Whitchurch Bridge Company

Toll Application Dated 31 October 2008

Proof of Evidence – Martin Brain, Oxfordshire County Council

1. Introduction

1.1 My name is Martin Brain. I am a Chartered Engineer and a Member of The Institution of Civil Engineers. I have specialised in the design, construction, assessment and maintenance of bridges for 25 years. I have been employed by Oxfordshire County Council in the Bridges Section since 1989, and have held the post of Principal Engineer since 1996.

1.2 Oxfordshire County Council was appointed by the Company of Proprietors of Whitchurch Bridge (hereafter referred to as the Whitchurch Bridge Company) in 1997 to act as its consultant in engineering matters relating to the toll bridge. On behalf of the Whitchurch Bridge Company the County Council's Bridges Section arranges for the following work to be undertaken;

- Bridge Inspections – Routine, Principal and Special Inspections plus Underwater Surveys.
- Maintenance Work – Routine and Structural.
- Load Assessments – calculation of current Load Carrying Capacity.
- Risk Assessments – identification of key risks and potential consequences.
- Procurement of specialist consultants for detailed architectural and engineering design.
- Procurement of specialist contractors for carrying out maintenance works and investigations.
- Supervision of maintenance works
- Provision of cost estimates for planned works.

1.3 All costs incurred by the County Council in carrying out this work, are reimbursed annually by the Whitchurch Bridge Company. This includes payments made to contractors and other consultants, together with the cost of my time and any other member of staff in the Council's Bridges Section who has an input.

1.4 My evidence to this Inquiry is presented as a member of the County Council's Bridges Section, on behalf of the Whitchurch Bridge Company. My views relate solely to the engineering issues associated with the bridge and are independent of any other opinions or statements which may be expressed by the County Council on wider issues such as Transport Policy and Planning.

1.5 In its role as Highway Authority, the County Council is responsible for the management and maintenance of over 1,000 highway structures. These include retaining walls, footbridges, culverts, subways, road and river bridges of varying sizes. The management of these structures is carried out within a framework of national engineering standards as set out in the Highways Agency Design Manual for Roads and Bridges (DMRB). These standards apply to all other Highway Authorities throughout the country, their purpose being to maintain the safety of all highway structures and to minimise the possible risks to highway users and others who may be affected. I have used my knowledge and experience of applying these standards to the county's bridgestock in order to advise the Whitchurch Bridge Company about the management of the toll bridge.

1.6 My evidence describing the work needed to the bridge is set out in the following Sections;

- 2 - Bridge Description

- 3 - Maintenance Strategy
- 4 - Condition of Bridge
- 5 – Major Maintenance and Structural Works Needed
- 6 – Load Assessment
- 7 – Risk Management Issues
- 8 – Summary of Structural and Risk Management Issues
- 9 – Reconstruction Proposals
- 10 – Reconstruction Costs

2. Bridge Description

2.1 Drawing No. B0479000/WHT/STR/001 [Ref: Statement of Reasons (SOR) Appendix J] shows the construction of the existing bridge which was built in 1902. It comprises four spans, each approximately 20.5m in length, and carries the B471 over the River Thames linking Whitchurch-on-Thames to Pangbourne. Each span comprises a pair of longitudinal wrought iron lattice girder trusses with transverse beams and jack arch buckle plates. The bridge is supported by brickwork abutments on each bank and by three intermediate piers in the river, each of which consists of a pair of piled, cast iron columns and associated cross bracing. The overall width of the bridge is 7.2m, with a 5.2m wide single carriageway carrying two way traffic and a narrow footway on one side only. The bridge has a 7.5t structural weight limit and carries a typical daily flow of 6,000 vehicles. It is designated as a Grade II Listed Structure and is situated within the Whitchurch Conservation Area.

3. Maintenance Strategy

3.1 Upon its appointment in 1997, the County Council prepared a Maintenance Strategy to cover the 25 year period up to 2022. This considered three different options for managing the bridge. Taking

account of its condition, its assessed load capacity and the maintenance work necessary, it was agreed with the Whitchurch Bridge Company that the optimum strategy was to programme for the reconstruction of the bridge in 2015, by which time it would be 113 years old.

3.2 I reviewed the strategy in 2004. I took into account several major maintenance and structural works which would need to be carried out over the following 5 – 10 years (repainting, rewaterproofing of the bridge deck, repairs to the cracked river pier columns) and the fact that these would require the bridge to be closed to the general public for several weeks at a time. I also took into account the likelihood that the existing 7.5t structural weight restriction would have to be reduced to 3t within 15 years, and the effect that would have on public service vehicles in general and buses in particular. Finally I also considered the inherent risks associated with the bridge's form of construction and the fact that the risks posed by overweight vehicles, vehicle impacts on the main girders and boat impacts on the river piers could not be reduced to an acceptable level unless reconstruction was carried out. My conclusion was to confirm the previous strategy, with the added rider that the reconstruction should not be deferred beyond 2015.

3.3 Since 2004 further Special Inspections have been carried out to investigate the cracking in the river pier column capitals and these have demonstrated that the cracks are still "live" i.e they are continuing to propagate. Since the cracks are caused by the lack of any provision for thermal movement in the original design, major works to introduce bearings at the top of the columns would be necessary. This would be very expensive because of the temporary works needed if carried out as an independent operation and would not help to deal with the other structural and maintenance issues, nor reduce other residual risks. My letter dated 24 October 2008 to

the Whitchurch Bridge Company [included as Appendix 1 to Document 1] therefore recommended that the pier repairs should be carried out in conjunction with the reconstruction work no later than 2015, but that in the meantime the frequency of the Special Inspections should be reduced to yearly.

4. Condition of Bridge

4.1 Inspections of the bridge are carried out in accordance with BD 63/07 (DMRB Vol.3). This states that General Inspections should be carried out at 2 yearly intervals and Principal Inspections at approximately 6 yearly intervals. Special Inspections are carried out only if a specific need arises and then at intervals appropriate to the particular purpose of the inspection.

4.2 The last Principal Inspection of Whitchurch Bridge was carried out in October 2003 by Babtie Group Ltd, the County Council's term consulting engineer at that time. This included a close up inspection of the river spans using a barge with scaffolding, Non-Destructive Testing (NDT) of the pier column capitals and a specialist condition survey of the bridge's paintwork.

4.3 The testing of the river piers showed that all 6 column capitals had cracks, varying in width from "hairline" to 1.5mm and with lengths from 320mm up to 1050mm long. Water penetration through the superstructure deck construction was noted in several places indicating breakdown of the deck waterproofing. The paint survey showed the coatings to be in generally good condition, but with localised breakdown on the deck soffit, consistent with the water penetration observed. This was particularly noticeable on the lower flanges of the main girders and transverse beams.

4.4 The principal recommendations in the Inspection Report were that

the rotted upstream timber fenders should be replaced and new fenders introduced at the downstream side, that increased weep holes through the deck construction should be installed and that a Special Inspection of the pier columns should be carried out in 2005 to monitor any changes in the recorded crack lengths.

4.5 The Whitchurch Bridge Company accepted the recommendations and the County Council subsequently prepared contract documents for the fender and drainage work which was carried out in early 2005.

4.6 In October 2005 the programmed Special Inspection was carried out by Jacobs Babtie with further NDT testing of the pier column cracks. This inspection also included a General Inspection of the remainder of the bridge. The testing confirmed that 2 of the cracks had increased in length by 3mm and 5mm. It was recommended that the Special Inspections should continue at 2 yearly intervals.

4.7 The Special Inspection planned for Autumn 2007 had to be postponed due to high river flows, but it was subsequently carried out by Jacobs in March 2008. This showed continued crack propagation, with a further increase of 5mm in one of the cracks and a new crack appearing (Ref: Special Inspection – Report Date June 2008 [Document 6]). My covering letter dated 26 March 2009 to the Whitchurch Bridge Company mentions the complexity of the operation needed to carry out permanent repairs and therefore repeats the recommendation that it should be carried out in conjunction with the reconstruction, providing that is not delayed beyond 2015, and providing the Special Inspections are continued to monitor the cracks.

4.8 My overall assessment of the bridge's condition is that, apart from the pier cracking, it is in reasonable condition for its age. However,

in addition to the pier repairs there are two major maintenance works operations which would have to be undertaken within the next 5 years; namely an overall maintenance painting of the whole structure and replacing the waterproofing membrane above the bridge deck. These are described in more detail in paragraphs 5.3 and 5.4 but both would cause considerable disruption whilst being carried out.

4.9 The bridge's form of construction is a contributory factor to these maintenance issues. The main lattice girders, transverse beams and curved buckle plates provide numerous water traps and therefore potential corrosion is an inbuilt, continuing problem. Any breakdown of the waterproofing membrane allows water to penetrate through the concrete infill above the buckle plates and then becomes trapped in the vicinity of the transverse beams. It is not possible to readily inspect these areas or the internal lower part of the lattice girders.

4.10 The purpose of current Highways Agency design standards is to ensure that any new structure will give a safe, low maintenance, 120 year design life. The existing bridge has understandably not been specifically designed for such maintenance considerations.

4.11 This, together with the other Load Assessment and Risk Management issues which are described in Sections 6 and 7, leads me to conclude that the 107 year old bridge is now approaching the end of what might reasonably be expected to be its useful working life.

5. Major Maintenance and Structural Works Needed

5.1 An outline of the maintenance and structural works needed has been given in the previous section. The following paragraphs

describe the background to this work in more detail.

5.2 Cracking of River Pier Column Capitals

5.2.1 The cracks which have been observed during the recent inspections are mentioned in paragraphs 4.3, 4.6 and 4.7 and documented in the Jacobs Special Inspection – Report Date June 2008 [Ref: Document 6].

5.2.2 These cracks are known to have been present since the 1940's, although no formal record of the crack positions and lengths had been maintained. Hence the NDT testing carried out in 2003, 2005 and 2008.

5.2.3 The cracks are located at the top of each cast iron pier column capital and upper plate, which directly support each longitudinal lattice girder. No provision for any thermal movement of the bridge (expansion and contraction) had been made in the original construction and this is the reason for the cracks. The current design standard BD 37/01 (DMRB Vol.1) would require that for a bridge of this type with an overall length of 83m, thermal movement of $\pm$ 30mm should be catered for.

5.2.4 Previous repairs have been undertaken. At the North Pier both columns have had doubler plates riveted and bolted to the vertical faces of the capitals. This work is believed to have been carried out prior to the 1970s. The Central and South Pier columns have all been strengthened with 20mm diameter tie bars fitted at the upper and lower levels of the casting. This work was carried out during the 1970s in conjunction with replacement of the bearings at the southern abutment intended to allow for some thermal movement.

5.2.5 Despite these works, the series of recent inspections demonstrates

that some of the cracks are still “live” and are continuing to propagate.

5.2.6 The cracks through the centre of the horizontal upper plate are such that the loads from the lattice girders may not be distributed evenly to the central portion of the capital casting. Instead, a greater proportion may be carried directly by the casting’s fins. A number of the cracks continue down the vertical face of the casting close to the position where the fin joins the central portion. This increases the possibility that the fin could separate from the casting (either partially or wholly), leading to loss of support of the main lattice girder.

5.2.7 Cast iron is a brittle material and therefore a sudden break cannot be ruled out. However, the purpose of the Special Inspections (now reduced to an annual frequency) is to institute a realistic monitoring regime to identify any progressive changes which are the more likely to occur, taking into account the historical nature of the cracks.

5.2.8 In view of the continuing propagation, a “do nothing” approach is not a credible option. As a short term measure, further strengthening plates and ties can be considered. However, the permanent solution is to introduce bearings at the top of each column (to isolate movement of the superstructure from that of the substructure) and to repair the cracked upper plates and castings. In the meantime the existing columns provide the only support to the lattice girders, without any redundancy, and therefore have to be considered a significant structural risk in the overall management of the bridge.

5.2.9 Work to introduce bearings would require the existing lattice girders to be raised and this would necessitate substantial temporary piled supports in the river at each column position to enable the girders to be jacked up. To avoid distortion of the transverse beams, all four girders at a pier would have to be raised simultaneously, requiring a

jacking force of approximately 300 tonnes (assuming dead loads only). This would enable the cracked upper plates to be removed and replaced, and the new bearings inserted.

5.2.10 However, it would not necessarily allow the cracked cast iron capitals to be repaired fully. Since some of these cracks follow a line at the junction of where the casting and fin meet at 90º, it would not be practicable to carry out the “stitch” repairs which would be the usual method adopted. Equally, it is unlikely that the lattice girders could be safely jacked up sufficiently to allow the capitals to be removed and taken to a workshop for the more substantial repairs needed, or for replacements to be recast.

5.2.11 I estimate that if this work was to be carried out as an independent operation it would cost at least £550,000 to allow for the temporary works and mobilization costs, and would require a road closure of at least 2 months. However, the same costs would be incurred again during the reconstruction work, since this also allows for the cost of lifting out the lattice girders temporarily for refurbishment. It would therefore be more economical to carry out the whole of the column crack repair and bearing work as part of the planned reconstruction work, and would also be more effective as it would be easier to remove the capital castings for a full repair.

5.2.12 For these reasons, I have recommended that providing the Special Inspections are continued yearly to monitor any further movement of the cracks, this work may be deferred until the planned reconstruction takes place. However, should the reconstruction be postponed beyond 2015, it would be necessary to bring forward this work which would then not be cost effective.

5.3 <u>Replacement of Waterproofing Membrane</u>

5.3.1 Carriageway surfacing materials are porous and therefore current bridge designs have a waterproofing membrane installed below the surfacing to prevent water seeping into the deck construction. This is covered by design standard BD 47/99 (DMRB Vol.2).

5.3.2 The existing waterproofing membrane was laid in 1985 on the original concrete infill which lies above the curved buckle plates. These plates extend across the full width of the bridge soffit, supported by the lower flanges of the transverse beams. These beams in turn are supported at each end by the narrow width of the lattice girder lower flanges.

5.3.3 The evidence of the 2003 Principal Inspection is that water is penetrating through the deck construction in several locations and is therefore trapped at the low points immediately above the the girder and beam lower flanges. These are the critical areas for support and therefore the waterproofing membrane should be replaced to minimize future corrosion. The weep holes through the deck soffit are only an interim measure intended to reduce water from ponding within the deck. However the curved buckle plates make it very difficult for these to be fully effective.

5.3.4 In order to replace the waterproofing the surfacing has to be removed and the underlying concrete surface repaired to ensure that it will provide the necessary bond for a new membrane to be applied. However, the 5.2m carriageway width is too narrow to enable this to be carried out safely without a full road closure. Therefore the bridge would have to be closed for several weeks during the work.

5.4 Maintenance Painting

5.4.1 Regular maintenance painting is essential to minimise corrosion of

the metalwork and as part of the original 1997 Maintenance Strategy a full repaint of both the superstructure and substructure was carried out in 1998.

5.4.2 Since the degree of paint breakdown was not excessive at the time the surface preparation was carried out by cleaning and abrading locally, rather than by blast cleaning which would have posed environmental problems in working over the river.

5.4.3 However, the pre-specification survey carried out before the work showed the presence of at least 16 coats of paint with a thickness in excess of 1250 microns. This compares with a typical system to the current standard BD 87/05 (DMRB Vol.3) which would have a thickness of 250 – 300 microns.

5.4.4 The system applied in 1998 has a life expectancy of about 12 years and therefore a full re-paint should be carried out within the next few years. However, because of the build up of previous coatings the opportunity should be taken to blast clean back to bare metal. This would require full encapsulation of the girders and other components with temporary sheeting to minimise dust and to protect the river. A road closure of several weeks would also be needed to allow for the encapsulation at carriageway level and to protect pedestrians.

5.5 Due to the road closures and disruption which would be caused by both the waterproofing replacement and maintenance painting, I have also recommended to the Whitchurch Bridge Company that these works should be carried out in conjunction with the planned reconstruction.

6. Load Assessment

6.1 The last formal assessment of the bridge's load carrying capacity was in 1993 by Howard Humphreys and Partners, the Whitchurch Bridge Company's previous consultant. The relevant standard at that time was BD 21/84 and the assessment showed that, strictly in accordance with the standard, the capacity should be 3t, although it was only marginally below the 7.5t limit. In view of the local conditions pertaining to the toll bridge, including slow speed traffic and a 7.5t environmental weight restriction in the area, it was decided to maintain the bridge's structural weight limit at 10t which had been in force since 1956.

6.2 The assessment found that the critical bridge elements are the longitudinal lattice girder trusses and the transverse beams. Approximately 75% of the girder capacity is accounted for by the self weight of the superstructure and, since these girders also act as the bridge parapets, there is also the risk that they may be subject to vehicle impacts, particularly on the eastern side where the effective verge width is less than 0.2m. The assessment had used a condition factor of 1.0 implying that all the bridge elements were in perfect condition. Any damage would therefore reduce the assessed capacity.

6.3 I reviewed the 1993 assessment in 2000 following a request from the Whitchurch Bridge Company for advice concerning an increase in the number of overweight vehicles approaching the bridge. This review took account of the bridge specific live loading concept introduced in BD 21/97 but confirmed the previous restricted capacity. It showed that by taking into account the lack of high speed, high impact effects and the absence of vehicle convoys, it would be possible, by exception for an isolated two axle vehicle up to 17t to cross the bridge. However, any individual heavier vehicle with three or more axles would cause damage to the bridge, due to

the closely spaced transverse beams being overstressed.

6.4 Based on this assessment work and following amendments to the Road Traffic Signs Regulations, the County Council, as Highway Authority, amended the original 1956 weight restriction order and in November 2003 a new structural weight limit of 7.5t was imposed.

6.5 The current assessment standard for highway bridges is now BD 21/01 (DMRB Vol. 3). The load carrying capacity for any particular element is calculated by determining the available Live Load capacity after deduction of the Dead Load effects and then evaluating this as a proportion of the full unrestricted Live Load. This gives a Reduction Factor “K” which is used in conjunction with a set of diagrams in BD 21/01 representing different traffic flows and surfacing conditions.

6.6 The “K” factor obtained from the assessment for the main longitudinal lattice girders is 0.29. Plotting this on the least onerous diagram representing Low Traffic and Good Surfacing (BD 21/01 Fig. 5.7) shows that it is just above the line corresponding to the 7.5t structural weight limit. However, it can also be seen that only a marginal reduction in the “K” factor would reduce the capacity to 3t.

6.7 Taking account of the continuing corrosion within the metal superstructure and the fact that a condition factor of 1.0 had been used in the 1993 assessment, I consider that when the next formal assessment is carried out it is quite likely that a 3t weight restriction would need to be imposed.

6.8 A 3t restriction would limit use of the bridge to cars and light vehicles only (see Fig. 7.1 from Transport in the Urban Environment published by The Institution of Highways & Transportation). Heavier delivery vehicles, together with public service vehicles and buses

would be prohibited, which would therefore cause considerable inconvenience to the local area.

6.9 The implications for emergency services would have to be considered carefully. Police and Ambulance vehicles would be permitted. However, strictly in accordance with BD 21/01 Fire Engines should be considered as travelling in a convoy of up to 3 vehicles. This would imply that the heavier appliances up to 16t (designated as Group 1 Fire Engines) would not be permitted.to cross the bridge – see BD21/01 Fig. 5.7.

6.10 Subject to detailed calculations being carried out it is likely that an exemption would be granted to allow the lighter appliances up to 7.5t (designated as Group 2 Fire Engines) to cross. Detailed discussions would be held with the Fire and Rescue authorities, but preliminary enquiries indicate that even if the heavier appliances were to be prohibited, they would be able to put into place satisfactory alternative arrangements.

6.11 The narrow carriageway width and curved alignment on the Pangbourne approach would also make it impracticable to construct the robust, physical measures needed to enforce a 3t weight restriction. A “gated” entrance comprising width and height restrictions to maintain 2 way traffic could not be constructed without reducing the already narrow footway width.

6.12 As an alternative to a 3t restriction, reduction of the carriageway width on the bridge to provide only a single lane of traffic could be considered. However, this would require traffic signals to control traffic over a length of at least 100m. The resulting queue lengths, particularly during the morning and afternoon peak hours, would be considerable. On the Pangbourne approach it is likely that the congestion would tail back beyond the restricted width railway

bridge, causing further problems in Pangbourne itself. Access to the Medical Centre and Meadow Car Park would also be blocked at times.

6.13 Until such time as the bridge reconstruction takes place the main longitudinal lattice girders will remain susceptible to damage arising, either directly from vehicle impacts and boat strikes, or indirectly from potential buckling of the compression flange as a result of overweight vehicles abusing the current weight restriction.

6.14 Given the marginal difference between the 7.5t and 3t assessed capacities referred to in paragraph 6.6, any damage to the lattice girder would be expected to reduce its condition factor, such that the weight restriction would have to be reconsidered. For example, a reduction in the girder condition factor to 0.95 or less would reduce the corresponding “K” factor to below 0.23. At that point, serious consideration would have to be given to closing the bridge to all vehicular traffic until appropriate repairs could be designed and carried out.

7. Risk Management Issues

7.1 The County Council prepares risk assessments for the Whitchurch Bridge Company to identify the principal risks associated with the management of the bridge. The most recent assessment was sent with my letter dated 21 April 2009 [Ref: SOR Appendix F]. The accompanying table set out the events which could give rise to particular risks, their potential consequencies, the measures which have already been adopted and other measures which should be considered to mitigate the risks. The following paragraphs describe the background to the key risks in more detail.

7.2 Overweight Vehicles

7.2.1 As indicated in paragraph 6.4 a 7.5t structural weight restriction has been in force since November 2003 and the bridge is signed with "7.5t Weak Bridge" signs in accordance with the Traffic Signs Regulations. In addition, there are several advance warning signs on the approaches, including some on the A4074 Reading – Wallingford road, 4 miles north of the bridge.

7.2.2 Despite these signs there is an increasing frequency of large HGV's approaching the bridge with the intention of crossing. These include vehicles up to 44t some of which are driven by foreign drivers. Those travelling from the north during the daytime are stopped by the toll collectors and, with difficulty in the narrow approach roads, turned around. However, overnight when the toll booth is not manned these vehicles, having already passed the advance warning signs, would continue to cross the bridge.

7.2.3 From the south, the 11' 00" limited headroom railway bridge on the approach does provide an element of physical restriction. However, this still allows many vehicles in excess of 7.5t to cross the bridge in contravention of the statutory weight restriction. With the toll booth situated at the north bank, the offending vehicles will have already crossed the bridge before they could be spotted, regardless of whether they are travelling by day or night.

7.2.4 Although the load assessment review in 2000 showed that an individual 17t two axle vehicle could cross the bridge, any heavier vehicle will have at least two closely spaced axles which will overstress the existing transverse beams which are at 1.25m centres. A 44t vehicle, in conjunction with other vehicles on the bridge, could cause buckling of the girder's compression flange which, as indicated in paragraph 6.13, would severely affect the

capacity of the bridge.

7.2.5 Physical restrictions on the approaches would not be practicable for the reasons outlined in paragraph 6.11, and therefore the risk of damage to the bridge will remain until the reconstruction is carried out.

7.3 Vehicle Collisions with Lattice Girders

7.3.1 The main lattice girder trusses act not only as the primary load bearing members for each span, but also as the bridge parapets providing protection for pedestrians and vehicles.

7.3.2 The current standard for bridge parapets is contained in TD 19/06 (DMRB Vol. 2), but by inspection the lattice girders are sub-standard with respect to their ability to contain errant vehicles. Moreover the eastern verge width of 0.2m is severely sub-standard as a separation of the parapet from the carriageway edge.

7.3.3 This increases the risk that a lattice girder could be damaged in any vehicle accident or impact. The relatively slow speed of traffic crossing the bridge is a mitigating factor, but the 5.2m wide carriageway is also sub-standard and therefore there is a significant risk that a vehicle accident could damage the girder.

7.3.4 Should the resulting damage be severe it would affect the ability of the girder to perform its primary function and therefore the overall capacity of the bridge would be reduced.

7.3.5 There is not sufficient width between the parapets to be able to introduce separate safety barriers and therefore the risk of damage will remain until the reconstruction.

7.4 Boat Collision with River Pier Supports

7.4.1 The four spans over the river are supported by brickwork abutments at each riverbank and three intermediate piers in the river. At each of those piers a single piled column supports the main lattice girders, the principal load bearing members. Bracings between the columns give some lateral stability at the pier and timber piles and fenders give a degree of protection from river traffic. Following the 2003 Principal Inspection the original upstream fenders were renewed and new fenders were added downstream.

7.4.2 Despite this enhanced protection the individual slender columns would be vulnerable in the event of a boat impact. This could affect the ability of a column to sustain its vertical loading. Major damage, causing displacement of the column, could lead to a loss of support of the main lattice girder and therefore partial collapse of the bridge. Even with a reduced vertical capacity, temporary piling would need to be installed as an alternative support and therefore the bridge would be closed for several months until repairs could be carried out.

7.4.3 The Environment Agency has advised that 15,000 vessels per year typically pass under the bridge and the increase in commercial traffic, such as the 150 tonne hotel barge Actief, means an increased risk of an impact occurring, particularly as the limited headroom under the bridge requires some of the larger vessels to pass close to the centre pier where the headroom is slightly greater.

7.4.4 Despite the timber fenders, the redundancy of the single column supports means that the risks associated with a boat collision cannot be reduced to an acceptable level without substantially reconstructing the piers.

7.5 Cracking of River Pier Column Capitals

7.5.1 The cracks have already been detailed in paragraphs 4.3, 4.6, 4.7 and 5.2.1 – 5.2.12.

7.5.2 The presence of the cracks increases the likelihood that damage affecting the bridge's capacity could occur in the event of a boat collision as described in paragraph 7.4.

7.5.3 Special Inspections will be continued at yearly intervals to monitor the cracks, but the logistics of the necessary work is such that in order for it to be cost effective it should be carried out in conjunction with the planned reconstruction.

8. Summary of Structural and Risk Management Issues

8.1 As indicated in the preceding sections, there are several issues which affect the ability of the bridge to continue to perform its primary purpose of carrying vehicular and pedestrian traffic.

8.2 A number of Major Maintenance and Structural Works are due as described in Section 5; principally the column capital crack repairs and associated thermal movement remedial works, as well as the replacement waterproofing and overall maintenance painting. For the reasons indicated, each of these, if carried out individually, would require road closures of the bridge and would therefore cause considerable disruption to the public.

8.3 However, carrying out these maintenance and structural works would not improve the Load Assessment issue described in Section 6. Regardless of the maintenance work, I would expect that the current 7.5t structural weight restriction would have to be reduced to 3t within the next 10 years.

8.4 Nor would the maintenance and structural works help to reduce the Risk Management issues described in Section 7. Overweight vehicles, vehicle accidents affecting the lattice girders and boat collisions affecting the river pier supports would all remain as significant long term risks.

8.5 Therefore, in view of these cumulative issues, my letter to the Whitchurch Bridge Company dated 24 October 2008 [included as Appendix 1 to Document 1] recommends that they should make provision for the reconstruction of the bridge no later than 2015 in order to address all the matters as part of a single contract. By then the bridge will have been carrying traffic for 113 years without modification and the reconstruction will give the opportunity to extend its life by a further 120 years.

9. Reconstruction Proposals

9.1 I will now describe the reconstruction proposals for the bridge which have been developed in more detail over the past 2 years in conjunction with our architectural and engineering consultants Jacobs. The proposed design is shown on Drwg. No. B0479000/WHT/STR/002 [Ref: SOR Appendix J].

9.2 There are several key planning and engineering constraints arising from the fact that the existing bridge is designated a Grade II Listed Structure and is situated within the Whitchurch Conservation Area.

9.3 This has driven the design philosophy with the Whitchurch Bridge Company and Oxfordshire County Council wishing to retain the existing overall appearance as far as is practicable. Accordingly, the intention has been to find a solution which enables the existing main longitudinal lattice girder trusses to be retained as the predominant

architectural feature.

9.4 However, as indicated in Section 6, the load carrying capacity of the lattice girders is limited and is the principal reason for the 7.5t structural weight restriction which applies to the bridge.

9.5 To overcome the risks associated with overweight vehicles crossing the bridge, the proposed design will be carried out in accordance with the current Highways Agency standard BD 37/01 (DMRB Vol. 1) which requires the structure to be capable of carrying vehicles up to 40/44t.

9.6 The design concept is to install 6 new longitudinal steel plate girders in each of the spans between the existing abutments and piers, such that they will become the new principal load bearing members. These girders, together with a composite reinforced concrete deck, will support the carriageway surfacing and footway, leaving the lattice girder trusses to act solely as the parapets. To accommodate the new girders, the existing transverse beams and buckle plates will be removed.

9.7 At each of the three river piers, new piled columns and a fabricated steel crosshead will be installed between the two existing columns to support the new girders. This will relieve the load on the existing cracked columns and will reduce the consequencies of any potential future boat collision.

9.8 The existing headroom between the river level and the underside of the bridge is already limited by the lattice girders to approximately 3.8m for the main navigation span. This is restrictive for many vessels using the River Thames and therefore the Environment Agency will not permit any reduction to that headroom. Accordingly, the new longitudinal girders must be set no lower than the bottom

flange of the lattice girders.

9.9 At carriageway level, a minimum parapet height of 1.15m must be maintained above the footway to the top of the lattice girders, in order to ensure safety for pedestrians crossing the bridge.

9.10 The overall height of the lattice girder is 1.90m (6’ 3”) and therefore, after allowing for the carriageway surfacing thickness and the above constraints, the construction depth of the new longitudinal girders and concrete deck must be restricted to no more than 0.57m. For a span of 20.5m between the piers, this is approximately 50% of the normally expected construction depth. This in turn requires the new girder flanges to be thicker and therefore much heavier than would normally be the case.

9.11 Adopting this design concept enables the deficiencies in the existing bridge to be overcome in the following manner;

- The 6 new longitudinal girders will enable the structure to be designed to carry 40/44t vehicles in accordance with current Highways Agency design standards. The “Weak Bridge” signing will be removed, but alternative signing will be provided to maintain a 7.5t limit in keeping with the associated 7.5t environmental limit in the area. Overweight vehicles will therefore no longer pose a risk to the structure.
- The existing river pier columns will no longer carry the main superstructure loadings. The new piled column supports will be more substantial and therefore boat collision risks will be reduced.
- The existing lattice girders will be required to act only as the parapets. Therefore the risks from a vehicle accident will be much reduced as there will no longer be a danger of bridge collapse.
- The construction method will require the lattice girders to be

lifted out temporarily to the riverbank for refurbishment and painting. This will give the opportunity for the blast cleaning and painting to be carried out within a tented enclosure away from the public, with much reduced environmental effects.

- Removal of the lattice girders will enable the cracked column capitals to be removed for either workshop repairs or recasting.
- The new reinforced concrete deck can be waterproofed more easily.

9.12 Carrying out the reconstruction in this way will upgrade the bridge to give it a new 120 year design life in accordance with current Highways Agency standards, whilst at the same time removing the substantial risks inherent in the existing structure. The work would all be carried out as part of a single contract and therefore the contractor's mobilization and set up costs, which would otherwise be incurred for individual maintenance and structural works, will be minimized.

10. Reconstruction Costs

10.1 I have prepared an estimate of the reconstruction cost which is shown on the sheet entitled Whitchurch Bridge Reconstruction Cost (October 2008) and which was appended to my letter dated 29 October 2008 to the Whitchurch Bridge Company [included as Appendix 2 to Document 1].

10.2 This shows the estimated costs of the principal items required for the reconstruction, together with percentage additions for the following;

- Contingencies.
- Contractor's preliminaries.
- Contractor's overheads and profit.
- The cost of further surveys and investigations

- Design fees, including preparation of contract documentation.
- Contract supervision.
- VAT.

10.3 The cost of the principal items has been established by calculating the quantities of each particular item and then applying typical contract rates for civil engineering projects as published in Spons Civil Engineering & Highway Works Price Book. Since there is a time lag between the dates when the prices are gathered and the subsequent publication date, adjustments have been made where appropriate using the Monthly Bulletin of Indices (Civil Engineering Formula – Series 1990) published by the Building Cost Information Service.

10.4 The overall contract cost will be heavily influenced by the many physical and environmental constraints surrounding the bridge's location. The contractor's road access across the 4 spans will be severed at an early stage when the transverse beams and buckle plates are removed. Thereafter the majority of the work will be carried out from the river using pontoons and barges for all plant and materials movements.

10.5 As a result the Environment Agency will require the majority of the work to be carried out during the 1st November – 31st March period to avoid interference with the much busier spring and summer use of the river. This will increase the likelihood of delays being caused by fast running, higher river flows which may make it difficult to move the pontoons.

10.6 There is little land adjacent to the bridge which can be used as a working area by the contractor. The only realistic area will be to the south east of the bridge on Pangbourne Meadow which is a valuable amenity area with difficult access. Considerable cost will therefore

be incurred in protecting this area as the contractor's compound is established, and in subsequently reinstating the area after completion.

10.7 For these reasons comparisons with normal contract rates, where access would be more straight forward, are not applicable and a 20% contingency has been added. This is in addition to a 10% contingency to allow for works which are as yet not fully defined. These include possible underpinning of the riverbank abutments due to uncertainties about the existing foundation levels, likely repairs to the lattice girders needed as part of their refurbishment as a key architectural feature, and determining the full extent and method of the repairs needed to the existing river pier columns.

10.8 The contractor's preliminaries have been taken at 20% to allow for the costs of his temporary office and supervisory staff for the duration of the contract, plus the cost of the office compound and associated equipment. Overheads and profit of 10% have been added to allow for the input needed by head office staff and insurances.

10.9 This gives an estimated contract cost of £2.38m to which a further allowance of 15% has been added. This caters for the costs of the following items;

- Further investigations to be carried out including, an underwater survey, ecological survey, flood study and more detailed investigation of the abutment construction.
- Further consultations with interested parties including, South Oxfordshire District Council, West Berkshire Council, Environment Agency, English Heritage and Statutory Undertakers. This also allows for the further preparatory work needed in submission of documents for a planning application.

- Consultants' fees for the detailed bridge design, contract document preparation, tender analysis and subsequent contract supervision on behalf of the Whitchurch Bridge Company.

10.10 This gives an estimated overall reconstruction cost of £2.74m to which VAT is added, giving an estimated project cost of £3.22m. My letter dated 29 October 2008 to the Whitchurch Bridge Company [included as Appendix 2 to Document 1] recommends that they should make financial provision, based on this estimate, to enable the reconstruction to be carried out no later than 2015.

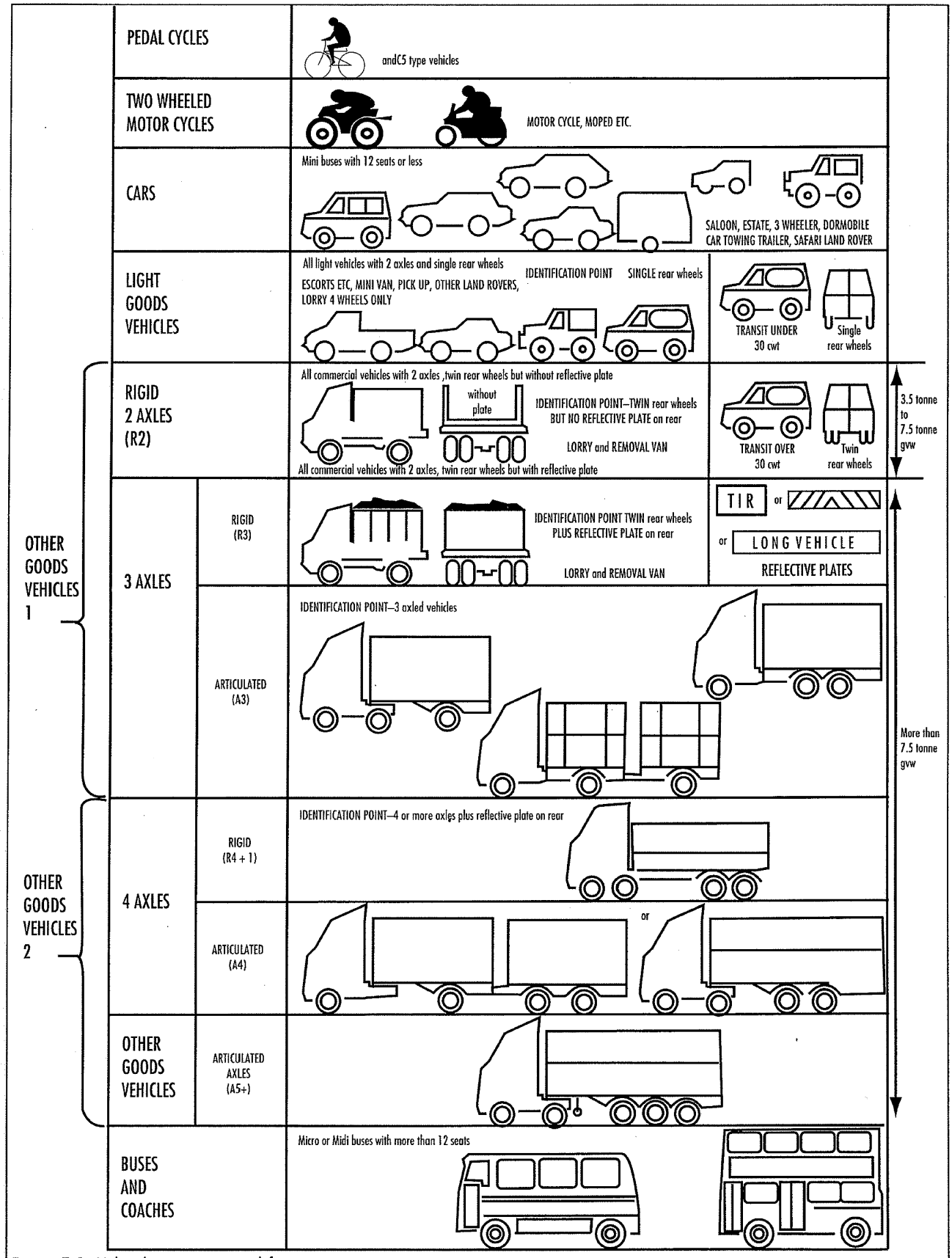

Figure 7.1: Vehical categories used for survey purposes.

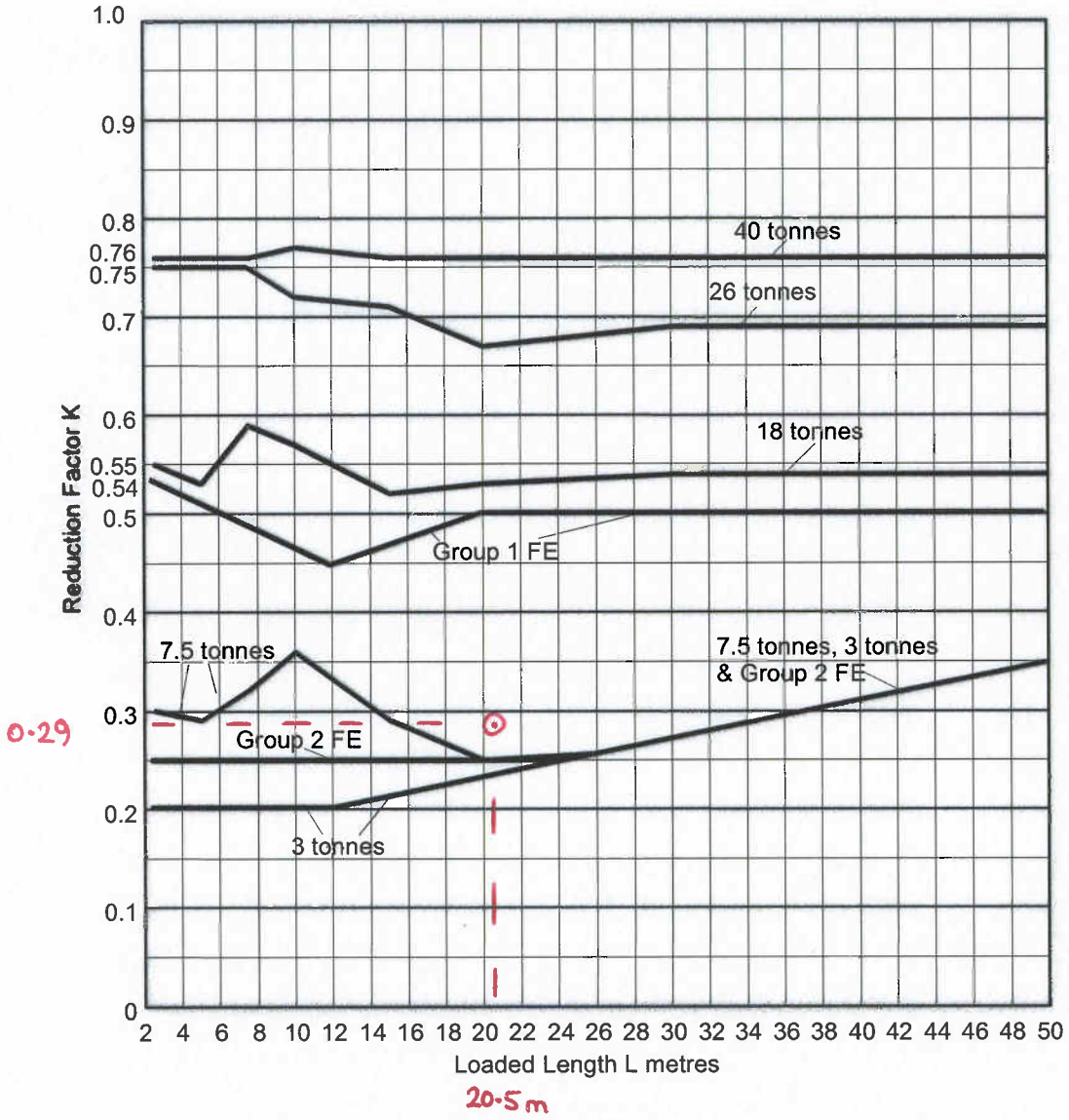

Figure 5.7 K Factors for Low Traffic Good Surface (Lg)