments carried out in 1998. It is noted that overall deflections have increased, which is indicative of a load shedding from the timber trusses to the Bailey systems

This is shown diagrammatically in Figure 3.

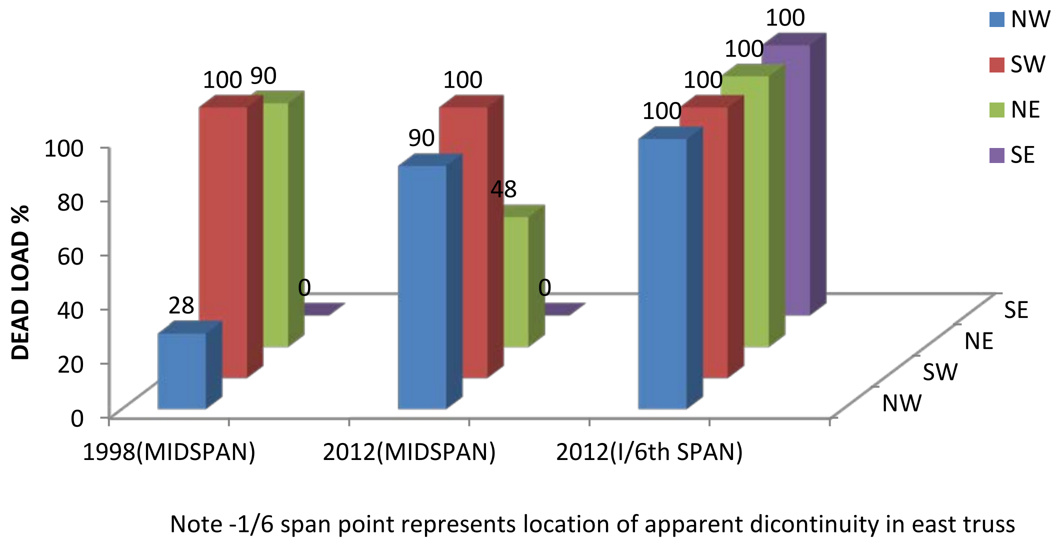


Figure. 3 Bailey Truss Dead Load Carrying Percentages 1998 and 2012

4.4 Summary and Observations

Based on these and subsequent observations current conditions may be summarised as follows:

- Bailey trusses are generally in good condition; however, high out of plane deviation toward east especially (up to 95 mm for South west top chord as mentioned earlier) affects the general stability of truss and should be addressed in next maintenance work.
- Lateral support for Bailey truss top chord bending capacity is crucial. A lateral support (connected to wood truss diagonal) was found at North of east bailey truss; however, there is a need for more lateral support about 4 m spacing to utilize the maximum bending moment capacity of Bailey truss; therefore, it is required to investigate the existence and efficiency of lateral support at along the trusses.
- Significant sag and distortion was noted in the superstructure. The sag in the spans was inherent during the 1998 renovations and a decision at that time was to maintain the Character of the bridge including maintenance of the existent sag. It is considered that the increase sag is a result of ongoing load shedding from the timber truss systems to the Bailey trusses.
- Lateral distortion of the cladding frames is noted with an apparent twist within the length of the structure. This can be partially attributed to the differential deflection of the Bailey trusses but must be more significantly attributed to the lack of rigidity at the portal frame Knees. The lateral distortion is primarily observed in areas between the top chords of the primary trusses i.e. the section over the pier and in the end portals. In these areas the stability is solely dependent on the portal joint rigidity and the external bracing from the needle beams.

- The original cross bracing beneath the structure is loose and likely not functional at this time. It is considered that the laminated deck now acts as a diaphragm fulfilling the function of the original cross bracing. Similarly the chord reinforcing in the original tensioned rods is considered not functional at this time.
- Although, the enclosed area of the bridge has been cleaned in previous years, significant dung deposits continue to accumulate through continued presence of raccoons using the bridge as their living space.
- Bolsters on the abutments and piers are split; however, they are structurally sound
- The board and batten wall cladding is in fair condition; although, it is loose in some areas.
- The roof components are relatively in good condition; however, some holes exist in roof sheathing, while it is not a structural problem, it means that rain water can penetrate through the cladding, wetting the rafters. The concrete wing walls are delaminated in some areas and exhibit light to medium erosion.

5 ISSUES & CONCERNS

The following section outlines the various risks to the structure, and provides a brief description of the mitigation options available.

5.1 Do Nothing

A do nothing or minimal reactive maintenance is considered unacceptable. This approach will eventually result general deterioration eventually reaching a level at which restoration/ maintenance becomes impossible resulting in closure or removal of the bridge.

5.2 Geometrics and Alignment

It has been noted during site reviews that the bridge has noticeable sags in each span and vertical misalignment of the enclosure.

During the 1999/2000 renovations to the structure a conscious decision was made to retain a component of the sag. It was considered that the sag formed an integral part of the character of the bridge. In addition it is cautioned that although elimination of the sag through jacking is relatively simple to achieve concerns are noted that the sag has evolved over a period of time with gradual accommodation and through time dependant deformation of the timbers and associated movements in the dry joints of the trusses. Any jacking of the structure to remove the sag must be carried out with extreme caution so as to minimize the potential for distress in the structure. It is further considered that the sag in the structure tempers the speed of vehicles travelling through the bridge.

The cladding support frames show significant out of true or twist within the structure. This is due to a combination of factors including differential movements of the truss systems, lack of transverse rigidity and loss of functionality of internal and external bracing systems. This twist within the structure appears to be progressing and should be addressed in any restoration/ maintenance work. Frames can be trued using jacking systems but the works will also require ships knees to maintain frames square and a restoration of bracing systems to a functional condition. The original interior horizontal bracing and (supplementary) cable bracing is loose. Further the connection details at the rafter level are currently of an undetermined nature and should be fully investigated to confirm positive functional attachments. The following table outlines the mitigation options for the geometric and alignment concerns.

MITIGATION	COMMENTS	COST
Jacking to Remove Sag	Can be carried out with caution.	$10,000 to 15,000
True portal frames	To include knee braces and restoration of existing bracing systems	$25,000
Restoration of bracing systems	Required to include bracing at underside of deck , wind bracing stays and bracing at portal frame horizontals	$10,000 to $ 15,000

5.3 Loading

As a part of previous investigations carried out under the auspices' of the Ministry of transportation, review of the structural capacity of the bridge was carried out. It was based on a rational analysis that the floor beams have a reserve capacity in moment for a 5 tonne axle load assuming an axle spacing greater than 11'-6".

In the MTO report 1997, based on an analysis of the Bailey assuming all load carried by the Bailey systems it was recommended that replacement or reinforcement the Bailey panels at the pier be carried out (e.g. with Mabey-Johnson Panel or equivalent [(Fy = 355 MPa]. To provide scale Down Factor of 0.41 [8 tonnes liveload only[or F = 0.30 [5 tonne including snow]) in order to protect the structure from damage due to unintentional overloads. This measure was implemented as a part of the 1999\2000 Repair program.

In order to further protect the structure the 3 tonne load limit was maintained. This a common practice in the preservation of historic covered bridges where the desire is to maintain limited operations through the structure in the historical context of use.

Analysis under the current Code identifies marginal changes to posting limits under traffic loading. However ratings are reduce when considering a full snow load on the structure as identified through consideration of the Building code The bridge is then considered marginal. It is to be noted that theses snow loads may not be representative of the actual conditions at the site as evidenced by recent observations. It is recommended that a snow impact study be carried out to identify more realistic loading conditions for inclusion in the analysis.

As can be seen through input from the local community and as demonstrated by the recent floor beam failure, violations of the Load Posting do occur.

It is considered that vehicles may be directed across the bridge during route mapping by GPS systems. Trucks have limited options if they reach the bridge site and it is therefore suggested that elimination of trucks along Rivers Edge Drive may reduce the incidences of 'accidental crossings' by heavy vehicles which arrive through GPS direction. Truck prohibitions along Rivers Edge Drive would require by-law designation by the Township.

The following measures can be considered to mitigate the frequency/consequences of these violations:

MITIGATION	COMMENTS	COST
Prohibit vehicular traffic on the bridge	Not considered to meet all objectives and considered a last resort	N/A
Prohibit vehicular traffic on the bridge with the exception of 'Buggies'	Not considered practical as buggies are a similar size to many automobiles	N/A
Prohibit selected categories of vehicles from crossing the bridge	Current prohibition for Trucks, buses, tractors, farm vehicles effective for 95% of traffic but offences will still occur. Difficult to enforce	N/A
Strengthening	Can be implemented but to what level. Whether strengthening should be carried out is questionable. The current strength levels of members dictate a first failure would occur in the floor beams. It is desirable to maintain this "fuse" rather than pushing the failure critical member to the bailey trusses. Therefore, strengthening would require strengthening of both floor beams and bailey trusses to maintain this balance a) Strengthening of floor beams only b) Strengthening of bridge bailey systems	 $100,000 $300,000 - $400,000
Overload detection, weigh in motion	Has been used in some applications and is used extensively for monitoring truck weights. To be effective in this location would link with monitored alarm and enforcement mechanism or 'automated gates' which would become visually intrusive	Up to $200,000 over a ten year period
Automated Gate system	The gate system would be linked to the Weigh–in-motion system .Similar operation to Rail grade crossing gates	$25,000
Improved Signage	Signage is effective in control of 95% of the motoring population but violations will still occur. However it is considered that improved signage with improvements in visibility, location and addition of advisory signs will reduce accidental violations of the load limits	$15,000-$25,000
Local Road Restrictions	Designation of Rivers Edge Drive as 'No Truck Route' may help in directing heavy traffic away from bridge site	

MITIGATION	COMMENTS	COST
Enforcement	Enforcement can be an effective deterrent however it is to be recognised that the Regional police force have limited resources and enforcement at the bridge would be on an ad hoc basis. Load limit enforcement is further limited by the need to establish actual vehicle weights at the time of the infraction	N/A

Reinforcing/strengthening systems have been integrated into the fabric of several covered bridges and range from full support of the heritage structure on steel beams to post-tension of chord members such as was done at the Hartland Bridge, New Brunswick. The Heartland Bridge also required significant strengthening to truss diagonals clearly visible within the structure to enable it to remain as a part of the Provincial highway system.

Strengthening of the floor beams at the West Montrose Bridge is considered viable but is not considered a critical area of risk at this time. As has been noted the capacity of the floor beams acts as a fuse link in the system. Failures of these members do not present a critical risk to the bridge. It is considered that strengthening of the floor beams should only be carried out if the overall capacity of the bridge is increased by strengthening the supplementary Bailey system by either full replacement or twining. Strengthening of floor beams can be easily and unobtrusively achieved by the addition of steel or carbon fibre plates anchored to the lower face of the floor beams.

Overall strengthening of the bridge can be accomplished by twinning of the bailey trusses. Twinning of the bailey can be accomplished but would result in an approximate 1.0m reduction in roadway width through the bridge.

5.4 Oversize Vehicles

Clearance through the bridge is approximately which is less than the maximum legal vehicle height permitted under the Highway Traffic Act. Hence there is a potential for damage from over-height vehicles.

As evidenced by the non-sympathetic replacement of overhead members within the covered bridge over height vehicles may have on occasion crossed the bridge with subsequent damage to the fabric of the structure. Wide vehicles are generally less of a problem as drivers can see the width restriction relative to their vehicle whereas few drivers recognize the height of their vehicle. However it is to be noted that no damage through over size vehicles has been recorded in the recent past.

It is to be added that oversize vehicles are generally linked to also being overweight and it is implied that the elimination of over-height vehicles reduces potential for overload conditions.

The following measures can be considered to mitigation against these violations:

MITIGATION	COMMENTS	COST
Signage (limit restrictions and alternate route, sign locations)	As with load limitations signage is effective in control of 95% of the motoring population. However it is to be noted that most vehicle operators do not know the height of their vehicle. It is considered that improved signage is a positive benefit at a relatively low cost	$15000 - $25000
Rigid height barrier	Rigid barriers are effective in the elimination of over height vehicles but are considered a negative visual intrusion at a heritage site	
Passive Electronic monitoring and alarm systems	Has been used at locations of low bridge overhead heights. Generally the systems rely on operator compliance upon receipt of warning alarm	
Surveillance cameras and photo record	Would provide a record of infraction but under current legalisation would be considered information only and not enforceable	Not considered an effective mitigation
Alarm activated gates	Gates similar to rail grade crossing gates would be linked would be activated by the alarm system to prevent vehicle access	$50,000.
Enforcement	Enforcement can be an effective deterrent however it is to be recognised that The Regional Police force have limited resources and enforcement at the bridge would be on an add hock basis. Officers would need to be present at the time of the infraction to enforce and charge the offender	Over height violations at the West Montrose bridge if height are within legal limits for the Ontario road system would not be chargeable offences

5.5 Fire

The nature of the construction materials used in covered bridges provides a significant fire risk. Many covered bridges throughout North America have been lost due to fire resulting from natural causes or arson. The remote location of this structure increases the risk of total loss due to potential response times of volunteer fire departments.

Pictured here are the remains of the White's Road Bridge, Michigan's oldest covered bridge, following arson set fire in July of this year. At least two other US bridges were lost this year due to fire. Similar losses have occurred in both Quebec and New Brunswick.

First response to West Montrose is from the Conestogo Fire Hall approximately 7.5 to 10km away from the bridge depending on the route taken from Conestogo. It is noted that average fire department response times are mandated by the Office of the Fire Marshal, and are to be 8 minutes or less. This average is bettered by the Woolwich Fire Department but must be kept in mind that these are average response times, not maximums. It has been seen recently that even with rapid response timber structures can be essentially destroyed in the minutes prior to the arrival of the first response. In the case of the West Montrose bridge, it is probable that the fabric of the bridge covering would be lost in its entirety with possibly only the primary truss members remaining to any extent.

Fire is probably the most prevalent cause of loss of covered bridges in North America and is arguably the highest risk associated with the West Montrose Covered Bridge.

To mitigate this risk alternatives to be considered include:

MITIGATION	COMMENTS	COST
Detection	Fire detection systems provide alarm in local monitoring center with relay to appropriate fire hall, however response time will result in significant loss of structure (although main truss system may be salvaged).	$15,000
Retardants (coatings)	Fire retardant coatings (spray on) delay flame spread to allow fire department response.	
Suppression (Fire Department and sprinkler system)	Installation of a dry stand pipe and sprinkler system to provide hook up for pumper unit. This, although cheaper than a full automated sprinkler suppression system, relies on fire department response times	
Suppression (Automated sprinkler system)	Fire suppression systems such as automated sprinkler systems (will require an automated pumping system and water supply) provide maximum protection	$300,000

In the foregoing a fire detection system represents a minimum requirement to enhance fire protection at the West Montrose Bridge. However, due to the remote location it is suggested that the minimum does not reduce the risk of loss to an acceptable level. The following provides brief descriptions of the additional mitigation measures that can be applied at the site.

Alarm Systems

It is proposed that the detection method for the bridge structure utilize Leaner Heat Detection (LHD) system. Detection cable loops will run at the ceiling level for the full length of the enclosure. Additional loops will run at the lower level within the Bailey truss enclosure to detect fire occurrences in these locations. A total of 3 loops will be required, ensuring full coverage of the structure.

A notification device (bell or horn) in a tamper proof enclosure would be located on the exterior of the structure to alert the general public of a fire emergency.

Sprinkler Systems

Utilizing a combination of a dry pipe system with the automatic activation of a diesel fire pump linked to a water supply, the spread of fire on the bridge is contained (and potentially extinguished) , affording the fire department time to arrive and continue management of the occurrence.

The sprinkler branches would run within the interior of the paneled enclosures and at the apex of the bridge roof, for the full length of the bridge to provide total coverage.

Upon sensing a fire, an alarm sounds and transmits a signal to local monitoring authorities to dispatch the fire department. The fire pump will activate and provide water to the sprinkler system giving approximately one hour of protection/suppression.

Fire Retardants

Fire retardants delay both the ignition and the spread of flames. This provides mitigation for the time lag between identification of an incident and response time from the fire department. Materials include pressure treatment or spray on coatings. Clear intumescent coatings allow the visual characteristics of the protected timbers to be maintained. However it is to be noted that the durability of these coatings has not been documented and the coatings may need periodic reapplication with the associated cleaning and preparation, particularly in areas exposed to the elements.

5.6 Maintenance Requirements

Maintenance is currently carried out on a reactive basis, i.e. when a problem becomes evident maintenance is carried out and repairs implemented. It is of essential to the preservation of the structure that a regular maintenance and inspection program be developed. Without a proactive program it is considered that the asset will slowly deteriorate. It is important that future maintenance be carried out in a manner that retains the character and aesthetics of the original structure.

Mandatory Maintenance tasks should include:

- Annual inspections
- Deformation/deflection monitoring
- Fire Systems testing
- Minor cladding and roofing repairs
- Cleaning

Programmed Capital Maintenance should include:

- Roof re-shingling
- Exterior painting
- Internal painting

5.7 Vandalism

All remote areas are subject to risk through vandalism. This can range from defacement, generally from spray paints, or more serious damage or arson. The prime source of fire in covered bridges is arson. The risk of fire has been addressed more fully in section 4.5. As in urban areas, incidents of vandalism can be reduced at more remote areas by observation and illumination, i.e. visibility. The following table outlines available mitigation options.

MITIGATION	COMMENTS	COST
Lighting	As in urban areas visibility greatly reduces the occurrence of vandalism. On a cost and effectiveness basis illumination and the removal of potentially obscured areas provides the most appropriate mitigation at this site	$35,000
Visual Monitoring (electronic surveillance)	Visual tracking systems with remote monitoring have been installed at some locations on an experimental basis. However without a rapid local response fabric in place these systems do little more than provide a record of the infraction. Cameras are also considered overly intrusive by many	

5.8 Illumination

Attributes included in the Heritage Designation included 'the system of illumination by decorative electric interior lamps. Electric illumination was introduced by the Ministry in 1950. Currently it is in the form of Standard Ministry underpass lighting units which are not considered decorative. It is thought that the reference to decorative is to an earlier installed illumination.

Illumination provides a valuable contribution to safety and a deterrent to vandalism. It is recommended that the current illumination units be replaced with a more heritage sensitive units.

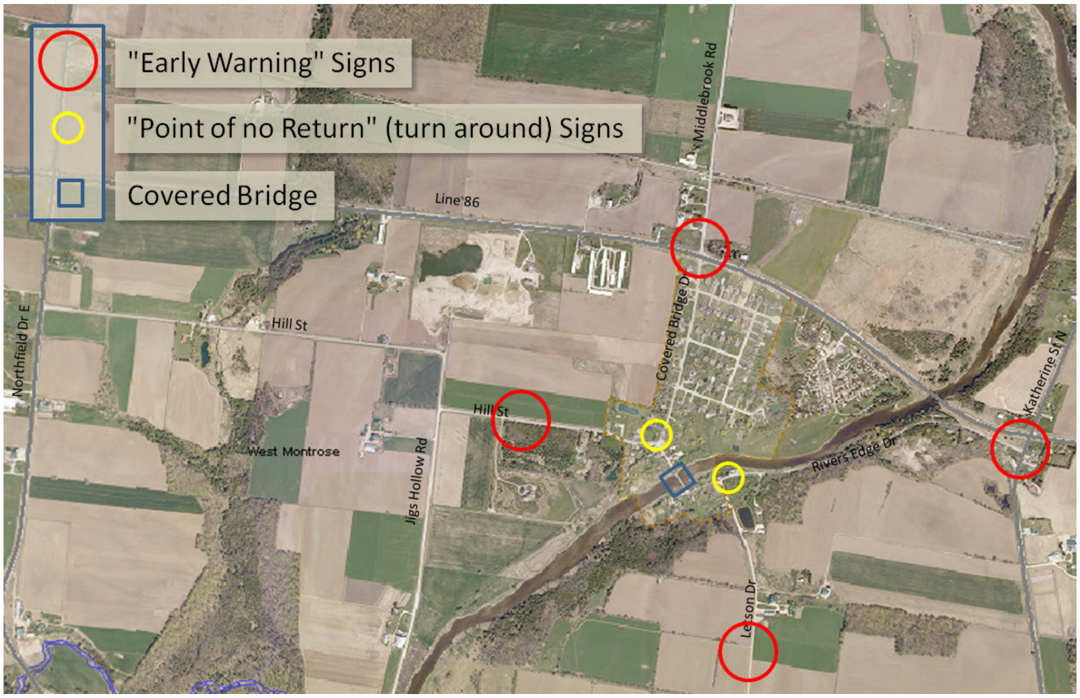
5.9 Signage and Operational Issues

The bridge operates as a single lane facility without significant incidents being noted. Traffic is self-managing with vehicles yielding to other vehicles and pedestrians. However there are operational constraints associated with the bridge including load restriction, vehicle restriction, and height restriction.

Although signage receives compliance by the majority of users as evidenced by reported observations, violations in all categories occur either by intent or ignorance.

Signage falls into two categories,' Regulatory' and "Advisory". Currently regulatory signage is located on the bridge approaches but is currently often misinterpreted.

The vehicle operator has limited options when reaching the regulatory signs. It has been agreed that advance warning signs be improved to clearly identify the constraints ahead in sufficient time for the operators to take an alternative route. In addition it has been agreed to add advisory signs to identify "point of no return" (turn around signs). Conceptual overviews of the proposed/ required improvements are shown below.



The signage details for the foregoing improvements are currently being developed for implementation in the near future.

5.10 Approaches

Currently the approaches are protected by cable guard systems. While providing some protection for errant vehicles on the approaches, the systems provide little protection for the bridge itself. Several covered bridges have received significant damage due to vehicles striking the bridge. Due to the low travel speeds within the bridge enclosure, the current timber curb system through the bridge is considered sufficient protection within the enclosure.

The cable system is considered insufficient protection on the approaches and should be replaced by a code compliant barrier system. Such a system would also provide a more significant fall protection for the public and reduce the region's exposure to risk. An appropriate timber system was utilized by the Region at the Mill Race bridge improvements in Cambridge.

Alignment modifications to restrict heavy vehicles are not feasible at the north approach. The south approach includes a wide throat with easy turning access for heavy vehicles. Consideration has been given to the realignment and constriction of the bridge approach to form a tee intersection at Rivers Edge Drive making turns for heavy vehicles difficult and thereby restricting access to the bridge. However it is considered that this geometry would result in excessive grades, thereby creating a hazardous condition for horses on the downward movement. This was evidenced during the closure of the bridge to all traffic except buggies during the recent repairs. The following table presents options for mitigating the approach safety risks.

MITIGATION	COMMENTS	COST
Addition of Code Compliant Barriers	Existing cable barriers are non-compliant. Must be replaced with site compatible compliant barriers	$20,000
Changes to Road way geometrics	Not considered viable at this site	N/A

5.11 Natural Hazards

Losses of covered bridges have occurred due to flood, ice flows, snow and possibly lightning strikes.

Flood levels have reached close to the soffit of the bridge and the identified threat is primarily that of debris carried downstream by the flood waters becoming lodged under the bridge to such an extent as to form a dam. High transverse loads are thus imposed on the bridge with potential for loss of the structure as has been the case for some US structures.

Similarly ice jams can form so as to impart high transverse loads to the bridge with subsequent loss of the structure. These conditions should be monitored as they occur with a mechanism established for monitoring and response to these situations should they occur. This would be one area where public awareness would be desirable. Flood by-pass measures are not considered practical at this site.

The River is under the jurisdiction and management of the Grand River Conservation Authority who provide flood level projections and data through their web site. Monitoring of this site would facilitate the implement of protection measures in the event of an imminent threat.

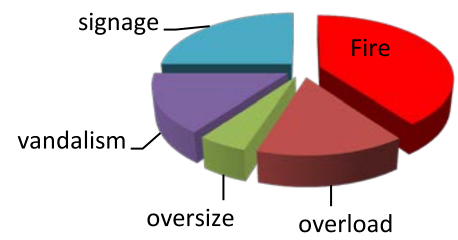
Lightning strikes represent a low but real risk. It is suggested that this risk be addressed by the addition of lightning arrestors.

A risk unique to this type of structure is the intrusion of wild life such as racoons which through there fecal deposits provide an avenue for rot of timbers as was seen prior to 2000. It is not considered practical to eliminate wild life from being domiciled in the enclosures but regular cleaning of the enclosed spaces must be continued as a part of the maintenance plan to address this risk. Based upon the current overall structural configuration consequences through this risk element are minor. Mitigation measures for natural hazards are shown in the following table.

RISK	COMMENTS	COST
Lightning	Low risk of occurrence but high risk of loss of structure through fire initiation. Add lightning arrestors	$10,000
Flood	Loading of structure in the event of significant flood warning to militate against wash out. Loading or addition of anchorage at pier and abutment	N/A
Snow	Visual Monitoring and drift removal as necessary	
Ice	Ice jams should be monitored and released by GRCA as appropriate	N/A
Animal Waste	To be included in regular maintenance bi-annually significant deteriorations caused by accumulation of animal waste	$2500
Manual Surveillance		N/A

6 DISCUSSION & EVALUATION OF ALTERNATIVES

Risks and potential mitigation alternatives have been identified in Section 4. The risks to the structure range from major where the consequence is the potential for total loss, to minor where the consequence is relatively minor. In the prioritisation of the implementation of mitigative measures the objective is to eliminate/reduce the most significant risks sequentially with the overall risk to the structure being reduced to an acceptable level over a time line compatible with funding availability, i.e. reduce highest risk by first mitigation, review and assess current highest risk, apply first mitigation to this item and continue process until risk levels for all items are reduced to an acceptable level. This permits proactive resolution of issues within a programmed budget on a predetermined time base.



Relative Risk Levels

Currently fire is considered the highest risk with the highest potential for consequential loss followed by signage deficiencies, overloading, vandalism and finally oversize vehicles. The relative levels of risk and consequential loss are shown schematically above.

The preservation plan must address risks on a prioritised basis within an acceptable financial plan and commitment of funding. The plan should first address the highest risk of loss of the structure and initiate mitigation to reduce the level of risk. First mitigation of the prime risk carried out within budgetary constraints lowers this risk level from this source. All risks are then reassessed and the highest risk re-established. Mitigation within budgetary constraints is then applied to that risk. This process is followed until all risks are considered mitigated to an acceptable level.

Fire is considered the single highest threat level with the consequence being the potential for total loss of the structure. The first level of mitigation with the highest priority is considered to be the installation of an alarm system linked to emergency responders. This is considered the minimum level mitigation at this site. However it is noted that with only this measure in place the structure still remains at a high level of risk of loss due to fire due to the finite response times of local responders. Hence with this first level mitigation fire still remains the highest risk to the structure.

Therefore the next priority with respect to fire risk mitigation and as an overall risk mitigation strategy for the bridge is to lower the risk associated fire department response times. On a first level this can be addressed by application of fire retardant materials, whereas an ultimate solution would be a fully automated sprinkler system,

Risk of loss due to overload is considered as a moderate risk and should be mitigated following reduction of the fire risk.

The bridge currently is posted at 3 tonnes based upon consideration of a rational analysis of the floor beams. This is also a common value applied to many covered bridges irrespective of their calculated capacities in order to minimize heavy vehicle usage and consequent wear-and-tear i.e. the posting is implemented as an overall preservation measure. Similar preservation measures have been implemented in the form of elimination of all motorized traffic and restriction to pedestrians only. This would clearly be in violation of the stated goals for this bridge.

In order of precedence the global load capacity of the bridge is governed first by the floor beam strength, secondly floor stringer strength and ultimately by the capacity of the supplementary support systems to which all loads are currently transferred. Strengthening of the structure is feasible to different levels dependent on the strategy adopted. It has been noted that a potential exists for damage due to oversize vehicles. Mitigative measures include signage (lowest level of mitigation) to physical height barriers install prior to the bridge. However during recent years no repairs have been required to address damage caused by over-height/width vehicles hence this risk is considered low.

Fixed barriers have been used at several covered (and other heritage structures) to restrict over-size vehicles. These installations are visually intrusive and impact negatively on the general aesthetics of the area. Electronic systems have also been used to detect oversize vehicles with audible or visual alarms being triggered. These systems although effective in detection rely on operator compliance for enforcement. It is considered that installation of detection\barrier systems would not significantly lower the risk of loss at this site and would have a low priority for implementation. Improved signage with identification of turn-back areas is considered satisfactory mitigation. In all risk scenarios signage plays a significant role in mitigation of risk. Current signage is considered inadequate with advisory signage being minimal. Improved signage visibility and addition of advisory signage to give advance warning and identification of turn back locations is strongly recommended and is considered one of the most cost effective mitigation measures available at this site. Enforcement of regulatory signage should be encouraged but it is recognised that enforcement is limited by resource availability.

Vandalism has been limited at the site to minor occurrences of deformation of the interior panelling. It is considered that the presence of illumination and frequent use of the bridge by residents greatly contributes to the control of vandalism. It is noted that the current illumination is not in keeping with the general aesthetics of the bridge. Illumination is a feature noted for preservation in the heritage designation. However it is suggested that a more sympathetic lighting system be installed I.e. period style luminaires.

Natural risks have been defined to include flood, snow, ice flows and intrusive animals. It is unlikely that the racoon population can be deterred or prevented from taking residence in the enclosures so it becomes important to include interior cleaning (dung and carcass removals) in the regular maintenance program. This proactively eliminates the damp environment adjacent to timbers which is conducive to the development of rot.

The Grand River is under the control and watch of the Grand River Conservation Authority who monitors potential ice jam formations and advises on potential flood conditions. In anticipation of high flood levels consideration can be given to loading the bridge to minimize washout potential or more appropriately adding restraint at piers and abutments to prevent wash out

Identified ice jams, if considered a threat to the bridge, can be removed by the GRCA. It is therefore considered essential that close monitoring by GRCA (and local residents) be carried out during icing conditions.

Snow build-up on the roof should be monitored during snow events. If appropriate, measures should be taken to remove the snow pile-up or traffic restrictions imposed temporarily.

7 MAINTENANCE

Maintenance items are considered items that are required to ensure the preservation of the bridge but are not considered critical single risk items

The maintenance program should be a proactive process to both maintain the structure in its current condition and to prevent further degradation where possible. The program should include:

- Systematic cleaning and general maintenance should be a part of any asset management plan including removal of feces from behind the interior board works.
- Annual review of structural systems,
- Tightening bracing and hanger rods
- Deflection and translation monitoring,
- Fire systems testing
- Annual review of roadway surface through the bridge with repair/replacement as required
- Roof maintenance with shingle replacement as required
- Tree pruning at portals
- Interior painting
- Exterior painting

Ongoing maintenance can also include capital improvement works to restore the structure to its original configuration.

- Periodically transverse portal frame members have been replaced but not in a sympathetic nature recognising the original construction. It is recommended that these members be replaced in authentic manner.

8 SUMMARY OF RECOMMENDATIONS / 10 YEAR CAPITAL PLAN

Based on the foregoing discussions and in line with the need for a proactive management plan for the West Montrose Covered Bridge a suggested 10 year capitol program for improvements and risk mitigation has been created. The first 5 years of the suggested program are outlined below:

Year One	Fire Alarm System Lightning Arrestor Regulatory and Advisory Signage improvements Approach barrier upgrade Bracing restoration Climate Studies Survey Sensor Installation
Year Two	Dry Sprinkler Header Illumination Upgrades
Year Three	Automated Sprinklers

Year Four General strengthening

Year Five Floor beam Strengthening

Regular maintenance on annual or regular programmed basis would include OSIM Inspection, deformation monitoring, fire systems testing, roof repairs\replacement, cladding repairs, interior and exterior painting, and other miscellaneous general maintenance items.

The foregoing is presented in tabular form with Budget Cost Estimates in Appendix 3.

The program suggested is illustrative only and should be adjusted subject to budgetary considerations with implementation of mitigation measures being brought forward where possible. Similarly many mitigation measures could be deferred until funding becomes available providing that a minimum level of risk mitigation is implemented in the near future. The minimal levels are highlighted in the attached table. Allowances for regular maintenance have been included to assist in budgetary planning. It is noted that the Capitol Plan has been developed to provide an overview of the needs in the preservation of the bridge and can be adjusted to meet budgetary constraints

9 COMMUNITY PARTICIPATION

As noted in section 2.6 community involvement has been a significant part of the asset history. Although opportunities for public participation in the preservation of the structure may be more limited in the future due to liability and risk exposure considerations it is considered that these valuable contributions be acknowledged and encouraged.

Opportunities occur in the general ‘housekeeping ‘for the structure including interior painting, cleaning, and most importantly monitoring occurrences particularly those introducing a threat to the structure.

10 ASSET VALUE / REPLACEMENT COST

The Covered bridge forms a significant asset in the Region’s inventory. If the current asset is destroyed the following represent replacement costs for various options

STRUCTURE	COMMENTS	COST
New Standard Bridge Replacement including new sub-structure	Single lane girder bridge of current design including new sub-structure	$ 1.6 mil
New Standard Bridge Replacement including new sub-structure	As above with replicated enclosure to maintain visual appearance	$ 2.0 mil
Single Lane Heritage Bridge	Replication of the single lane Heritage Bridge including timber truss members utilizing existing sub structure	$ 1.4 mil

Appendices

APPENDICES

Appendix 1 – Bridge Chronology

1880	John Bear Retained for Design
1881 Jan.	Tenders
1881	Construction
1882	Painting with 'residue oil and brown fire-proof paint'
1885 Dec.	Lamps (coal oil) added
Circa 1900 ?	Stone Pier Constructed to Replace Timber Pier
1904	Deck planked (over existing)
1933	Lower chord spliced. Needle beam replaced.
1937	DMO assumed bridge (2 Ton on posting/10 mph)
1950	Lamp lighting terminated/ electric illumination installed
1954-?5	• Laminated deck to replace oak planking • New centre pier bearings and Structure Leveling • Rebuilt approaches • Shutter type windows renovated • Electrical light set in lanterns (3-100 watt bulbs)
1955	Posting 2 Ton/5 mph
1959	Major Repairs (5 Ton posting) • Steel reinforced, poured concrete cap on centre pier • Needle beams removed and replaced • Floor beams removed and replaced • Rotted and cracked lower chord beams replaced • Corner bearer blocks replaced • Rub rail installed • Damaged concrete removed and re-poured on ballast walls • Concrete wall poured on north end to prevent further undermining of abutment wall • 1" dia. steel reinforcing chord, end to end with turn buckles (2 sides) • Vertical sheathing (6') installed on two sides • Structure painted complete Cont. IB 15-60 • Deck coated with colas and pea gravel • Bailey installed to carry bridge while repairs were being made, supported on pavement on ends and on centre pier.
1959	Semi-retired (new bridge upstream)
1960 Aug. 28	Recognized as provincial historic site
1963	Recommendations made to tighten reinforcing rods, take levels to monitor sag, enforce 5 Ton limit

1965 ? or more likely 1966	Major Rehabilitation by Ministry: • Tightening rods and hangers. • Erection of Internal Bailey Trusses started. • Needle beams and floor beams treated with coal tar preservative
Early 1970's	Repairs and repainted.
1971 Summer	Truss rods tightened. Ridge boards and battens tightened/repaired. Timber truss treated with preservative.
1971 October	Painting - interior and exterior
1986	Underwater inspection
1987	Re-roofing (K-W Record)
1995-96	Needle beam extensions replaced (using 2x12.laminations?)
1998	***Structure Acquired by the Regional Municipality of Waterloo***
1998	• Repairs to pier • Emergency repairs to needle beam using 2x12 lamination for the extensions • Temporary Deck Repairs • Reconstruction of north approach • Repairs to north abutment
1999/2000	Major Rehabilitation including • Repairs to timber trusses (replacement of rotted sections) • Cladding repair • Strengthening of Bailey trusses (panel replacements) • Bearing leveling • Full re-decking (Mennonite labour)
2000	Incorporation into Trans Canada Trail
2001?	Repairs to Pier, repointing all joints
2004	Bridge repainted
2007	Heritage Designation under Part IV of the Ontario Heritage Act
2011	North East bearing seat repair and bearing replacement
2012	Interior painting
2012	Floor beam replacement
2013	Roof repairs. Shingle repairs and ridge cap replacement

Notes:

1. Date replacement of abutments is not recorded, however believed to be late 19 century.
2. Undermining of pier and differential settlement took place prior to 1942.

Appendix 2 – Bridge Drawing's 1999 Rehabilitation

31 Aug 99

REPAIRS TO

WEST MONTROSE COVERED BRIDGE

VILLAGE OF WEST MONTROSE

TOWNSHIP OF WOOLWICH

Giffels

Giffels Associates Limited
Consulting Engineers and Architects

CONTRACT No. 99038

KEN SEILING
REGIONAL CHAIRMAN

J. F. HAMMER, P. ENG.
ACTING COMMISSIONER OF ENGINEERING

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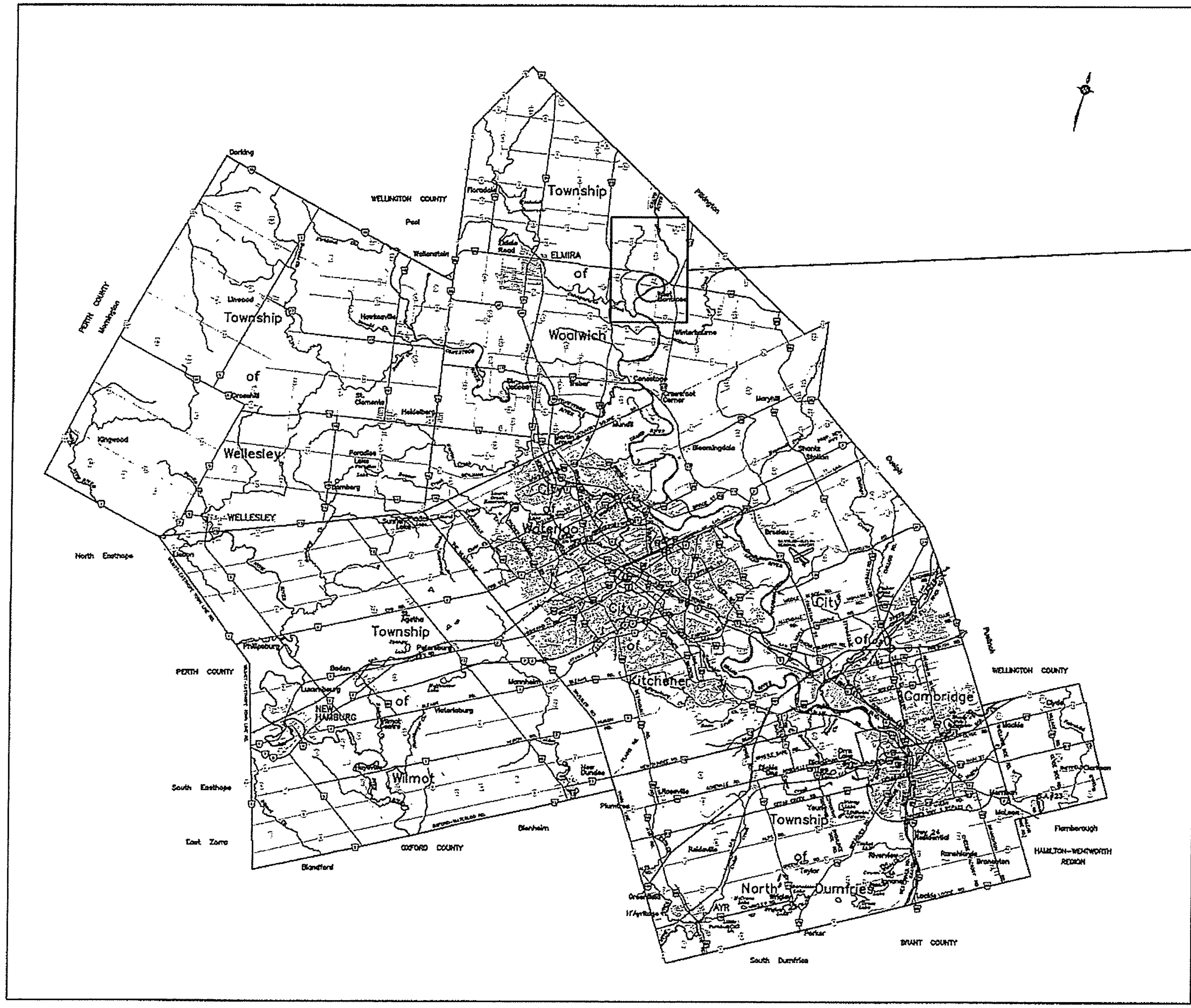
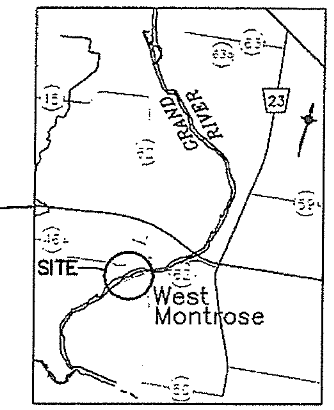
The Regional Municipality of Waterloo





KEY PLAN
NTS

ROAD No ______ ROAD NAME ______

WORK OF REPAIRS TO THE WEST MONTROSE COVERED BRIDGE

CONTRACT No 99038 FILE No 5885 SECTION No ______

LOCATION ______

MUNICIPALITY TOWNSHIP OF WOOLWICH

LIMITS : STATION ______ TO STATION ______

SOILS REPORT ______

DRAWING INDEX

SHEET No	DESCRIPTION
	TITLE PAGE
	INDEX PAGE
1.	GENERAL ARRANGEMENT
2.	TEMPORARY SUPPORT SCHEME FOR BAILEY PANEL REPLACEMENT
3.	TIMBER TRUSS REPAIRS
4.	REPAIR DETAILS 1
5.	REPAIR DETAILS 2
6.	DECK REPLACEMENT

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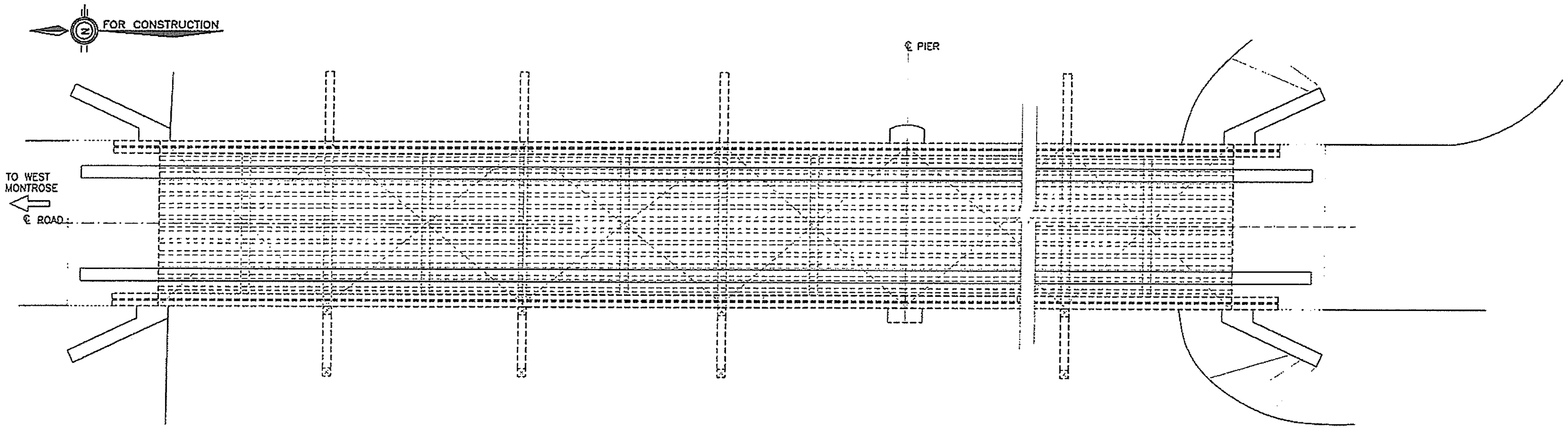
FOR CONSTRUCTION



PLAN
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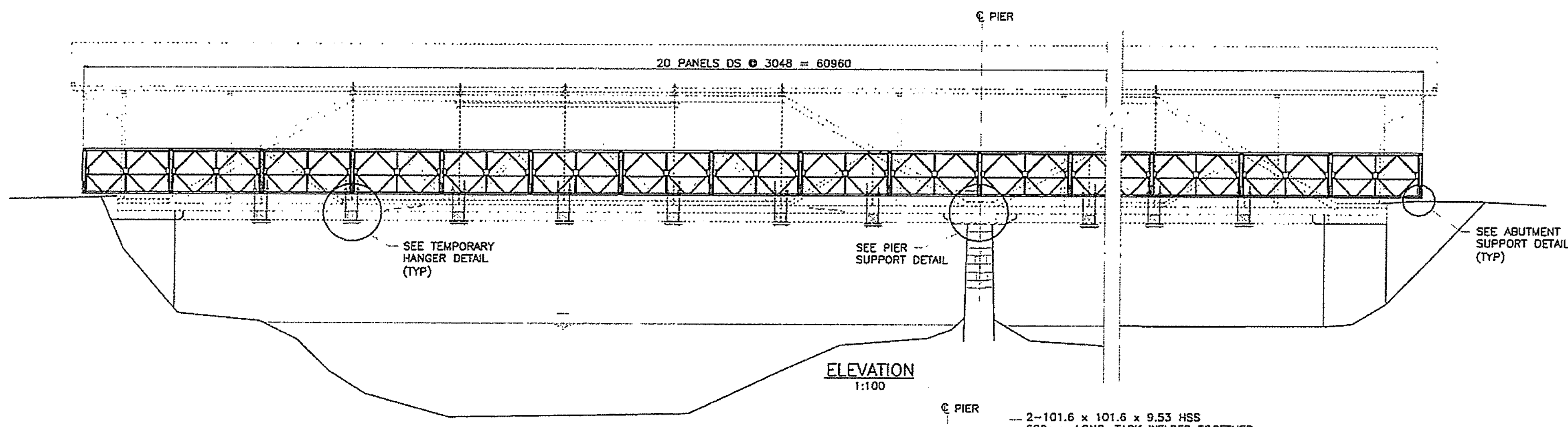

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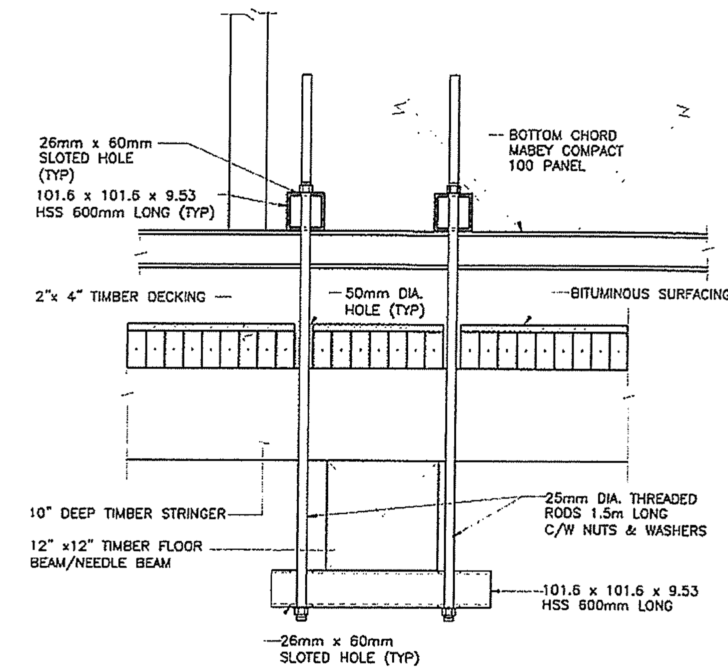

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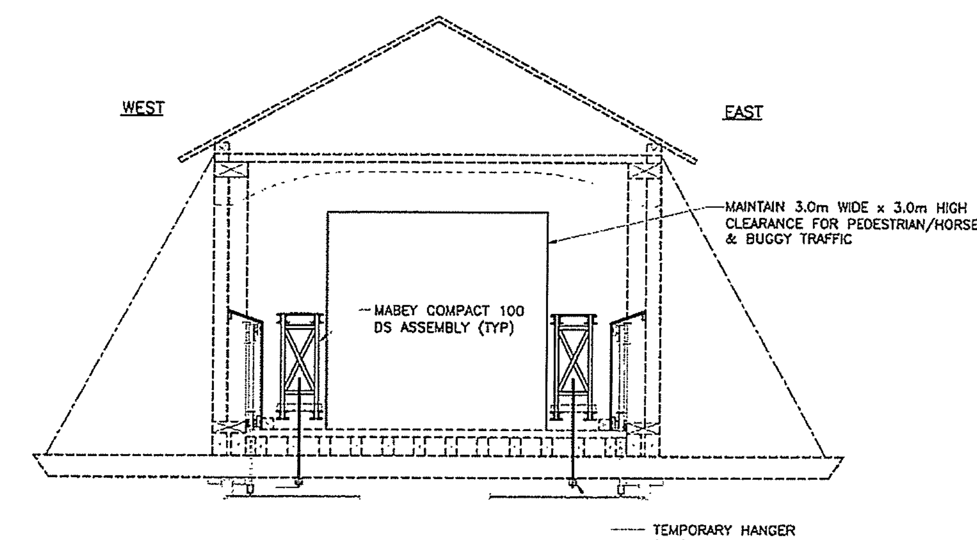

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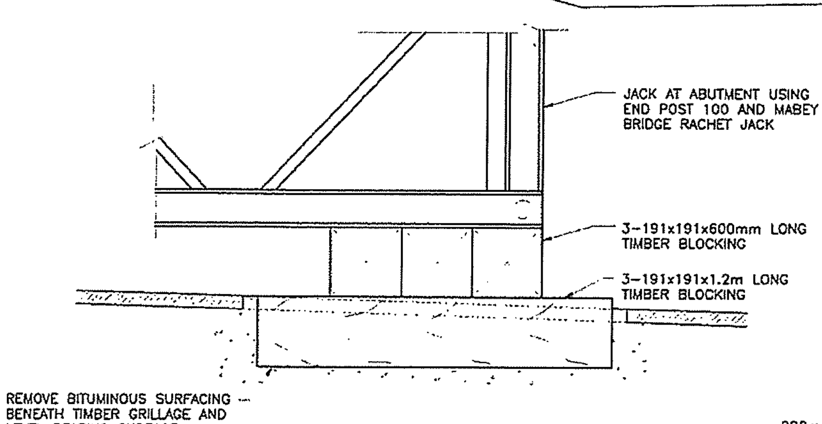

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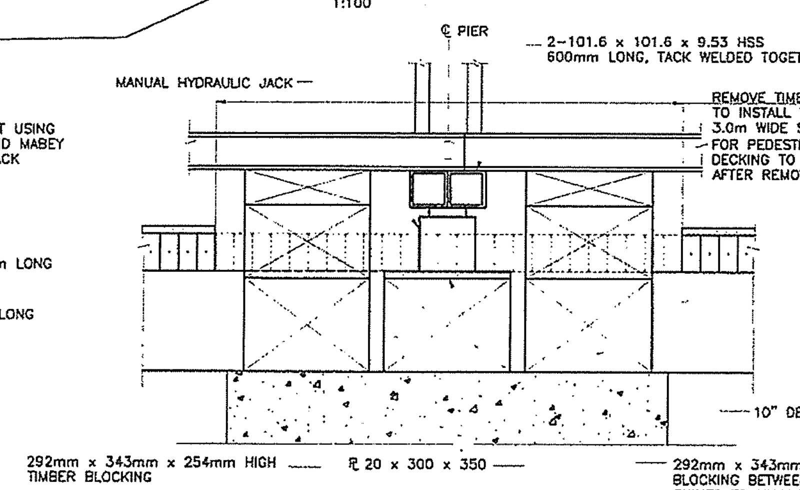

PIER SUPPORT DETAIL
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TEMPORARY SUPPORT REACTIONS AT SERVICEABILITY STATE		
LOAD	LOCATION	
	ABUTMENT	PIER
DEAD LOAD	100 kN	360 kN

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FIELD BOOK No:

CONTROLLING BM:

LICENSED PROFESSIONAL ENGINEER D.B.MOORE PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER E.P.BRUBRITT PROVINCE OF ONTARIO

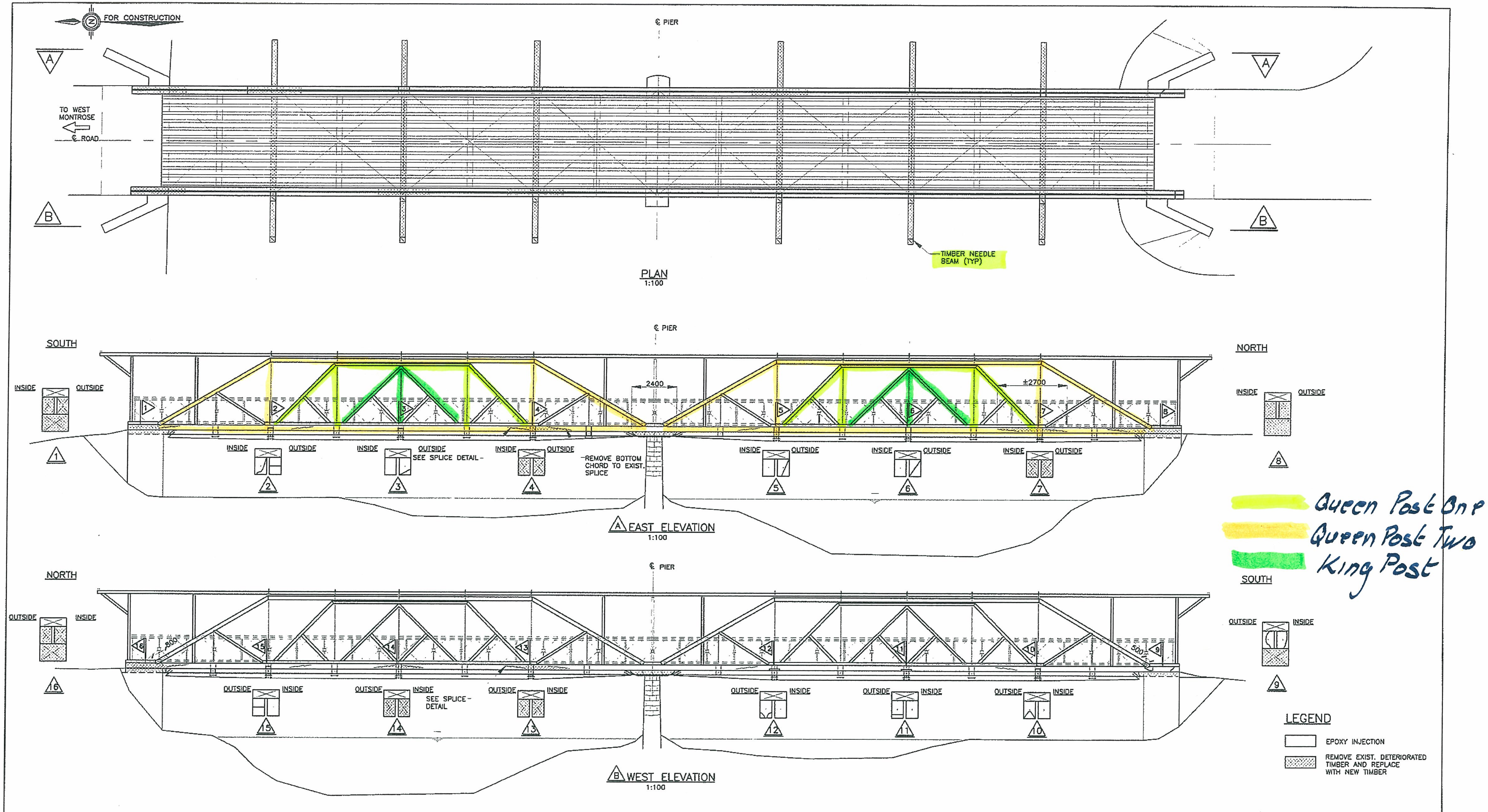
No	REVISIONS	BY	DATE
	ISSUED FOR TENDER		SEPT. 7/99

The Regional Municipality of Waterloo

WEST MONTROSE COVERED BRIDGE REPAIRS

TEMPORARY SUPPORT SCHEME FOR BAILEY PANEL REPLACEMENT

SCALE: AS SHOWN
DWN: DG
CHK'D: DBM
DWG No:
DATE: AUG. 1999
FILE No: 5885
CONTRACT No: 99038
CADD FILE NAME:
SHEET 2 OF 6



FIELD BOOK No:

D.B.MOORE — LICENSED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO

E.P.BRUMFITT — REGISTERED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO

CONTROLLING BM:

No	REVISIONS	BY	DATE
	ISSUED FOR TENDER		SEPT. 7/99

The Regional Municipality of Waterloo

WEST MONTROSE COVERED BRIDGE REPAIRS

TIMBER TRUSS REPAIRS

SCALE: AS SHOWN

FILE No: 5885

DWN: DC CHK'D: DBM

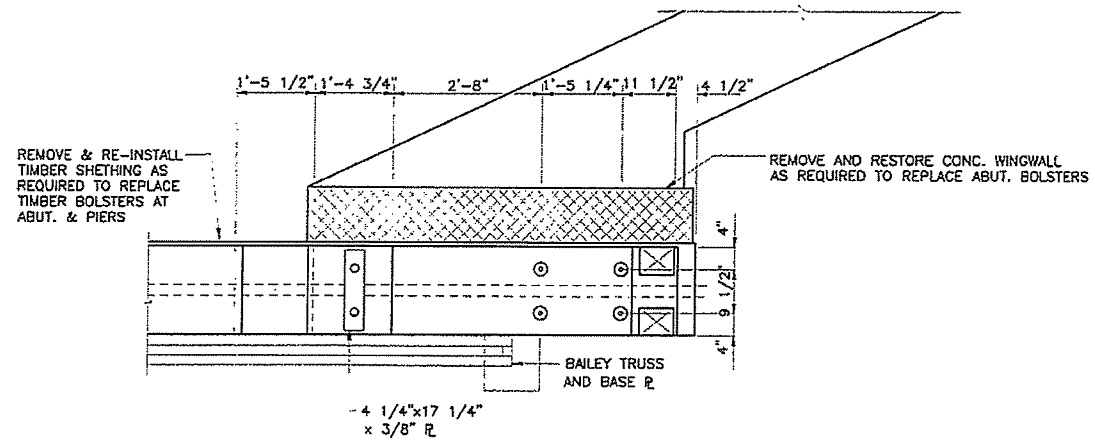
DATE: AUG. 1999

CONTRACT No: 99038

DWG No:

CADD FILE NAME:

SHEET 3 OF 6



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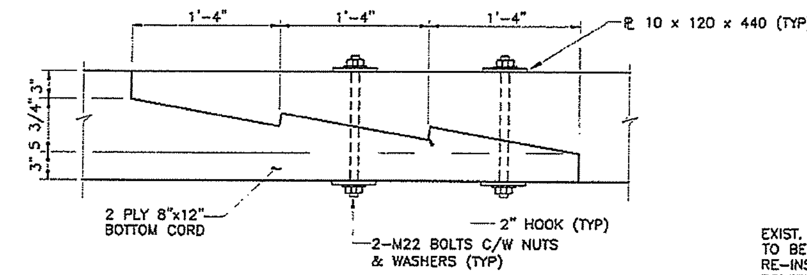

BOTTOM CHORD SPLICE DETAIL

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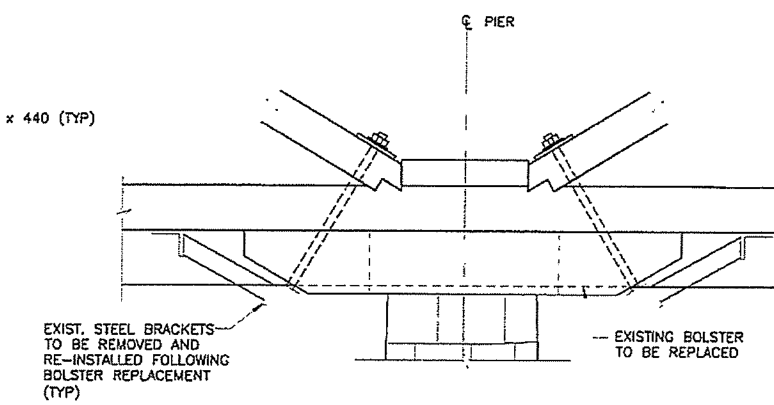

PIER BOLSTER REPLACEMENT DETAIL

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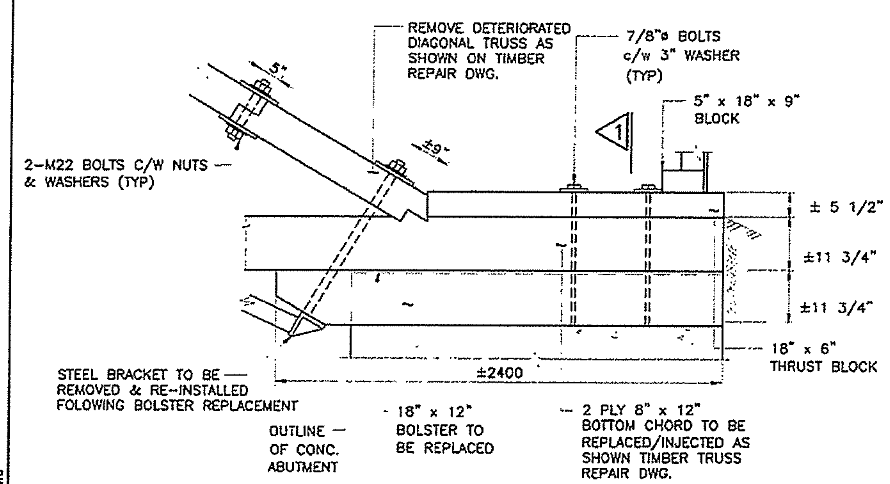

ELEVATION

B ABUTMENT BOLSTER REPLACEMENT DETAIL

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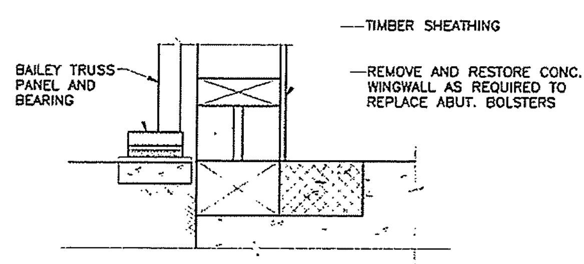

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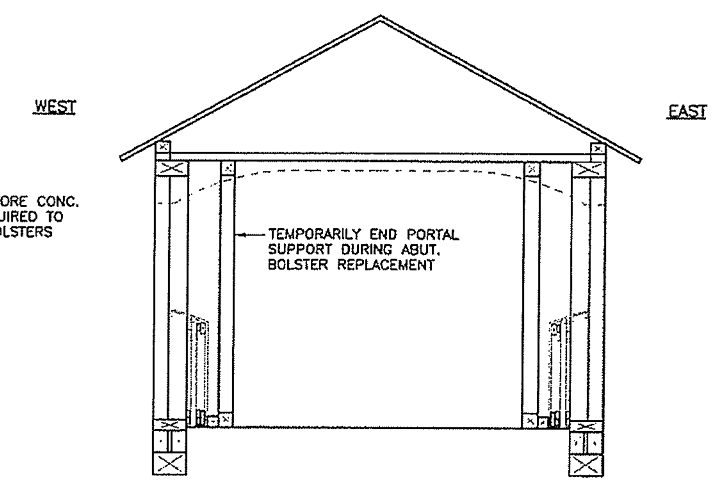
1:20



TYPICAL SECTION

1:50

P:\W99080\DEPT_47\WESTMONTROSE\WMCBR072.DWG

FIELD BOOK No:

D.B.MOORE — LICENSED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO

E.P.BRUMFITT — REGISTERED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO

CONTROLLING BM:

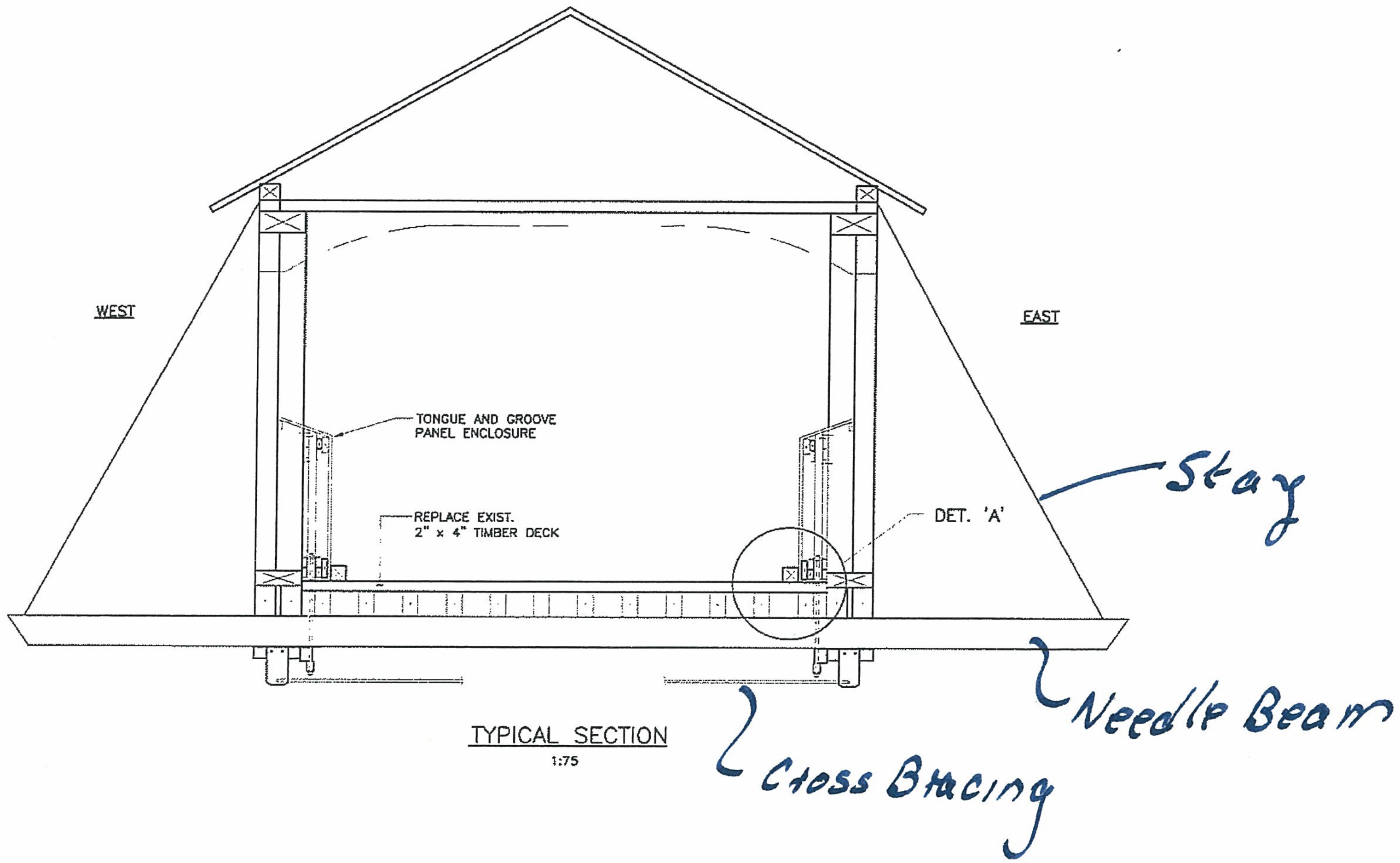
No	REVISIONS	BY	DATE
	ISSUED FOR TENDER		SEPT. 7/99

The Regional Municipality of Waterloo

WEST MONTROSE COVERED BRIDGE REPAIRS

REPAIR DETAILS 2

SCALE: AS SHOWN	DWN: DG / CHK'D: DBM / DATE: AUG. 1999	DWG No:	
FILE No: 5885	CONTRACT No: 99038	CADD FILE NAME:	SHEET 5 OF 6



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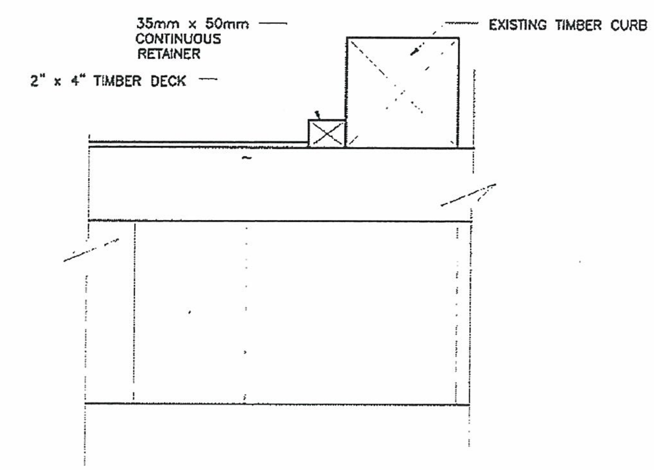
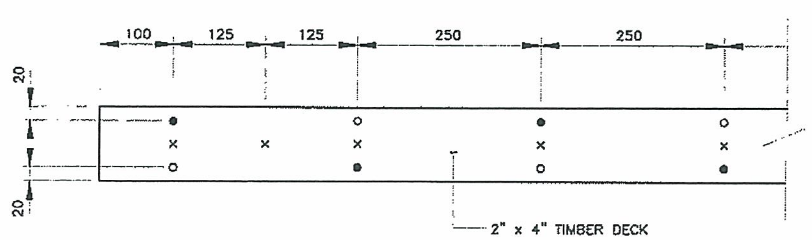


DETAIL 'A'
1:20



NAILING PATTERN
1:20

NOTES:

- ● INDICATES NAILING OF 1st LAMINATION
- ○ INDICATES NAILING OF 2nd LAMINATION
- × INDICATES NAILING OF 3rd LAMINATION

100mm LONG COMMON NAILS IN ACCORDANCE WITH CSA STANDARD B111-1974, SHALL BE USED

EACH LAMINATE TO BE TOE NAILED TO EACH STRINGER

CONSTRUCTION SEQUENCE:

1. REMOVE AND SALVAGE TIMBER CURB.
2. REMOVE AND SALVAGE TONGUE & GROOVE PANELING.
3. REMOVE EXISTING 2" x 4" LAMINATED DECK.
4. RE-ALIGN FLOOR STRINGERS.
5. INSTALL NEW DECK.
6. REINSTALL TONGUE & GROOVE ENCLOSURE.
7. REINSTALL CURB PLUS RETAINER STRIP.
8. INSTALL DECK WEARING SURFACING.

FIELD BOOK No:

D.B.MOORE — LICENSED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO

E.P.BRUMFITT — REGISTERED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO

CONTROLLING BM:

No	REVISIONS	BY	DATE
	ISSUED FOR TENDER		SEPT. 7/99

The Regional Municipality of Waterloo

WEST MONTROSE COVERED BRIDGE REPAIRS

DECK REPLACEMENT

SCALE: AS SHOWN
FILE No: 5885
DWN: DG
CHK'D: DBM
DATE: AUG, 1999
CONTRACT No: 99038
DWG No:
CADD FILE NAME:
SHEET 6 OF 6

Appendix 3 – 10-Year Capital Plan

West Montrose Covered Bridge 10 Year Capital Plan

		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
CAPITAL IMPROVEMENTS		Cost ($000's)											
Fire Protection	Fire alarm	15											
	Retardant Coating												
	Dry Sprinkler Header		40										
	Automated Sprinklers			225									
	Lightning Arrestor	10											
Signage	Regulatory	10											
	Advisory	15											
Safety	Illumination		35										
	Approach Works	20											
	Load Postings	In Place											
Structural	Strengthening Floor Beams					100							
	Strengthening General (add Bailey)				350								
	Bracing Restoration	10											
Natural Hazards	Climate Investigations	20											
CAPITAL MAINTENANCE		Cost ($000's)											
Survey Sensor Installation		5											
Roof Reshingling (25 yr cycle)						75							
Exterior Painting									50				
Interior Painting				10									
Capital Works Total		$ 105	$ 75	$ 235	$ 350	$ 175	$ -	$ -	$ 50	$ -	$ -	$ -	$ 990
DISCRETIONARY WORKS		Cost ($000's)											
Discretionary	Reduce Sag				10								
	True Frames	10											
Discretionary Total		$ 10	$ -	$ -	$ 10	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 20
MANDATORY MAINTENANCE		Cost ($000's)											
Inspection		2	2	2	2	2	2	2	2	2	2	2	
Monitoring Surveys		2	2	2	2	2		2		2		2	
Fire Systems Testing		2	2	2	2	2	2	2	2	2	2	2	
Cladding Repairs					2				2				
Maintenance Works Allowance		6	6	6	6	6	6	6	6	6	6	6	
Maintenance Total		$ 12	$ 12	$ 12	$ 14	$ 12	$ 10	$ 12	$ 12	$ 12	$ 10	$ 12	$ 130
Yearly Total		**$ 127**	**$ 87**	**$ 247**	**$ 374**	**$ 187**	**$ 10**	**$ 12**	**$ 62**	**$ 12**	**$ 10**	**$ 12**	**$ 1,140**

Importance	Key/Totals ($000)
High/Mandatory	$ 365
Moderate /Optional	$ 485
Capital Maintenance	$ 140
Dicretionary	$ 20
Mandatory Maintenance	$ 130

Appendix 4 – Fire Detection System Overview

Fire alarm system detection control panel located in the fire pump/sprinkler system room.

The fire alarm system control panel will be addressable based on Chubb Edwards's system ETS firm ware.

Designed will be based on ULC-S524: the standard for the" Installation of Fire Alarm Systems" in conjunction section 32 of the "Ontario Electrical Safety Code" (OESC)

System verification will be as per the requirements of ULC-S537 "the standard for the "Verification of Fire Alarm System"

The final system design will be reviewed with the local Authority Having Jurisdiction (AHJ) for conformance to the local by-laws.

System will be provided with output relays for third party monitoring. This will allows monitoring by land line and cellular phone (wireless connection).

The detection method for the bridge structure will utilize a "Thermo Cable System", "Leaner Heat Detection" (LHD)

A class "A" cables loop will run at the ceiling level for the full length of the enclosure. Two class "A" loops that will run at the lower level in the Bailey trust enclosure on either side of the structure. A total 3 loops will be utilized for maximum detector.

A 200 deg.F. Fixed temperature fire detector will be installed in the pump room.

Fire alarm system manual pull station will be located at the interior of the door of the pump room.

Notification device (bell or horn) in tamper proof enclosure will be located on the exterior of the pump room to alert the general public of a fire emergency.

Fire alarm panel will monitor for the following:

- The dry sprinkler system valves for tamper and water flow.
- Fire pump, based on the requirements of NFPA 20 "the standard for the "Installation of Stationary Pump for Fire protection".

Appendix 5 – MTO Structural Evaluation Report

STRUCTURAL EVALUATION REPORT

West Montrose Covered Bridge
Site 33-58

Ministry of Transportation, Ontario

Submitted by:

Giffels Associates Limited
Giffels Project No. W97129

Table of Contents

Page No.

Appendices

1.0 Introduction

1.1 Background

Throughout the 19th century the construction of covered timber truss bridges proliferated in North America. In the period from the construction of the first recorded bridge at the turn of the century (by Timothy Palmer in Philadelphia) to shortly after the American Civil War it is estimated 10,000 to 12,000 such bridges were erected in the USA alone. Although generally associated with the Eastern States it is worthy of note that Western states should be accorded the same association. Neglect, fire, flood and "progress" has sadly depleted that number significantly. 1300 were recorded by Adams 1963 as remaining in USA; by Petersen 1965, 1154; and by McKee 1977, 844.

Similarly, for the same reasons and in spite of many such bridges being constructed in New Brunswick in the twentieth century, numbers in Canada dwindled from a recorded 425 in 1965 (Petersen) to less than half that number in 1997.

The Harringtons (1975) record seven historic covered bridges built in Ontario; West Montrose, Frankford, Napanee, Peterborough, Trenton, Williamstown and Martintown. To these should be added the crossing at Shingle Bridge (Blair) on the Huron Road. West Montrose's Kissing Bridge represents the sole survivor of these. (It is noted one other covered timber truss bridge was constructed in Ontario for pedestrians in Guelph 1992).

Giffels Associates Limited was retained by the Ministry of Transportation, Southwestern Region to carry out a detailed inspection and structural evaluation of the West Montrose Covered Bridge (Site 33-58) (photos 1 through 5). Quaile Engineering Ltd. was retained by Giffels as special consultant to perform inspection and evaluation of the timber components.

1.2 Structure History

The structure is located on a township road off Waterloo Regional Road 86 over the Grand River in Lot 71, Township of Woolwich, the Regional Municipality of Waterloo. The township road formerly formed part of Regional Road 86.

Following design in 1880 (see Appendix E for specifications)

> *"The covered bridge at West Montrose was built for Woolwich Township, Waterloo County, by the Bear (or Baer) brothers Sam and John in 1881, at a cost of $,3179.50.*

The finest pine timbers some of them 9" X 18" X 50' were cut and hauled from Doon. Their finished bridge measured 196.5 feet across the Grand River with an additional 6-foot overhang at each portal. The bridge was 17 feet wide inside with a 13-foot clearance, and consisted of two equal spans resting on cedar cribs, now replaced by concrete (wing) abutments and a stone centre pier. The louvered window openings admitted air and light while keeping out snow and rain. The 3-inch oak planking was laid transversely and not nailed down" (Harrington, 1975).

By 1933,

"in spite of sheeting outside and to a height of 5 feet inside, moisture had rotted part of the lower chord. A needle beam was replaced and the timber chord spliced with steel plates" (Harrington, 1975).

At this time (or possibly later) much of the exterior sheeting of the west wall and part of the east wall was replaced. It is noted the original sheeting is tongue and groove battens between boards while the 'new' is butting barn boards with a batten covering the joints.

A major rehabilitation of the structure was carried out by the Ontario Department of Highways in 1950 when the original flooring was replaced with a laminated deck (2" x 4" laminations). The 2" x 4" spruce timber deck is covered with 1"± asphalt and is supported on a mixture of 5" x 10" No.1 White Pine (original) and 6" x 12" No. 1 Douglas Fir (new) stringers at 18"± centres. It is also recorded that approach modifications, installation of electric lighting and rebuilding of the centre pier (top?) was also included in the work. Highway 86 was re-routed north of the existing road (and the Village of West Montrose) in 1950.

As a result of concerns over the structural integrity of the bridge, in 1965 the Ministry reinforced the bridge by the introduction of Bailey Panel Trusses placed parallel to and adjacent to the existing timber trusses.

The original internal paneling (to protect the lower 5' - 0" of the timber truss) was removed to place the Bailey Trusses. After installation, new tongue & groove paneling was added to enclose the Bailey (see drawings Appendix C) resulting in a sympathetic reinforcement of the structure retaining the visual characteristics of the original, the Bailey being completely hidden (Photos 10 through 13).

The original roofing fabric (No. 1 shingles, 5 inches to the weather) was replaced in 1987.

A chronological record of construction/maintenance of the bridge is included as Appendix D This summary is based on Ministry of Transportation Records, newspaper reports, literature reviews and reports from historical documents in the care of the Waterloo Historical Society

The superstructure is now supported on concrete abutments and a masonry pier (photos 1, 2, and 55). The date of replacement of the originally specified timber substructure is unknown, as are details of the current substructure.

The bridge provides a roadway width of approximately 15' between timber curbs and accommodates a single lane of vehicular traffic.

1.3 Structural Systems

The trusses of the West Montrose Bridge are commonly referred to in literature as Queen Post Trusses. However their configuration does not truly represent a Queen Post and is probably more correctly described as a hybrid Howe configuration. The confusion probably arises from the unusual (if not unique) top chord configuration which gives the impression of two superimposed Queen Posts with a King Post at mid-span (photos 9 through 11). A true Queen Post includes two or three verticals, single uniform top chord and inclined end members (i.e. no interior diagonals). Queen Posts were entirely of heavy timber construction.

William Howe introduced iron rods as a modification to the popular 'Long' truss in 1840. He substituted iron rods with nuts and turn buckles for the timber uprights of the 'Long' configuration. However, as noted, the top chord configuration and joint configurations of the West Montrose Bridge represents a unique departure from the typical 'Howe' truss.

Cross bracing (iron rods) is included below the bottom chord (photo 26) to transfer lateral loads to the support points. The cross bracing was supplemented with longitudinal chord reinforcing rods in 1959 (photos 28 and 33).

The enclosure is simple post and beam construction typical of framed buildings of the time. However the system providing lateral stability of the frame is rare. Lateral stability is provided by the extension of alternate floor beams (needle beams) beyond the trusses to accommodate an inclined exterior rod brace (photos 1 through 4). This system was considered poor practice since it was considered that *"each passage of load would throw the top of the truss* (and enclosure) *back and forth on account of the deflection of the floor beam" (Fletcher & Snow in American Wooden Bridges 1976)*. The system has been supplemented by steel ships knees and cable bracing (photos 18 and 19)

Few examples of this form of bracing have been found in the literature and those found incorporate enclosures around the brace/needle beam to prevent the deterioration observed at

West Montrose. (Protection of some kind was an original intent at West Montrose, see Appendix E although it is not known if it was included in the original construction.)

Although added at a later date and of secondary interest, the Bailey system is of some historical significance. The system was developed by Donald Bailey of the Experimental Bridging Establishment in 1941 for the use of Allied Forces. Full scale production started in July 1941 with almost 700,000 panels being produced over final war years. The panels included in the West Montrose Bridge are part of this number being date marked 1944 and including the steel mill designated Frodingham.

> *"The Bailey Panel, BB.1, is a welded fabrication comprising two chord members interconnected by vertical and diagonal bracing. These members are made from special high tensile steel. At one end of the panel both chords terminate in male lugs and at the other end in female jaws. Panels are connected together end-to-end by engaging these lugs and jaws and inserting panel pins through the pin-holes."*

The bearing plates are modified type, B.B. 19. (photos 42 through 48)

> *The Bearing, BB.19, is a flat plate upon which a round bar is supported by four shaped stiffeners which divide the round bar into three sections. It accepts the loads from the end posts of the bridge and transfers them to baseplates or to concrete foundations. In single truss bridges, the end post sits on the centre section of the bearing bar.* (Bailey Uniflote Handbook)

Modification of this bearing by removal of end section of the bearing bar together with the selected placement location of the end post results in an uneven pressure distribution under the plate. The modifications were presumably made to facilitate installation and permit enclosure construction and timber curb placement to provide maximum roadway width.

2.0 Field Review

2.1 General

In order to determine the current condition of the structure, to confirm documentation and to obtain data for use in the structural evaluation process, a detailed field investigation was carried out. The inspection was carried out on June 4, 1997 through to June 10, 1997. The timber components including the truss members, timber decking, stringers and floor beams were inspected by Stephen Boyd, P. Eng., from Quaile Engineering Ltd. The Bailey reinforcing and substructure was inspected by D.B. Moore, P. Eng., from Giffels Associates Limited.

Inspection of the Bailey reinforcing and enclosed areas was made more difficult by a family of raccoons living behind the timber sheeting. It appears by the amount of dung and the number of raccoon carcasses found along the bottom chord of the truss, that the animals have been making the bridge their home for some time (photos 8 and 41).

2.2 Procedures

The inspection was carried out in accordance with Ministry procedures and included:

- A complete visual inspection of the structure from below, including visual inspection, sounding and coring of the cross beams and joists, the sills, the truss bottom chords, the deck, bracing and the hangers connecting the needle beams to the Baileys. As part of our procedure, each of the beams and chord members was drilled (and/or cored) in at least two locations, each in a sufficient number of locations so that any decay or deterioration observed or detected by sounding can be quantified. Test holes were treated with copper napthenate and treated plugs were inserted to prevent infection of the interior. The joists and deck were also sampled according to the sounding results. Drilling was also done at suspect locations.

- Inspection and testing of the structure interior including the main timber trusses, the truss connections and the wall and roof framing, the roofing and cladding (see Appendix A).

- Recording of member and connection details, dimensions and photos for the purpose of preparing record drawings and analysis. (see Appendices B and C)

- Identification of Bailey components.

- Inspection of Bailey components particularly in areas of modification, bearing points and connection pins and retainers.
- Inspection of bearing packing at support points.
- Review of hanger connections and components at Bailey chords.
- Inspection of chord bolts for tightness or evidence of distress.
- Review of Bailey/timber truss attachment.
- Visual inspection of pier and abutments.
- Riverbed sounding adjacent to pier to identify areas of possible scour.

Inspection of the underside bridge soffit was carried out from a specially constructed raft. Procedures were reviewed with the Grand River Conservation Authority prior to carrying out the work. The raft was also utilized for pier inspection and river sounding (photo 6).

In order to review the Bailey structure and condition of the lower portion of the truss, selective removal of the tongue and groove panelling was required (photo 7). Removal and reinstatement was carried out by Care Carpentry.

The structure operates as a single lane facility. During interior inspection, barriers were placed at either entrance and traffic escorted through the work area at walking speed. Traffic control was provided by Giffels Associates Limited.

2.3 Observations

2.3.1 Bailey Components

The Bailey Truss reinforcing consists of single-single panels with top and bottom chord reinforcing, except at the end panels where the bottom chord reinforcing has been omitted. The Bailey panels and chord reinforcing are in good condition with only light corrosion and pitting in the paint surface. No noticeable section loss was observed (photo 34 through 39).

The Bailey panels are connected to the floor beams with hangers consisting of two 1" dia. rods bolted to two 4" x 4" x 5/16" angles welded together to form a box (photo 29). The hanger assemblies exhibit medium to severe corrosion with between 5% to 20% section loss. The hangers on the west side of the structure are in worse condition than those on the right which is consistent with the deterioration of the needle beams. There is no evidence of a protective coating system on the hanger assemblies.

The Bailey reinforcing is supported by built up structural steel blocking at the pier. The bearings appear to be built up from plates and wide flange members. The bearings exhibit medium corrosion throughout with no evidence of a protective coating system. The reinforcing detail for the lower portion of the centre vertical at the pier bearing as shown on the Bailey reinforcing drawings (Appendix C) was not implemented.

The bearings at the abutments were covered with several inches of raccoon dung, dirt and debris (photos 38 & 40). All of the bearings exhibit a noticeable tilt of approximately 15°± to the outside (photos 42 through 48). The standard Bailey bearings were cut to fit and installed off centre. The grout pads beneath the bearings have disintegrated, (with possible uneven movements which resulting in the tilt). The bearings exhibit only light corrosion, however, the bearing base plates are severely corroded and as such the movement of the superstructure is probably occurring between the base plates and the disintegrated levelling pad.

A differential elevation survey was also done at exposed top chord locations along each panel line. The shots were taken at the top of the chord reinforcing and at the top of asphalt adjacent to the curb. The results indicate that the Bailey reinforcing was installed after the trusses began to sag but the deflection in the Bailey indicates that some of the dead load has since transferred to the Bailey. (A significant sag can be seen in the roadway and truss top chord as compared to the level line of the top edge of the paneling installed with the Bailey, see photos 9 through 11).

Comparison of top chord elevations at support locations suggest no overall settlement of the substructure has occurred since the installation of the Bailey.

2.3.2 Heavy Timber Construction

A detailed description of areas of deterioration of the timber components is included in Appendix A, "Inspection of Timber Components, West Montrose Covered Bridge" Quaile Engineering Ltd. The findings may be summarized as follows:

a) The 2 x 4 deck was found to be in good condition with no serious deterioration.

b) The timber stringers are generally in good condition. Some of the 5" x 10" white pine members have surface decay. One stringer has a large split at grid line 8 and requires reinforcing. Many stringers are not fastened to the deck and are not bearing tight on top of the 12 x 12 inch beams.

c) Each of the 12 x 12 inch needle beams that extends out past the face of the bridge along grid lines 2, 4 and 6 is seriously decayed. Typically the decay extends from the ends of the 12 x 12 beam inward under the trusses (photo 32).

d) The bottom chords of the trusses are decayed where they cross over the needle beams. In a number of locations over half of the chord area has decayed. The decay is extremely severe at grid lines 2, 4 and 6 of the north span. In particular, the bottom chord of the north-east truss at grid line 2 is almost fully decayed.

The bottom chords are also decayed at the abutment. The decay also extends up the top chord in three of the four locations.

As a result of the decay, the bottom chords have lost most of their load-carrying capability.

e) The bolts connecting the thrust block to the bottom chords are loose.

f) The 12 x 12 beams along lines 1, 3, 5, and 7 are all in good condition (they do not extend out past the sidewalls of the bridge) (photo 29).

g) The timber bolsters at the centre pier are severely decayed (photos 65 and 68). This has resulted in crushing of the wood, in particular the east bolster at the north abutment has crushed recently since fresh wood is visible (photo 24).

As a result of the decay, the heels of the trusses have lost most of their load-carrying capability, i.e. load transfer to the abutments is primarily through the Bailey. In addition, continued deterioration will result in additional settlement.

h) The bottom chord splice in the southwest truss between lines 6 and 7 has failed. Also, the splice in the northwest truss between grid lines 2 and 3 has failed (see photo 7). The splices near grid line 7 on the east trusses have been reinforced with a 6 x 10 Douglas Fir block and split rings.

i) The rod cross bracing and chord reinforcement rods below the deck are very loose (photo 26). All of the steel hardware including the rods are corroded.

The truss components above the deck are generally in good condition with no decay. The following two defects were however noted:

a) A diagonal crack in the top chord of the southwest truss. It has been reinforced with bolted steel plates above and below the chord.

b) There are large gaps between the end diagonal web and the top and bottom chord of the north trusses at grid lines 1 and 2.

c) Split diagonal member within enclosure (photos 36 and 37).

2.3.3 Roof Structure and Wall Cladding

a) The 6 x 6 post at the southeast abutment (line 0) has a large split at the top.

b) The scarf joint in the 7 x 6 roof beam at grid line 8 (east side) has pulled apart. The joint has been reinforced with three 2 x 8 members bolted to the underside of the beam. Cables connecting the beam to the west trusses have also been added.

c) The top of the 6 x 6 post at grid line 7 at the northeast truss is split.

d) The other roof components are in good condition (photos 18 and 19). Some of the rafters and roof sheathing have surface decay, but it is not serious.

The board and batten wall cladding is in fair condition (photos 2 and 4). It is weathered and loose in many areas. The bottom of the cladding is decayed, particularly at the abutments (photo 23). While the deterioration is not a structural problem, it does mean that rain water can penetrate through the cladding and wet the trusses.

Some distortion and displacement of the portals was also observed (photos 12 and 13).

2.3.4 Substructure

The southwest concrete wingwall is extensively delaminated and exhibits light to medium erosion, and horizontal cracking with stained exudation (photo 56). The top of the wingwall adjacent to the truss bearing has been patched with concrete.

The south abutment face has light to medium erosion (photo 55). The bearing seat below the stringers has been patched. Four of the patches are delaminated (photo 57). The concrete patch below the southwest truss bearing is also delaminated (photo 58).

The southeast wingwall (photo 55)has three small areas of delaminated concrete, light to medium erosion and cracking stained with exudation. Also noted were cold joints and spalled concrete at the end of the wall.

The north abutment and wingwalls have severe erosion at the water line (photos 51 through 53). A past attempt to repair the erosion with a reinforced concrete facing and rock filled gabion baskets has failed (photos 50 through 51).

The concrete below the northwest truss bearing is disintegrated.

The northeast wingwall has been patched and exhibits spalled concrete with an exposed corroded reinforcing steel bar.

The east end masonry pier has settled approximately 0.3 m with respect to west end (photo 2). The masonry exhibits a deep loss of mortar over small areas (photos 60 and 61). Previous mortar repairs were noted. The bearing seats for the timber stringer and truss has been levelled with concrete Photos 62 through 64).

3.0 Evaluation

The structural evaluation was made assuming the following criteria:

1. Live loads equivalent to the Ontario Highway Bridge Evaluation Load Level 1 in accordance with the Ontario Highway Bridge Design Code-91.

2. Snow loading in accordance with Ontario Building Code has been included in Ultimate Load Combination 1 with a load factor of 1.0.

3. The abutment and pier foundations are adequate to support the superimposed dead and live loads. (No recent pier settlement or distress attributed to overloading was noted).

4. The structure was constructed in accordance with the detailed plan.

5. Timber unit weights are as follows:

Cedar	3.5 kN/m^3 (Shingles)
Douglas Fir	5.3 kN/m^3 (Floor Beams)
White Pine	4.1 kN/m^3 (Truss, Sheathing, etc.)
Spruce	4.7 kN/m^3 (Deck)

6. The timber strengths are as follows:

Species	Specified Bending Strength (MPa)	Specified Shear Strength (MPa)
Douglas Fir No. 1	20.0	1.1
White Pine No. 1 *	6.6	0.8

* specified strengths for White Pine are not available in Table 9-11.2 of OHBDC 91 - values shown have been interpolated from Tables 9-11.2 (a) and 9-11.2(b) for Red Pine.

The timber stringers and floor beams are in good condition and do not require a reduction in factored resistance for defects and deterioration. However, the effects of end splits have been taken into account when calculating the factored resistance for shear capacity.

7. The Bailey truss is constructed of old material ($F_y = 238$ MPa) with an ultimate moment capacity of 1726 kN·m and an ultimate shear capacity of 268 kN. Moment of inertia of a

SSR panel is 130.3 x 10^8 mm^4. The Bailey truss is in good condition, no reduction in factored resistance due to deterioration is required.

Summary of Findings

Component	Scale Down Factor	Bridge Posting	Including Snow	
			Scale Down Factor	Bridge Posting
Bailey Positive Moment	0.48	11 tonnes	0.39	8 tonnes
Bailey Shear at Abutment	0.48	11 tonnes	0.38	8 tonnes
Bailey Shear at Pier	0.22	* Consider Closure **	0.16	*Consider Closure
Stringers - Moment - Shear	0.31 1.53	5 tonnes No posting	-	-
Floor Beams - Moment - Shear	0.17 0.68	* Consider Closure	-	-

* From OHBDC CL 11-7.3.1c

** Extrapolation of Chart OHBDC Figure 11-7.3 provides posting requirement of 2.5 Tonnes

Computer modeling indicates that the Bailey Truss should deflect a maximum of 14.5 mm due to the total weight of the timber bridge. The following table shows the measured deflections, deflections corrected for estimated sag and elastic deflection due to Bailey self-weight and estimated percentage of the total weight of the superstructure transferred to the Bailey truss.

Location	Measures Max. Δ in Bailey (mm)	Estimated Bailey Sag and Deflect (mm)	Deflection Due to Truss (mm)	Estimated % of Truss Transferred to Bailey (Δ/14.5)
NW	43	39	4	28%
SW	73	39	34	100%
NE	52	39	13	90%
SE	20	39	-	0

The evaluation was carried out assuming all load carried by the Bailey systems. It is evident from field observation and consideration of deflections that this is not so. Acknowledging this fact and recognizing that vehicular traffic is effectively restricted to light vehicles, closure is not considered required at this time (the current posting of 3 Tonnes should be maintained). However, if the structure continues to carry traffic and deterioration of the truss continues shear capacity at the pier will cause serious concerns. If the bridge is to remain open indefinitely it is recommended to replace or reinforce the panels at the pier (e.g. with Mabey-Johnson Panel or equivalent (Fy = 355 MPa). F = 0.41 (8 tonnes) or F = 0.30 (5 tonne) with snow loading).

Although not in accordance to the OHBDC 91, it is estimated that based on a rational analysis the floor beams have a reserve capacity in moment for a 5 tonne axle load assuming an axle spacing greater than 11'-6".

4.0 Discussion

4.1 Rehabilitation Methodology

Recommendations provided in the following are based on the philosophy that the rehabilitation work be sensitive to historical significance and character of the structure, be unobtrusive and maximize the preservation of the historic fabric and features, whilst ensuring public safety.

Significant sag and distortion was noted in the superstructure. It is considered, however, that the majority of this occurred prior to the installation of the Bailey System. Review of the elevations taken and the lines of the interior paneling suggest the distortions are now stable. No attempt has therefore been made to reduce these distortions rather ensuring no further progression. The distortions are considered a part of the historic character of this site.

It is inappropriate to attempt to upgrade the carrying capacity of the structure and it is recommended the current posting be retained. Concern has been expressed by several local residents with regard to violations of the posting, particularly by a vehicle. It is suggested that it may be appropriate at this time to close the bridge to motorized vehicles and thus eliminate these concerns. Constant impact loading by traffic, which is a source of advancement of deterioration in this type of facility (particularly at this abutment), would also be eliminated. The tourist industry would be unaffected as currently tour buses stop in the village to disembark passengers who then walk to the bridge. Meanwhile the busses travel to the south side of the river via Regional Road 86 (and the new bridge) to pick up their passengers.

This approach has been adopted at several other historic covered bridges and is probably more effective than trying to control load limits by other intrusive methods.

4.2 Bailey Components

The Bailey truss panels in general were found to be in good condition and hence require no maintenance at this time. A strength deficiency has however been identified at the pier location. The construction also differs from the 1965 contract drawings. At this location it is necessary to replace or reinforce the existing panels to ensure adequate shear capacity under full load (i.e., carrying total structure and live load) if the bridge is to remain open to traffic.

The abutment bearing assemblies are not level (photos 42 through 48). The condition at installation is not known, however, it is presumed that the base plates would be set level. The subsequent displacement may be attributed to deterioration of grout pad and shims and uneven load transfer between the timber truss and Bailey truss upon progressive disintegration and failure of the timber bolster seats. It is recommended that the bearings be re-levelled and grouted to ensure future stability of the facility.

The hanger systems installed with the bailey truss providing support to the needle/floor beams are in fair to poor condition. The systems on the west side of the bridge are in significantly worse condition than those to the east. It is recommended that these be replaced/refurbished as necessary.

4.3 Heavy Timber Construction

The timber needle beams are in poor to critical condition. Emergency repairs have been carried out when failures have occurred (photos 27 and 31). These beams form an essential part of the lateral stability of the enclosure and in this form are one of the unique features of this bridge. It is therefore recommended that all needle beams be replaced in entirety using the original form of construction. Alternatively the need to beam extensions could be eliminated (see Appendix A) thus removing future maintenance concerns. Internal knee braces would then be required to ensure lateral stability of the enclosure. If this work is not carried out within the next 9 to 12 months temporary repairs should be made at these locations.

Concurrent with this work, splice/reinforcing plates should be added to the chord members at locations where rot was detected.

At the pier and abutments, the bearing bolsters have rotted and crushed (photos 20 through 23, 65, 69) and at this time are not considered to be giving any support to the structure at this time. It is recommended that they be replaced with treated timber.

4.4 Enclosure

Much of the original sheeting remains, particularly on the east face. This is generally in fair condition although some rain penetration does occur at gaps and knot holes. The replacement siding is somewhat better condition and the batten strips over the barn board joints provides an adequate weather seal. Overall moisture penetration does not raise undue concern at this time. However, significant gaps should be repaired and missing boards replaced. Of greater concern is the presence of raccoons. Significant dung deposits are associated with all areas of rot in the enclosed areas. It is recommended that the raccoons be removed and their access eliminated, if possible.

4.5 Substructure

Scour and erosion was noted at the north abutment and the upstream end of the pier. The conditions do not appear to have changed significantly from the 1986 inspection carried out by Golder Associates. It is however recommended that total erosion protection in the form of gabion baskets and armour stone be added at the north abutment. Similarly, armour stone should be added at the upstream end of the pier.

No recent (at least since installation of the Bailey system) settlements were discernable at the pier or abutments. However, extensive loss of mortar in the masonry joints was noted particularly at water lines. These areas should be re-pointed. As with the re-pointing of historic masonry, care should be taken in selection of the mortar design. The guidelines provided by the Ministry of Citizenship and Culture should be following in this respect.

4.6 Other Considerations

The bituminous wearing surface is in poor condition with exposed board in many locations (photo 16 and 17). It is recommended that this be replaced.

In view of its road location relative to the wide flood plain it is not considered that flood conditions pose a threat to the superstructure. However this should be confirmed with a hydraulic review of the crossing which is beyond the scope of this investigation.

The remaining major threat to structures of this type is fire. The remote location of this structure leaves it particularly vulnerable. Consideration should therefore be given to application of fire retardants and/or the installation of a fire detection/protection system. Removal of all refuse and debris is also considered essential.

5.0 Cost Estimates

Cost to carry out the foregoing rehabilitation and preservation works are summarized as follows:

a)	Bailey Components		
	Pier Panel Replacement/Reinforcement	15,000	
	Repairs to Bearings (excl. temporary support)	5,000	
	Hanger Replacement (excl. temporary support)	15,000	
	Sub-total	35,000	35,000
b)	Heavy Timber Construction		
	Replace Needle Beams and Floor Beams	25,000	
	Replace Bolsters	10,000	
	Truss Repairs	10,000	
	Sub-total	45,000	45,000
c)	Enclosure		
	Cladding Repairs	3,000	
	Framing Repairs	2,000	
	Sub-total	5,000	5,000
d)	Substructure Repairs		
	North Abutment Erosion Protections	7,000	
	Pier Scour Protection	7,000	
	Pressure Grout/Pointing Pier	6,000	
	Sub-total	20,000	20,000
e)	Temporary Support during Work, Allowance		25,000
	Removal/Reinstall paneling		10,000
	Miscellaneous (cleaning, paneling repairs, painting approach works etc)		20,000
	Contingency		20,000
	Engineering and Supervision		50,000
	Total		**$225,000**

The estimates presented are dependent on the philosophy adopted for the preservation of the structure and represent budget costs only.

6.0 Summary of Recommendations

The rehabilitation/preservation work may be summarized as follows:

- Replace/reinforce centre Bailey panel.
- Repair/realign bearings.
- Replace hangers.
- Replace needle beams and floor beams.
- Replace Bolsters.
- Truss repairs.
- Minor repairs to siding.
- Add scour/erosion protection at pier and north abutment.
- Grout and repoint masonry pier.
- Carry out hydraulic review.
- Review fire protection.
- Review electrical installations.

7.0 References

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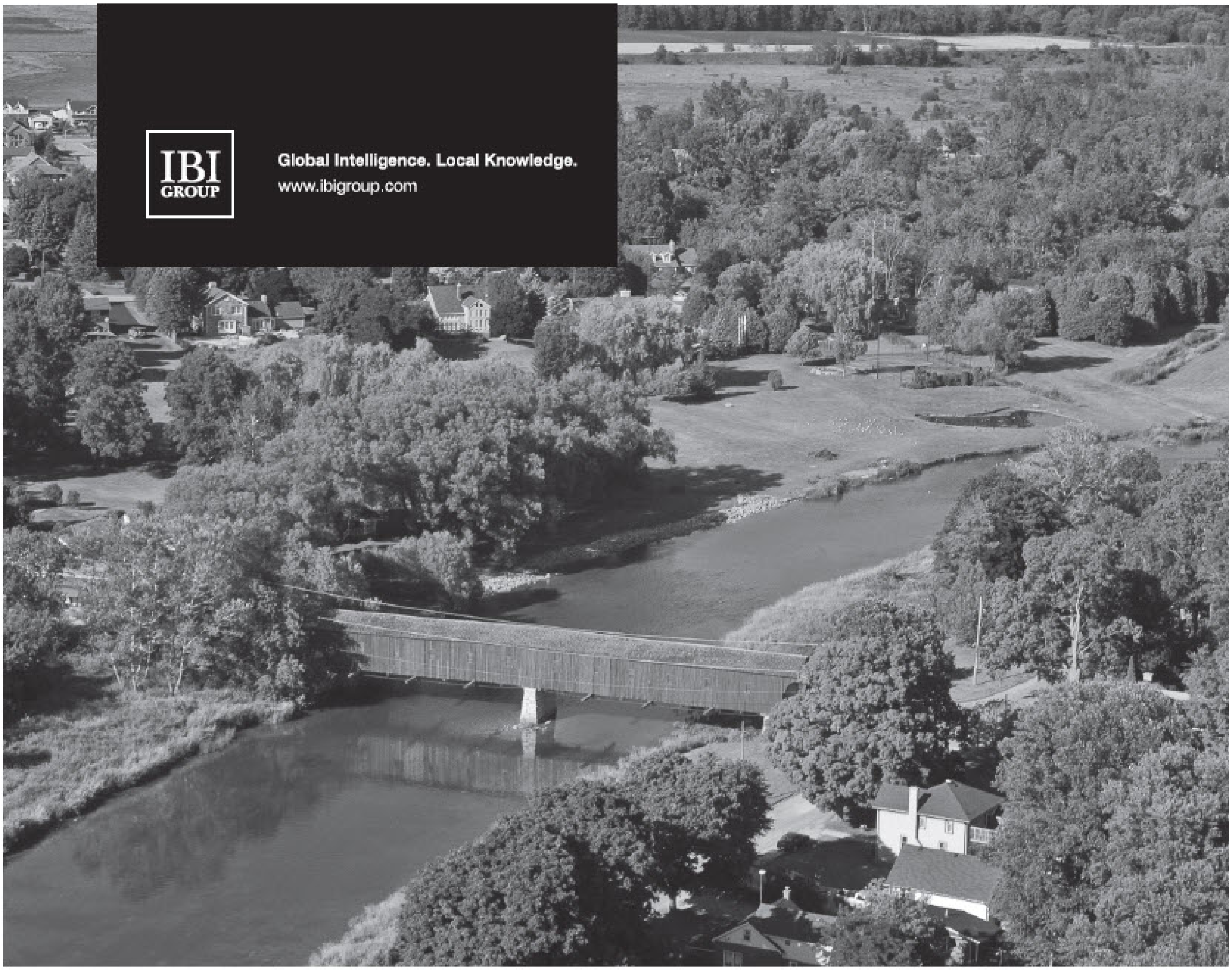

CONTACT US

IBI Group
30 International Blvd.
Toronto, Ontario M9W 5P3

tel 416 679 1930
fax 416 675 4620