LoBEG Good Practice Guide

Creating Consistent Element Inventories for Highway Structures

Version 2.0

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London Bridges Engineering Group

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Table of Contents

1 Introduction

1.1 General

1.1.1 This Good Practice Guide (GPG) has been prepared by the London Bridges Engineering Group (LoBEG) Asset Management Working Group to provide guidance and an approach for **creating consistent element inventories** for highway structures. The Group considers this approach to be appropriate for bridges and other highway structures.

1.1.2 Furthermore the Group considers that the approach will support improved Asset Management Planning and Financial Reporting towards meeting the requirements specified by the CIPFA Code of Practice on Transport Infrastructure Assets [1].

1.2 Background

1.2.1 A sound knowledge of the asset is fundamental to bridge management, not just at a high level, but in sufficient detail to support the maintenance planning and other management activities and also support decision making. The CSS Bridge Condition Indicator (BCI) [2, 3, 4, 5] has provided standardised lists of elements for bridges, culverts, retaining walls and sign/signal gantries. These standardised lists of elements have also acted as the template for developing element inventories, i.e. those elements reported on during inspections form the element inventory for each structure. This has enabled highway structure owners to take a major step forward in the development of consistent element inventories.

1.2.2 Although the CSS BCI process represents a considerable improvement in consistency and standardisation, studies by the CSS Bridges Group and CSS Area Bridge Conferences have shown that there is variability in how element inventories are created, for example:

- Inconsistency in the identification of elements (and their condition);
- Inconsistency in the breakdown of structures, e.g. by construction type and span;

1.2.3 Consistency is vital to current and developing bridge management techniques, e.g. Bridge Condition Indicator calculation, prioritising maintenance, asset valuation/depreciation, lifecycle planning, long-term financial planning and trending and comparison (of any of these) between authorities. To ensure these approaches are suitably supported, it is essential that element breakdowns are created in a consistent manner, especially as authorities look to define more detailed element inventories above and beyond the CSS BCI guidance, that is:

- Inspectors, engineers and managers are becoming familiar with the standard CSS BCI approach and are now looking to refine the detail of the standard CSS BCI inventory list;
- Bridge Management Systems provide the functionality to develop more refined element inventories, offering a high degree of inventory flexibility in some cases; and
- There is a growing realisation that more refined element inventories are required for some structures, in particular more complex bridge types.

1.2.4 Appropriate consistency and refinement of element inventories can be achieved, while still providing a degree of inventory flexibility, through a combination of formalised training and guidance. This *LoBEG Good Practice Guide (GPG)* sets down an approach which is considered to enable refined element inventories to be developed in a consistent manner.

1.3 Purpose

1.3.1 The purpose of this Good Practice Guide (GPG) is:

- To set down an approach for the consistent development of element inventories for highway structures;

- To achieve an approach that is fully aligned with the CSS Bridge Condition Indicator;
- To ensure consistent evaluation of the Bridge Condition Indicator (BCI) by providing guidance on how it should be evaluated when more refined element inventories are developed;
- To provide an approach that has sufficient flexibility to allow users to enter more detailed element breakdowns where appropriate, but still complies with the standard CSS inventory;
- To provide an approach that enables data of sufficient quality to be collected for evaluating the BCI and for supporting other asset management tools such as maintenance prioritisation, lifecycle planning and financial planning.
- To support the development of Transport Asset Management Plans (TAMP), Highway Asset Management Plans (HAMP), Structures Asset Management Plans (SAMPS), etc.

1.4 Content of this Good Practice Guide (GPG)

1.4.1 The contents of this *LoBEG Good Practice Guide (GPG)* are summarised in Table 1.

Table 1: Contents of this Good Practice Guide (GPG)

Section	Description
2. Assumptions	Presents the assumptions that were discussed and agreed by the LoBEG Asset Management Working Group and form the basis of the approach described herein.
3. Standardisation of Element Breakdown	Describes the approach for consistent element breakdown for two refinement levels, i.e. minimum and refined.
4. Bridge Condition Indicator Evaluation	Describes the approach that should be adopted for evaluating the Bridge Condition Indicator (BCI) for the above refinement levels.
5. Examples	Contains worked examples to illustrate consistent breakdown of inventory and BCI evaluation for the above levels of refinement.
6. References	Lists relevant documents referred to for the purpose of this work.
Appendices	Provides supporting information, including: • Standard Element Lists for different Structure Types; • Structure/Element breakdown using the different refinement levels defined in Section 3.

2 Assumptions

2.1.1 The following assumptions form the basis of the approach set out in this *LoBEG Good Practice Guide (GPG)*.

- The established CSS BCI evaluation approach and associated guidance form the basis for this guide;
- This guide caters to asset owners/managers who are at different stages of inventory development, i.e. basic vs. refined;
- This guide **does not** put forward an approach that requires deviation from the accepted CSS BCI evaluation approach and **does not** require asset owners/managers to discard/change the existing inventories;
- The CSS BCI standardised element list (see Appendix A) is taken to represent the base minimum element inventory. It is recognised that there are likely to be additional elements above and beyond the lists provided in Appendix A. It is essential that all elements are linked back (i.e. can be mapped) to the CSS BCI elements, however, where this is not possible a new element type should be identified and added to the table (and a BCI importance assigned as per Section 4 of the Guidance Note on Evaluation of Bridge Condition Indicators [3, 5]).
- Elements that cannot be mapped to the CSS BCI elements, are excluded from the BCI calculation but could be recorded for management purposes and to support activities such as prioritisation, lifecycle planning, depreciation.
- The approach described herein demonstrates how the CSS BCI evaluation approach can be extended/refined to enable more element detail to be defined, where appropriate.
- The approach **does not** create inconsistencies in the evaluation of the CSS BCI calculation.

2.1.2 The guide has been reviewed and endorsed by the LoBEG Asset Management Working Group, supported by their Technical Advisors. The approach in this guide represents good practice and reflects the practicalities and needs required for the management of highway structures.

3 Standardisation of Element Breakdown

3.1 Overview

3.1.1 All highway structures should comply with a *Minimum Element Breakdown* and then where appropriate a more *Refined Element Breakdown* can be developed. The descriptions of these two breakdowns are:

- *Minimum Element Breakdown* – uses the standard CSS BCI element list.
- *Refined Element Breakdown* – subdivides the CSS BCI elements where appropriate (e.g. abutments are divided into North and South Abutments) and/or at a global level superstructure/substructure and span/construction form breakdowns are introduced.

3.1.2 Figure 1 provides an overview of the approach, illustrating how the refined breakdown is based on a minimum breakdown. Levels 1a, 1b and 1c define the level of refinement for structure breakdown and levels 2a, 2b and 2c define the level of refinement for element breakdown. Levels 1a and 2a are the minimum/essential level of breakdown to identify the structure type and the elements on the structure.

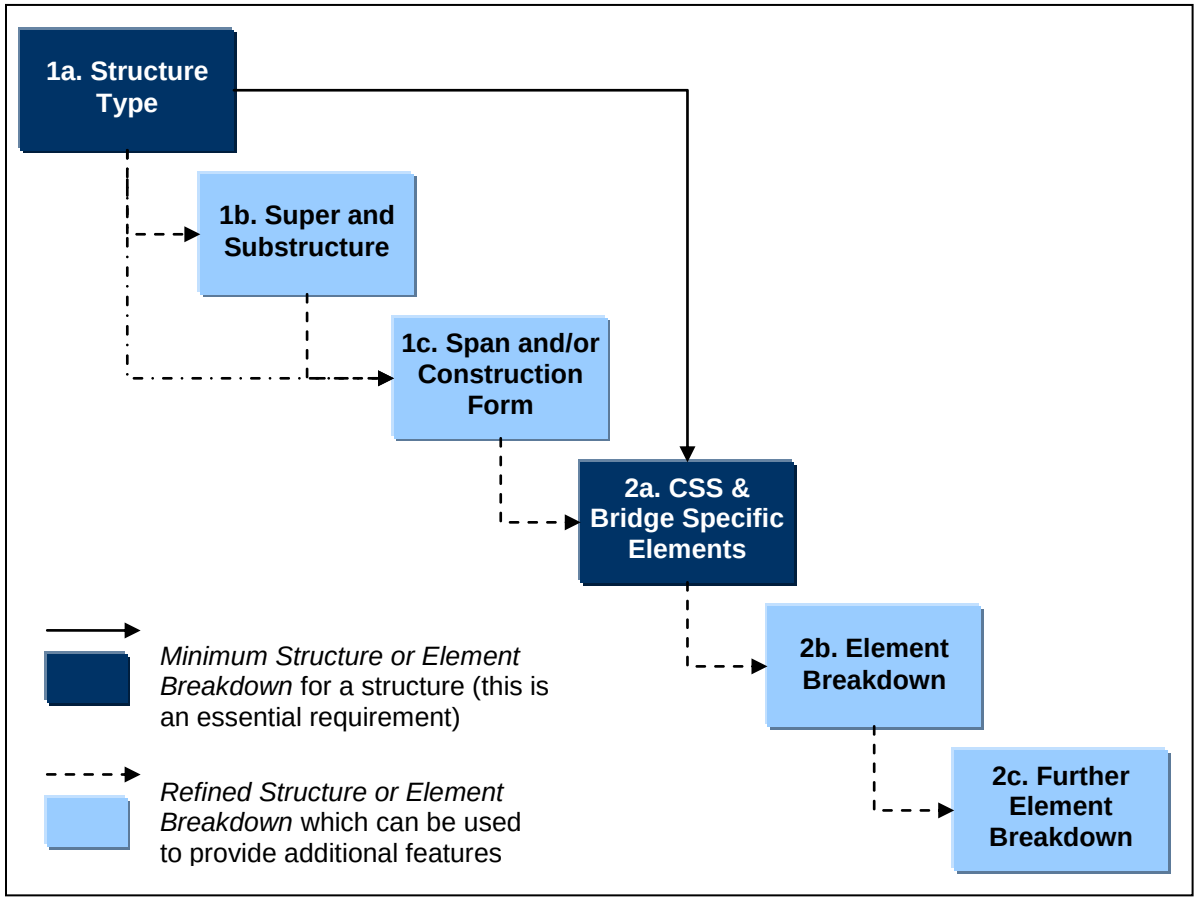

Figure 1: Overview of Structure and Element Breakdown

3.2 Setting up the Inventory

3.2.1 Sufficient time and resources should be set aside when creating an element inventory, if done correctly the first time this will stand the user in good stead for many years to come. Key points that need to be considered are:

- The Minimum Element Breakdown will be the default option in the majority of instances;
- What specific structure features/characteristics merit the need for a more refined element inventory?
- What level of refinement should be used for reporting the condition of elements; minimum or refined?
- Will the inventory be locked-down after it has been created?
- What is the protocol for updating and refining the inventory in the future?
- Who will have permissions to amend the element inventory?

3.2.2 Table 2 presents a list of common structure types and the suggested levels of refinement, for structure and element breakdown. These are considered appropriate for collecting and maintaining consistent condition information and consistently evaluating Condition Indicators. Each asset owning authority must select the appropriate level of refinement, for each structure type in their stock, and agree these with the Inspectors/Consultants commissioned to inspect the structures and maintain their inventory. Once agreed these should be 'locked-down'. However, if the authority wishes to deviate from the suggested levels, it is essential to ensure that the selected level of refinement should not be below the minimum level of 1a at structure level and 2a at element level.

3.2.3 The approach presented herein enables the minimum element breakdown to be produced, if appropriate, the level of granularity can be increased over time given the consistency and comparability are retained. A justification for change, however, should be captured/recorded for future reference.

Table 2: Recommended Levels of Refinement

Structure Type	Recommended Level of Refinement	
	Structure Breakdown	Element Breakdown
Bridge: Vehicular		
Single span	1a	2a
Multi span	1a	2b
Bridge: Pedestrian/cycle		
Single span	1a	2a
Mulit span	1a	2b
Cantilever Road Sign	1a	2a
Chamber / Vault / Cellar	1a	2a
Culvert		
Single span	1a	2a
Mulit span	1a	2b
High Mast Lighting	1a	2a
Retaining Wall / Structural earthworks - reinforced/strengthened soil/fill structure		
Height ≤ 3m	1a	2a
Height > 3m	1a	2a
Sign / Signal Gantry		
Cantilever	1a	2a
Spanning	1a	2a
Subway: Pipe	1a	2a
Tunnel	1a	2b
Underpass (or subway) :Pedestrian	1a	2a
Underpass: Vehicular	1a	2a
Miscellaneous (including Special Structures)	1a	2a

3.3 Level 1a: Structure Type

3.3.1 This is an essential feature of the breakdown because:

- It supports grouping and analysis of structures based on type;
- Identifies which standard list of CSS BCI elements should be used for the subsequent element breakdown.

3.3.2 Table 3 below lists the CSS BCI elements that should be used in relation to common structure types. Table 3 is intended as a guide and it is recognised that in some instances an alternative CSS BCI list, to that suggested below, may be more appropriate, or in some instances a mix of elements from more than one CSS BCI list may be appropriate. It is also recognised that the CSS BCI element list may not provide sufficient coverage of all element types, where this is the case additional elements should be included and mapped to the CSS BCI element list, as appropriate.

Table 3: Structure Types

Structure Type	Comment on Level 2 Element Breakdown
Bridge: Vehicular	
Single span	Use standard list of 38 CSS elements for bridges
Multi span	
Bridge: Pedestrian/cycle	
Single span	Use standard list of 38 CSS elements for bridges
Mulit span	
Cantilever Road Sign	Use standard list of 16 CSS elements for sign/signal gantries
Chamber / Vault / Cellar	Use standard list of 38 CSS elements for bridges
Culvert	
Single span	Use standard list of 38 CSS elements for bridges
Mulit span	
High Mast Lighting	Use most appropriate CSS elements*
Retaining Wall / Structural earthworks - reinforced/strengthened soil/fill structure	
Height ≤ 3m	Use standard list of 20 CSS elements for retaining walls
Height > 3m	
Sign / Signal Gantry	
Cantilever	Use standard list of 16 CSS elements for sign/signal gantries
Spanning	
Subway: Pipe	Use standard list of 38 CSS elements for bridges
Tunnel	Use standard list of 38 CSS elements for bridges
Underpass (or subway) :Pedestrian	Use standard list of 38 CSS elements for bridges
Underpass: Vehicular	Use standard list of 38 CSS elements for bridges
Miscellaneous (including Special Structures)	Use most appropriate CSS elements*

* Select elements from one or a combination of CSS lists that best define this structure; this may also include elements outside the scope of the CSS lists, see paragraph 3.3.3.

3.3.3 Appendix A provides the standard list of CSS elements for bridges, retaining walls and sign/signal gantries. It is recognised that there are likely to be additional elements above and beyond the lists provided in Appendix A. Wherever possible elements should be aligned to those shown in Appendix A, however, where this is not possible a new element type should be identified and added to the table (and a BCI importance assigned as per Section 4 of the Guidance Note on Evaluation of Bridge Condition Indicators [3, 5]).

3.4 Level 2a: CSS & Bridge Specific Elements

3.4.1 Provided no refinement is required for the global breakdown of the structure (see Section 3.5), the element inventory should be identified as follows:

- Use the relevant CSS BCI element list (see Table 3) to identify the element inventory
- Select the relevant elements from the CSS BCI standard list; and
- Identify additional elements that are not on the standard CSS BCI list. Wherever possible these elements should be aligned to those shown in Appendix A, however, where this is not possible a new element type should be identified and added to the table (and a BCI importance assigned as per Section 4 of the Guidance Note on Evaluation of Bridge Condition Indicators [3, 5]). Additional elements that are not included in the BCI calculation should be recorded for management purposes.

3.4.2 It is important that the best element description is provided for the structure; however, it is also essential that the element breakdown is not changed without appropriate reasoning, for example, element types should not be changed at a subsequent inspection, as this has implications on consistency. When setting up the element inventory sufficient time and effort should be taken to ensure it is correct and this inventory is then 'locked down'. Appendix B presents an example of the minimum element breakdown at level 2a.

3.4.3 The element inventory can still be refined through subsequent inspections (as per this guide), as the refinement builds on the standard element list. A justification for change, however, should be captured/recorded for future reference.

3.5 Level 1b and 1c Structure Breakdown

3.5.1 If a more refined global breakdown of the structure (e.g. by span, construction type, etc.) is preferred and/or required, then Levels 1b and 1c can be used to achieve this.

3.5.2 ***Level 1b:*** The structure can be broken down into super and substructure. To effectively use the super/sub structure approach the asset manager should consider which elements are linked to superstructure, substructure and the whole structure, whereby these are defined as:

- *Superstructure*[6] – all elements above and excluding the bearings, e.g. primary and secondary deck elements, parapets and expansion joints.
- *Substructure*[6] – all elements below and including the bearings, e.g. abutments, piers/columns and foundations; and
- *Whole Structure* – those elements that may be more appropriately reported against the whole structure, e.g. signs, machinery and lighting.

3.5.3 ***Level 1c:*** The structure can be broken down by span or construction form.

3.5.4 Appendix C provides elements listed under these three headings and different examples/options of how the Level 1b/1c breakdown can be used to produce consistent inventories. To effectively use this approach:

- The asset manager should consider which level of refinement is appropriate for the structure. A certain level of flexibility could be introduced so that the asset manager can

report some elements at a refined level and some at a higher level, for example, the asset manager may wish to only report primary and secondary deck elements via the superstructure/span breakdown; however other superstructure elements (e.g. expansion joints and parapets) could be reported for the whole structure.

- These relationships, once defined, should be fixed in order to support consistent evaluation of the CSS BCI, i.e. if two spans are reported under Superstructure (as shown in Appendix C) then how should the overall the condition rating be evaluated (e.g. weightings based on span dimensions).

3.5.5 The following table shows different ways in which the super/substructure, span and construction form breakdown could be used to globally define a structure:

Table 4: Level 1b/1c Refinements

Option 1 (see Appendix C – C1: Option 1)	Option 2 (see Appendix C – C2: Option 2)	Option 3 (see Appendix C – C3: Option 3)
Bridge: Vehicular Superstructure Span 1 Span2 Substructure	Bridge: Vehicular Span 1 Span 2 … Span n	Bridge: Vehicular Span 1 Structure form 1 Span 2 Structure form 2 … Span n

3.6 Level 2b and 2c Element Breakdown

3.6.1 Levels 2b and 2c provide the capability to subdivide an element into any number of sub-elements; see Appendix D.

3.6.2 For more complex structures these levels of refinement may be considered more appropriate.

3.6.3 The following Section 4 explains the procedure for evaluating the BCI for the different levels of refinement.

4 Bridge Condition Indicator Evaluation

4.1 Overview

4.1.1 This section describes the approach for evaluating the Bridge Condition Indicators.

4.1.2 As described previously in Section 3.2, inspectors/asset managers are encouraged, depending on the structure type, to follow the recommended levels of refinement (for structure and element breakdown) as listed in Table 2. However, if the authorities wish to deviate from the suggested levels, it is essential to ensure that the selected level of refinement should not be below the minimum level of 1a at structure level and 2a at element level.

4.1.3 The BCI calculation for the different levels of refinement can be undertaken as described in the following sections.

4.2 Level 1a/2a Refinement

4.2.1 *Single Span or Simple Structures:* The BCI calculation should follow the procedure set in Guidance Note on Evaluation of Bridge Condition Indicators [3, 5].

4.2.2 *Multi-Span or Complex Structures:* If the level 1a/2a refinement is followed, then as a minimum it is advisable to use the standard elements given in Appendix A to condition mark the elements. The inspectors should report the most critical defect for an element. For example, even if conditions of the primary deck element on span 1 and span 2 are assessed separately, the most critical one should be reported in the standard element list, i.e. if the condition of span 1 primary deck element is 2B and the condition of span 2 primary deck element is 3C, then the inspector should report the condition of primary deck element as 3C.

4.2.3 If the *Refined Element Breakdown* is used, then the following procedure should be used.

4.3 Level 1b Refinement

4.3.1 For the purpose of inventory reporting the elements can be broken down to superstructure and substructure levels, according to the guidance provided in the Inspection Manual[6] and as shown in Appendix C1. However, for evaluating the BCI the following is recommended:

4.3.2 *Single Span Structures:* The elements should be condition marked at level 2a and the BCI calculation should follow the procedure set in Guidance Note on Evaluation of Bridge Condition Indicators [3, 5].

4.3.3 *Multi-Span Structures:* The elements can be condition marked to either level 2a or 2b and BCI calculation can be undertaken as described in Section 4.2 or 4.5 respectively. For multi-span structures the recommended level of refinement is 2b for which the BCI calculation can be undertaken as described in Section 4.5

4.4 Level 1c Refinement

Structure Breakdown by Span

4.4.1 *Single Span Structures*: The elements should be condition marked at Level 1a/2a and the BCI calculation should be carried out using the condition ratings of the standard Level 2a elements, in accordance with the Guidance Note on Evaluation of Bridge Condition Indicators [3, 5].

4.4.2 *Multi-Span Structures*: The elements should be condition marked at Level 1c/2a, i.e. elements relating to each span should be condition marked to level 2a and Condition Indices for each span evaluated separately. Even if the structure is broken down to different spans, it is

essential to link each of the different spans back to the parent structure, to maintain consistency. Therefore, Condition Indices calculated for the different spans (Condition Index span 1, Condition index span 2, etc.) should be combined to evaluate the overall BCI for the structure. Refer to Section 5.3, Example 2.2 for details.

4.4.3 For multi-span structures the recommended level of refinement is 1a/2b for which the BCI calculation can be undertaken as described in Section 4.5

Structure Breakdown by Construction Form

4.4.4 *Simple structures (one construction form):* The elements should be condition marked at Level 1a/2a and the BCI calculation should be carried out using the condition ratings of the standard Level 2a elements, in accordance with the Guidance Note on Evaluation of Bridge Condition Indicators [3, 5].

4.4.5 *Complex structures (more than one construction form):* Although the structure can be broken down to level 1c (by construction form) for inventory reporting, elements should be condition marked at either Level 2a or 2b and the BCI calculation should be carried out as described in Section 4.2 or 4.5 respectively.

4.5 Level 2b Refinement

4.5.1 *Single Span Structures:* If elements are condition marked at level 2b (as shown in Table 5), then the condition of the elements should be dealt with in accordance with Section 5.3 of the Guidance Document for Performance Measurement of Highway Structures, Part B1: Condition Performance Indicator[5]. For the example in Table 5, this process will provide one condition score for the Primary Deck Element, which can then be used for evaluating the BCI for the structure, i.e. a condition score of 3.03, based on the worst severity and weighted average of the defect extent, will be used for evaluating the BCI.

Table 5: Level 2b Condition Reporting (Single Span Structures)

Level 2a	Level 2b	Severity	Extent	Extent Numeric Value	Element Dimension	Sub-element Weighting (W_{SE})	Overall Extent Score	ECS = Severity + Extent score
1. Primary deck element	Half Through Beam 1	1	A	0.0	15m	1.0	0.03	3.03
	Half Through Beam 2	2	B	0.0	15m	1.0		
	Half Through Beam 3	3	C	0.1	15m	1.0		

4.5.2 *Multi-Span Structures:* If elements are condition marked at level 2b (as shown in Table 6), then the condition of the elements should be dealt with in accordance with Section 5.3 of the Guidance Document for Performance Measurement of Highway Structures, Part B1: Condition Performance Indicator[5]. For the example in Table 6, this process will provide one condition score for the Primary Deck Element, which can then be used for evaluating the BCI for the structure, i.e. a condition score of 3.03, based on the worst severity and weighted average of the defect extent, will be used for evaluating the BCI.

Table 6: Level 2b Condition Reporting (Multi-Span Structures)

Level 2a	Level 2b	Severity	Extent	Extent Numeric Value	Element Dimension	Sub-element Weighting (W_{SE})	Overall Extent score	ECS = Severity + Extent score
1. Primary deck element	Span 1	1	A	0.0	15m	1.0	0.03	3.03
	Span 2	2	B	0.0	15m	1.0		
	Span 3	3	C	0.1	15m	1.0		

4.6 Level 2c Refinement

4.6.1 Level 2c is a more detailed element inventory breakdown, i.e. this level of refinement may be considered suitable for reporting the inventory of complex structures. However for evaluating the BCI, the elements should be condition marked to a minimum level of 2a and a maximum level of 2b.

5 Examples

5.1 Overview

5.1.1 This section presents examples of the BCI calculations for the different levels of refinement for the following structure types: (i) Single Span Bridge: Vehicular, (ii) Multi Span Bridge: Vehicular, (iii) Culvert and (iv) Retaining Wall. The BCI calculations presented herein have been undertaken in accordance with the guidelines provided in Section 4 of this GPG.

5.2 Example 1: Single Span Bridge

5.2.1 The Lea Road Bridge (Structure Ref: 11/B/LA/012) owned by the London Borough of Hackney is used as an example to illustrate the different levels of element breakdown. This bridge comprises half-through deck with transverse beams and slab, simply supported on brick abutments with concrete bearing shelves. The structure carries the A104 over the Lea River. The following figures (Figure 2, Figure 3, Figure 4 and Figure 5) illustrate a few of the elements that are present on the structure.

Figure 2: Lea Road Bridge – South Elevation

Figure 3: Lea Road Bridge – General View of Deck soffit

Figure 4: Lea Road Bridge – View showing Abutments and Bearing Plinth/Shelf

Figure 5: Lea Road Bridge – North East View showing Carriageway, Footway and Parapets

Example 1.1: Single Span Bridge to Level 1a/2a

5.2.2 For Lea Road Bridge, the following element breakdown can be made at level 1a/2a:

Level 1a	Level 2a
Bridge: Vehicular	1. Primary deck element
	2. Transverse beams
	6. Parapet beam or cantilever
	8. Foundations
	9. Abutments (incl. arch springing)
	13. Bearings
	14. Bearing plinth/shelf
	15. Superstructure drainage
	16. Substructure drainage
	17. Waterproofing
	18. Movement/expansion joints
	19. Finishes: deck elements
	21. Finishes: parapets/safety fences
	23. Handrail/parapets/safety fences
	24. Carriageway surfacing
	25. Footway/verge/footbridge surfacing
	26. Invert/River Bed
	28. Fenders/cutwaters/collision prot.
	32. Retaining walls
	35. Approach rails/barriers/walls
	38. Services

5.2.3 This is the minimum level of refinement required in any inspection report and supports the development of a consistent condition marking system.

5.2.4 The ECS values based on the severity/extent values marked by the inspector for these elements (see Appendix E), except the ancillary elements, i.e. approach rails/barriers/walls, are used in the BCI calculation.

5.2.5 The BCI of this bridge was calculated from the inspection records, using the BCI calculation procedure described in Guidance Note on Evaluation of Bridge Condition Indicators [3, 5]. The BCI_{Av} and BCI_{Crit} for this bridge were calculated to be 86.6 and 81.0 respectively.

5.2.6 In the following sections, other possible levels of refinements are exemplified. BCI calculations are carried out by assuming different condition ratings for some of the elements, in each level, to identify the sensitivities of the refinement levels on the evaluation of the final BCI.

Example 1.2: Single Span Bridge to Level 1b/2a

5.2.7 For Lea Road Bridge, the following element breakdown can be made at level 1b/2a:

Level 1a	Level 1b	Level 2a
Bridge: Vehicular	Superstructure	1. Primary element (Half Through Beams)
		2. Transverse Beams
		6. Parapet beam or cantilever
		15. Superstructure drainage
		17. Waterproofing
		18. Movement/expansion joints
		19. Finishes: deck elements
		21. Finishes: parapets/safety fences
		23. Handrail/parapets/safety fences
		24. Carriageway surfacing
		25. Footway/verge/footbridge surfacing
	Substructure	8. Foundations
		9. Abutments (incl. arch springing)
		13. Bearings
		14. Bearing plinth/shelf
		16. Substructure Drainage
		26. Invert/river bed
		28. Fenders/cutwaters/collision prot.
		32. Retaining walls
	Whole Structure	35. Approach rails/barriers/walls
		38. Services

5.2.8 Although inventory reporting may be carried out at Level 1b/2a, the condition of individual elements should be marked to Level 1a/2a (see Appendix F), since no further refinement is considered. Hence, the BCI values for this bridge would be 86.6 (BCI_{Av}) and 81.0 (BCI_{Crit}) regardless of the Level 1b classification.

5.2.9 Level 1c classification is not appropriate for this bridge since it is a single span bridge and has only one construction form.

Example 1.3: Single Span Bridge to Level 1a/2b

5.2.10 For Lea Road Bridge the following element breakdown can be made at level 1a/2b:

Level 1a	Level 2a	Level 2b
Bridge: Vehicular	1. Primary deck element	Half Through Beam 1 (North Girder)
		Half Through Beam 2 (Central Girder)
		Half Through Beam 3 (South Girder)
	2. Transverse beams	Transverse Beam 1
		Transverse Beam 2
		Transverse Beam….
	6. Parapet beam or cantilever	Parapet Beam 1 (North)
		Parapet Beam 1 (South)
	8. Foundations	Foundation 1 (East Foundation)
		Foundation 2 (West Foundation)
	9. Abutments (incl. arch springing)	Abutment 1 (East Abutment)
		Abutment 2 (West Abutment)
	13. Bearings	Bearing 1 (East)
		Bearing 2 (East)
		Bearing ……
	14. Bearing plinth/shelf	Bearing Shelf 1 (East)
		Bearing Shelf 2 (East)
		Bearing Shelf……
	15. Superstructure drainage	
	16. Substructure drainage	
	17. Waterproofing	
	18. Movement/expansion joints	Expansion Joint 1 (East)
		Expansion Joint 2 (West)
	19. Finishes: deck elements	
	21. Finishes: parapets/safety	
	23. Handrail/parapets/safety fences	Handrails 1 (North)
		Handrails 2 (South)
	24. Carriageway surfacing	
	25. Footway/verge/footbridge	
	26. Invert/River Bed	
	28. Fenders/cutwaters/collision	
	32. Retaining walls	Retaining wall 1 (East)
		Retaining wall 2 (West)
	35. Approach rails/barriers/walls	Approach rail 1 (East)
		Approach rail 2 (West)
	38. Services	

5.2.11 Although it is possible to break down all the standard elements to level 2b as illustrated above, it is recommended that Authorities review the specific details of each structure and determine the elements that need to be condition marked at a more refined level.

5.2.12 For instance, elements with Very High and High importance may be condition marked at level 2b and the other elements may be reported at level 2a.

5.2.13 For example, the condition of the primary deck element (three half through beams) for this bridge (Lea Road Bridge) was recorded as 2 (severity) B (extent), at the last inspection. This

means that the element has early signs of deterioration in less than 5% of the element. The following scenarios could have led to this condition marking:

1. All three beams in condition 2B
2. Two beams in 1A and one beam in 2B
3. Two beams in 1A and one beam in 2C
4. One beam in 1A and two beams in 2B

5.2.14 There are two ways of calculating the BCI:

- ***Option 1:*** Each element rating is treated separately in the BCI calculation. In this case, the calculation procedure will be same as that described in the BCI Condition Indicator Evaluation Guidelines [3, 5]. The only difference is that, for example, there would be three separate primary deck element ratings that will be used in the calculation. Using the described approach the condition indices calculated for these scenarios, and their percentage differences with the BCI using Level 2a breakdown are given in Table 7.

  Note: The BCI values in the Table 7 have been calculated using condition markings at Level 2b for '01 – Primary Deck Element' and condition markings at Level 2a for the remaining elements (see Appendix G1).

- ***Option 2:*** Conditions identified at level 2b should be dealt with in accordance with the approach described in Section 4.5. For the aforementioned scenarios this process will provide one condition for the Primary Deck Element, which can then be used for evaluating the BCI for the structure. Using this approach the condition indices calculated for these scenarios, and their percentage differences with the BCI using Level 2a breakdown are given in Table 7.

  Note: The BCI values in the Table 7 have been calculated using condition markings at Level 2b for '01 – Primary Deck Element' and condition markings at Level 2a for the remaining elements (see Appendix G2).

Table 7: BCI for Level 2b – Option 1 vs. Option 2

Scenario	Description	Level 1a/2a		OPTION 1				OPTION 2			
		BCI_{Av}	BCI_{Crit}	BCI_{Av}	BCI_{Crit}	% Deference with level 2a scores		BCI_{Av}	BCI_{Crit}	% Deference with level 2a scores	
						BCI_{Av}	BCI_{Crit}			BCI_{Av}	BCI_{Crit}
1	All three beams in condition 2B	86.6	81.0	85.8	81.0	-0.9	0	86.6	81.0	0	0
2	Two beams in 1A and one beam in 2B			88.7	81.0	2.4	0	86.6	81.0	0	0
3	Two beams in 1A and one beam in 2C			88.5	78.9	2.2	-2.6	86.5	80.3	-0.1	-0.9
4	One beam in 1A and two beams in 2B			87.2	81.0	0.7	0	86.6	81.0	0	0

5.2.16 From Table 7 it can be observed that there is little or no variation between the BCI values calculated using Option 2 and those evaluated at level 1a/2a (Example 1.1).

5.2.17 Minor variations can be observed between BCI values calculated using Option 1 and those evaluated at level 1a/2a. Although the difference in condition indices in this example is small, it could become significant, when the severity and the extent of the damage vary. For example, if one beam is in 2E and the others are in 1A, the inspector could possibly mark the condition as 2C, if the BCI calculations are performed at Level 1a/2a. Table 8 presents the BCI values for the structure using option 1 and option 2 and also the percentage deference from the BCI values calculated using the level 1a/2a approach.

Table 8: Variation in BCI - Option 1 vs. Option 2

Scenario Description	Level 1a/2a		OPTION 1				OPTION 2			
	BCI_{Av}	BCI_{Crit}	BCI_{Av}	BCI_{Crit}	% Deference with level 2a scores		BCI_{Av}	BCI_{Crit}	% Deference with level 2a scores	
					BCI_{Av}	BCI_{Crit}			BCI_{Av}	BCI_{Crit}
Two beams in 1A and one beam in 2E	86.4	78.9	88.3	65.3	2.2	-17.2	86.2	76.0	-0.2	-3.7

5.2.18 It can be observed that there is a 17% variation between the BCI_{Crit} values calculated using option 1 and those calculated at level 1a/2a. When more elements (e.g. primary element, transverse beams, abutments, etc.) are condition marked separately, the variation in both indices could be expected to increase.

5.2.19 The BCI values using option 2 indicate minor variation from those calculated at level 1a/2a. Therefore, to maintain consistency and to prevent significant variations in BCI values for the different levels of refinement it is recommended that BCI for level 2b refinement should be calculated using option 2.

Example 1.4: Single Span Bridge to Level 1a/2c

5.2.20 For Lea Road Bridge the following element breakdown can be made at level 1a/2c:

Level 1a	Level 2a	Level 2b	Level 2c
Bridge: Vehicular	1. Primary deck element	Half Through Beam 1 (North Girder)	End Plate 1 (East)
			End Plate 2 (West)
			Splice 1
			Splice 2
			…..
		Half Through Beam 2 (Central Girder)	End Plate 1 (East)
			End Plate 2 (West)
			Splice 1
			Splice 2
			…..
		Half Through Beam 3 (South Girder)	End Plate 1 (East)
			End Plate 2 (West)
			Splice 1
			Splice 2
			…..
	23. Handrail/parapets/safety fences	Handrails 1 (North)	Pilaster 1 (East)
			Pilaster 2 (West)
			Coping Stone
			…..
		Handrails 2 (South)	Pilaster 1 (East)
			Pilaster 2 (West)
			Coping Stone
			…..

5.2.21 Authorities may decide on the details of the element classification at level 2c, depending on the importance of the structure.

5.2.22 Although inventory reporting may be carried out at Level 1a/2c, the condition of individual elements should be marked to either Level 1a/2a or Level 1a/2b and the condition index can be calculated as described in the previous examples.

5.3 Example 2: Multi Span Bridge

5.3.1 The Thundery Hill Bridge (Structure Ref: C21/2292) owned by the Surrey County Council is used as an example to illustrate the different levels of refinements for a multi span bridge. The bridge is a three span reinforced concrete slab bridge and is supported by reinforced concrete abutments and piers. The following figures (Figure 6, Figure 7, Figure 8 and Figure 9) illustrate a few of the elements that are present on the structure.

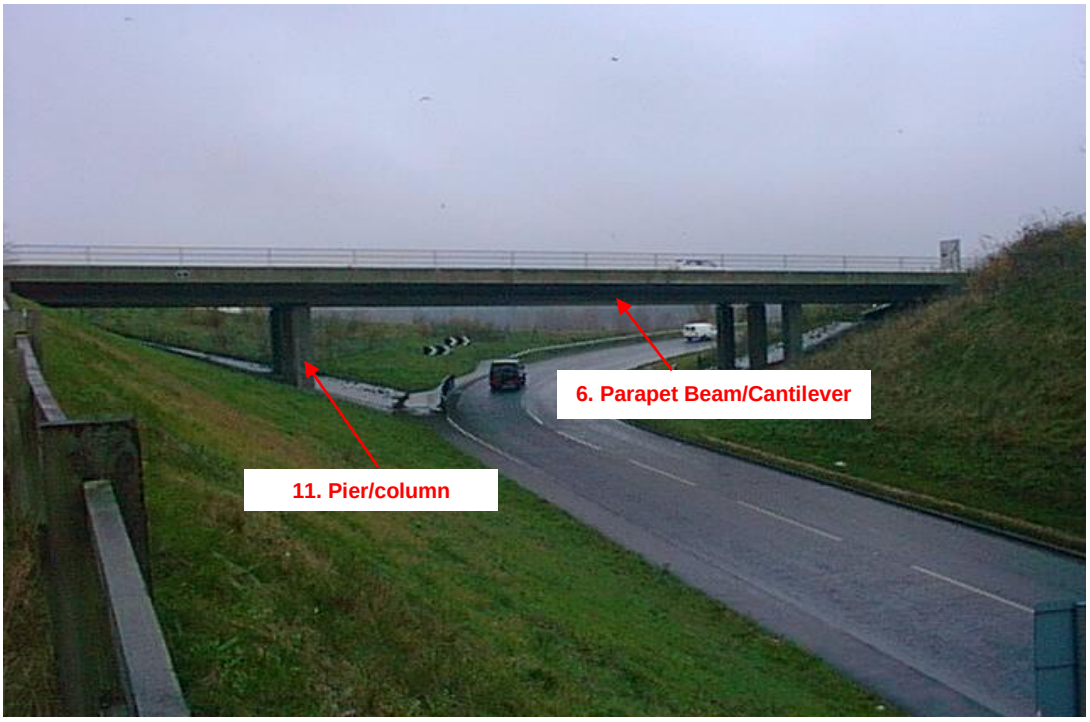

Figure 6: Thundery Hill Bridge – Elevation

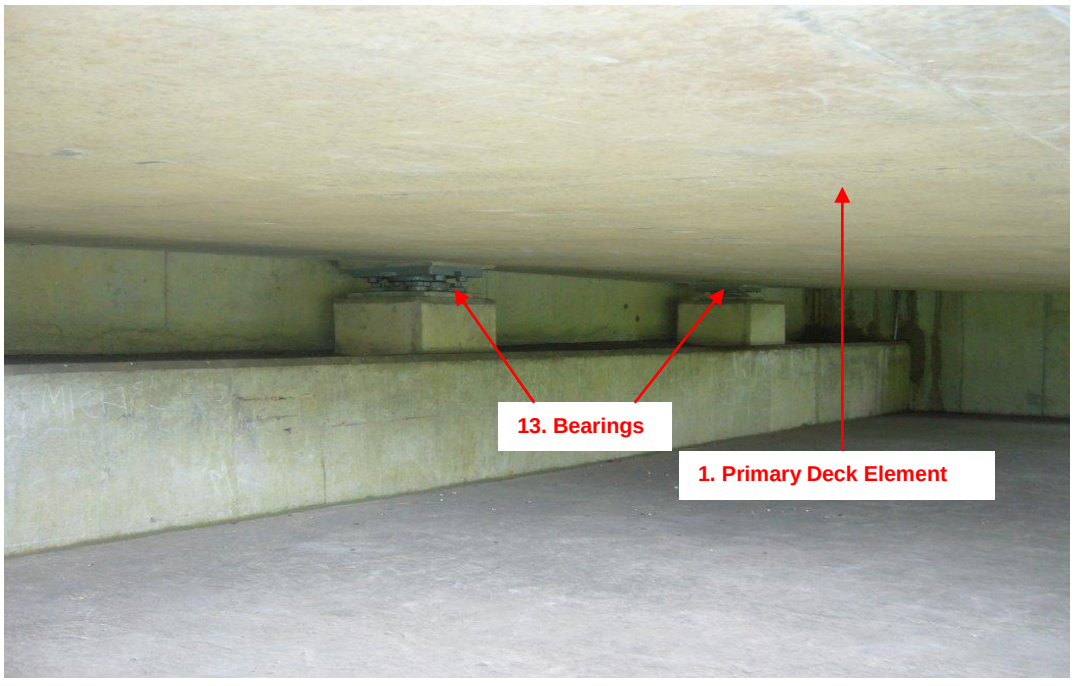

Figure 7: Thundery Hill Bridge – View Showing Bearings and Deck Soffit

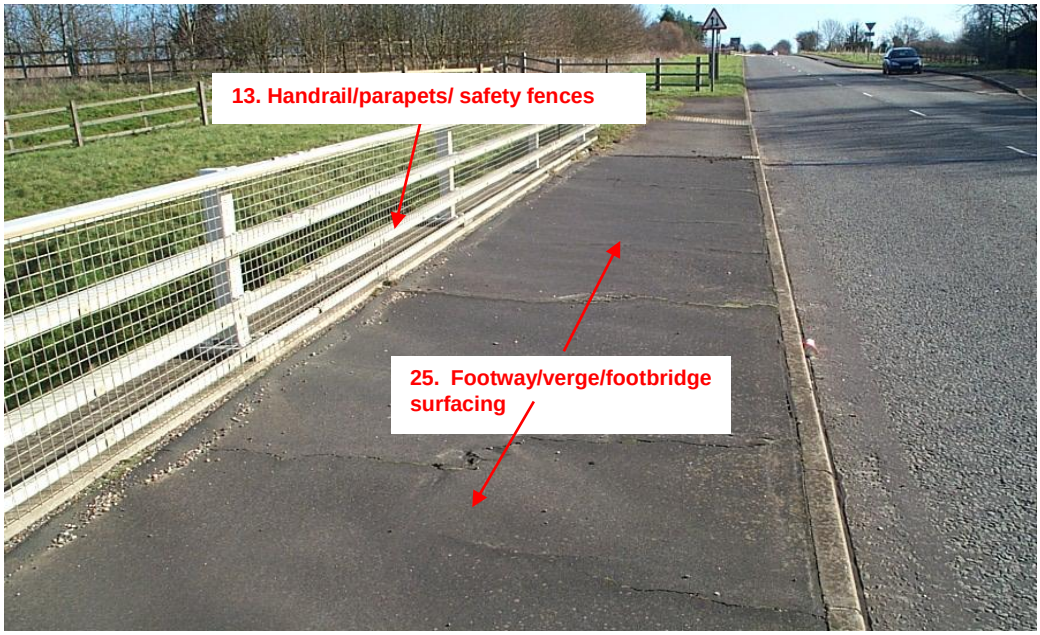

Figure 8: Thundery Hill Bridge – View Showing Hand Rails and Footway Surfacing

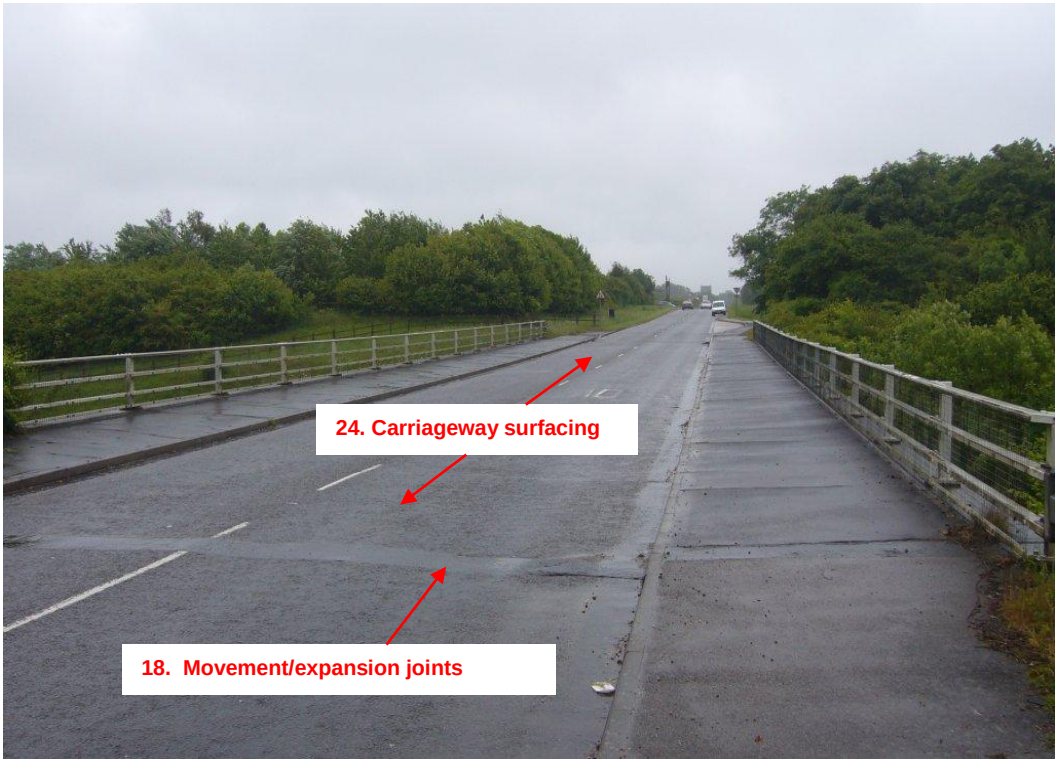

Figure 9: Thundery Hill Bridge – View at Road Level

Example 2.1: Multi Span Bridge to Level 1a/2a

5.3.2 The Thundery Hill bridge has the following elements under Level 1a/2a breakdown:

Level 1a	Level 2a
Bridge: Vehicular	1. Primary deck element
	6. Parapet beam or cantilever
	8. Foundations
	9. Abutments (incl. arch springing)
	11. Pier/column
	13. Bearings
	14. Bearing plinth/shelf
	15. Superstructure drainage
	17. Waterproofing
	18. Movement/expansion joints
	21. Finishes: parapets/safety fences
	23. Handrail/parapets/safety fences
	24. Carriageway surfacing
	25. Footway/verge/footbridge surfacing
	30. Revetment/batter paving
	35. Approach rails/barriers/walls
	38. Services

5.3.3 This is the minimum level of refinement required for the structure inventory and supports the development of a consistent condition marking system.

NOTE: The last inspection report revealed that the bridge is in a good condition with a BCI_{Crit} score of 100. However, for the purpose of this example, in order to identify the sensitivities of the different refinement levels on the evaluation of the final BCI, condition ratings for some critical elements were assumed as shown in Appendix H.

5.3.4 The BCI of this bridge was calculated using the BCI calculation procedure described in Guidance Note on Evaluation of Bridge Condition Indicators [3, 5]. The BCI_{Av} and BCI_{Crit} of this bridge calculated at level 1a/2a were found to be 72.2 and 58.0 respectively.

5.3.5 In the following sections, other possible levels of refinement are exemplified. BCI calculations are carried out by breaking down the elements at different levels, to identify the sensitivities of the refinement levels on the evaluation of the final BCI.

Example 2.2: Multi Span Bridge to Level 1c/2a

5.3.6 For Thundery Hill Bridge the following classification can be made at level 1c/2a:

Level 1a	Level 1c	Level 2a
Bridge: Vehicular	Span 1 (West Span)	1. Primary deck element
		6. Parapet beam or cantilever
		8. Foundations
		9. Abutments (incl. arch springing)
		11. Pier/column
		13. Bearings
		14. Bearing plinth/shelf
		15. Superstructure drainage
		17. Waterproofing
		18. Movement/expansion joints
		21. Finishes: parapets/safety fences
		23. Handrail/parapets/safety fences
		24. Carriageway surfacing
		25. Footway/verge/footbridge surfacing
		30. Revetment/batter paving
		35. Approach rails/barriers/walls
		38. Services
	Span 2 (Centre Span)	1. Primary deck element
		6. Parapet beam or cantilever
		8. Foundations
		9. Abutments (incl. arch springing)
		11. Pier/column
		13. Bearings
		14. Bearing plinth/shelf
		15. Superstructure drainage
		17. Waterproofing
		18. Movement/expansion joints
		21. Finishes: parapets/safety fences
		23. Handrail/parapets/safety fences
		24. Carriageway surfacing
		25. Footway/verge/footbridge surfacing
		30. Revetment/batter paving
		35. Approach rails/barriers/walls
		38. Services
	Span 1 (East Span)	1. Primary deck element
		6. Parapet beam or cantilever
		8. Foundations
		9. Abutments (incl. arch springing)
		11. Pier/column
		13. Bearings
		14. Bearing plinth/shelf
		15. Superstructure drainage
		17. Waterproofing
		18. Movement/expansion joints
		21. Finishes: parapets/safety fences
		23. Handrail/parapets/safety fences
		24. Carriageway surfacing
		25. Footway/verge/footbridge surfacing
		30. Revetment/batter paving
		35. Approach rails/barriers/walls
		38. Services

5.3.7 Both the inventory and condition reporting can be carried out at level 1c/2a, i.e. treating each span of the bridge as an individual structure at level 1a with condition of the elements marked at level 2a and BCI values are calculated for each span separately.

NOTE: The last inspection report revealed that the bridge is in a good condition with a BCI_{Crit} score of 100. However, for the purpose of this example, in order to identify the sensitivities of the refinement levels on the evaluation of the final BCI condition ratings for some critical elements were assumed as shown in Appendix I. The BCI_{Av} and BCI_{Crit} values for each of the three spans are presented in Table 9.

Table 9: BCI values for each span

Span	BCI_{Av}	BCI_{Crit}
1	77.5	81.0
2	75.7	78.9
3	79.4	58.0

5.3.8 The following provides details of how the BCI_{Av} and BCI_{Crit} for the overall bridge is evaluated:

- ***BCI_{Av} for Multi Span Bridge at Level 1c/2a***: The BCI_{Av} for the overall bridge can be calculated by taking the weighted average (with respect to deck area) of the BCI_{Av} values relating to each span (see Table 9), i.e.

$$BCI_{Av} = \frac{\sum_{i=1}^{S}(BCI_{Av} \times Span\ Deck\ Area)_i}{Whole\ Bridge\ Deck\ Area}$$

  Using this approach the BCI_{Av} for Thundery Hilll Bridge was calculated to be 77.2.

- ***BCI_{Crit} for Multi Span Bridge at Level 1c/2a***: The lowest/worst BCI_{Crit} score relating to the different spans (see Table 9) is taken as the BCI_{Crit} for the overall bridge, i.e. for Thundery Hill Bridge the BCI_{Crit} is 58.0.

  NOTE: Although the Guidance Note on Evaluation of Bridge Condition Indicators [3, 5] suggests taking a weighted average of the BCI_{Crit} values relating to each span, it is considered that this approach leads to a wide variation between the BCI_{Crit} values obtained from the different levels of refinement. Furthermore, a weighted average is considered to skew the results and not provide complete visibility of spans/structures with low scores that may have critical elements in poor or very poor condition.

Example 2.3: Multi Span Bridge to Level 1b/1c/2a

5.3.9 For Thundery Hill Bridge the following classification can be made at level 1b/1c/2a where the structure can be broken down both at levels 1b and 1c and elements can be broken down to level 2a.

Level 1a	Level 1b	Level 1c	Level 2a
Structure Type	**Super and Substructure**	**Span and/or Construction Form**	**CSS BCI Elements**
Bridge: Vehicular	Superstructure	Span 1 West Span	1. Primary deck element
			2. Transverse beams
			3. Secondary deck element/s
			4. Half joints
			5. Tie beam/rod
			6. Parapet beam or cantilever
			7. Deck bracing
			10. Spandrel wall/head wall
			13. Bearings
			15. Superstructure drainage
			17. Waterproofing
			18. Movement/expansion joints
			19. Finishes: deck elements
			21. Finishes: parapets/safety fences
			23. Handrail/parapets/safety fences
			24. Carriageway surfacing
			25. Footway/verge/footbridge surfacing
		Span 2 Centre Span	1. Primary deck element
			2. Transverse beams
			3. Secondary deck element/s
			4. Half joints
			5. Tie beam/rod
			6. Parapet beam or cantilever
			7. Deck bracing
			10. Spandrel wall/head wall
			13. Bearings
			15. Superstructure drainage
			17. Waterproofing
			18. Movement/expansion joints
			19. Finishes: deck elements
			21. Finishes: parapets/safety fences
			23. Handrail/parapets/safety fences
			24. Carriageway surfacing
			25. Footway/verge/footbridge surfacing
		Span 3 East Span	1. Primary deck element
			2. Transverse beams
			3. Secondary deck element/s
			4. Half joints
			5. Tie beam/rod
			6. Parapet beam or cantilever
			7. Deck bracing
			10. Spandrel wall/head wall
			13. Bearings
			15. Superstructure drainage
			17. Waterproofing
			18. Movement/expansion joints
			19. Finishes: deck elements
			21. Finishes: parapets/safety fences
			23. Handrail/parapets/safety fences
			24. Carriageway surfacing
			25. Footway/verge/footbridge surfacing

Level 1a	Level 1b	Level 1c	Level 2a
Structure Type	**Super and Substructure**	**Span and/or Construction Form**	**CSS BCI Elements**
Bridge: Vehicular	Substructure	West Abutment	8. Foundations
			9. Abutments (incl. arch springing)
			11. Pier/column
			12. Cross-head/capping beam
			14. Bearing plinth/shelf
			16. Substructure drainage
			20. Finishes: substructure elements
			22. Access/walkways/gantries
			26. Invert/river bed
			27. Aprons
			28. Fenders/cutwaters/collision prot.
			29. River training works
			30. Revetment/batter paving
			31. Wing walls
			32. Retaining walls
			33. Embankments
		West Pier	8. Foundations
			9. Abutments (incl. arch springing)
			11. Pier/column
			12. Cross-head/capping beam
			14. Bearing plinth/shelf
			16. Substructure drainage
			20. Finishes: substructure elements
			22. Access/walkways/gantries
			26. Invert/river bed
			27. Aprons
			28. Fenders/cutwaters/collision prot.
			29. River training works
			30. Revetment/batter paving
			31. Wing walls
			32. Retaining walls
			33. Embankments
		East Pier	8. Foundations
			9. Abutments (incl. arch springing)
			11. Pier/column
			12. Cross-head/capping beam
			14. Bearing plinth/shelf
			16. Substructure drainage
			20. Finishes: substructure elements
			22. Access/walkways/gantries
			26. Invert/river bed
			27. Aprons
			28. Fenders/cutwaters/collision prot.
			29. River training works
			30. Revetment/batter paving
			31. Wing walls
			32. Retaining walls
			33. Embankments
		East Abutment	8. Foundations
			9. Abutments (incl. arch springing)
			11. Pier/column
			12. Cross-head/capping beam
			14. Bearing plinth/shelf
			16. Substructure drainage
			20. Finishes: substructure elements
			22. Access/walkways/gantries
			26. Invert/river bed
			27. Aprons
			28. Fenders/cutwaters/collision prot.
			29. River training works
			30. Revetment/batter paving
			31. Wing walls
			32. Retaining walls
			33. Embankments
	Whole Structure	Not required for BCI calculation	34. Machinery
			35. Approach rails/barriers/walls
			36. Signs
			37. Lighting
			38. Services

5.3.10 Although inventory reporting may be carried out at Level 1b/1c/2a, the condition of individual elements should be marked to Level 1c/2a or Level 1a/2b (recommended for multi-span structures). Hence, the BCI values for this bridge, using Level 1c/2a refinement (Example 2.2), would be 77.2 (BCI_{Av}) and 58.0 (BCI_{Crit}). Level 1a/2b is described in the following section.

Example 2.3: Multi Span Bridge to Level 1a/2b

5.3.11 For Thundery Hill Bridge the following classification can be made at level 1a/2b:

Level 1a	Level 2a	Level 2b
Bridge: Vehicular	1. Primary deck element	West Span
		Centre Span
		East Span
	6. Parapet beam or cantilever	West Span
		Centre Span
		East Span
	8. Foundations	West Abutment
		West Pier
		East Pier
		East Abutment
	9. Abutments (incl. arch springing)	West Abutment
		East Abutment
	11. Pier/column	West Pier
		East Pier
	13. Bearings	West Abutment
		East Abutment
	14. Bearing plinth/shelf	West Abutment
		East Abutment
	15. Superstructure drainage	West Span
		East Span
	17. Waterproofing	West Span
		West Span
		East Span
	18. Movement/expansion joints	West Span
		East Span
	21. Finishes: parapets/safety fences	West Span
		Centre Span
		East Span
	23. Handrail/parapets/safety fences	West Span
		Centre Span
		East Span
	24. Carriageway surfacing	West Span
		Centre Span
		East Span
	25. Footway/verge/footbridge surfacing	West Span
		Centre Span
		East Span
	30. Revetment/batter paving	West Abutment
		East Abutment
	35. Approach rails/barriers/walls	
	38. Services	

5.3.12 **NOTE:** The last inspection report revealed that the bridge is in a good condition with a BCIcrit score of 100. However, for the purpose of this example, in order to identify the sensitivities of the refinement levels on the evaluation of the final BCI condition ratings for some critical elements were assumed as shown in Appendix H.

5.3.13 For evaluating the BCI at level 1a/2b each element rating is dealt with in accordance with Section 5.3 of the Guidance Document for Performance Measurement of Highway Structures, Part B1: Condition Performance Indicator[5]. Using this approach the BCI_{Av} and BCI_{Crit} values calculated at level 1a/2b for this bridge are 73.8 and 58.0 respectively.

Example 2.4: Multi Span Bridge to Level 1a/2c

5.3.14 If a more refined level of reporting is required, the following classification could be used:

Level 1a	Level 2a	Level 2b	Level 2c
Bridge: Vehicular	1. Primary deck element	West Span	Slab
			Soffit
			…
	6. Parapet beam or cantilever	West Span	Beam 1
			Beam 2
			…
	13. Bearings	West Abutment	Free Bearing
			Fixed Bearing
	14. Bearing plinth/shelf	West Abutment	Bearing plinth
			Bearing shelf
			Bearing shelf drainage

5.3.15 Authorities may decide on the details of the element classification at level 1a/2c, depending on the importance of the structure.

5.3.16 Although inventory reporting may be carried out at Level 1a/2c, the condition of individual elements should be marked to either Level 1a/2a or Level 1c/2a or Level 1a/2b (recommended for multi-span structures) and the condition index can be calculated as described in the previous examples.

Variation in Condition Index due to different levels of refinement

5.3.17 Table 10 presents the BCI_{Av} and BCI_{Crit} values for the Thundery Hill Bridge evaluated for the different levels of refinement in the previous sections.

Table 10: Variation in Condition Index

Level of Refinement	BCI_{Av}	BCI_{Crit}
1a/2a (Example 2.1)	72.2	58.0
1c/2a (Example 2.2)	77.2	58.0
1a/2b (Example 2.3)	73.8	58.0

5.3.18 The table indicates that the BCI values vary depending on the level of refinement. It can be observed that there is a slight difference (7%) in the BCI_{Av} values between level 1c/2a and level 1a/2a. This variation may have a significant impact once the BCI values for individual structures are aggregated to evaluate the BCI for the stock.

5.3.19 Therefore it is essential that an asset owning authority defines the appropriate level of refinement for their structure stock, for both the inventory and condition reporting. Once agreed these should be 'locked-down'. Level 1a/2b is the recommended level for multi-span structures.

5.4 Example 3: Culvert

5.4.1 The George V Avenue Culvert (Structure Ref: 14/M/LA/PX22) owned by the London Borough of Harrow is used as an example to illustrate condition reporting and BCI evaluation for culverts. The culvert carries the River Pinn under George V Avenue in a north-east to south west direction. The culvert is a reinforced concrete box culvert, which is 38.5m long, 2.44m wide and has an internal height of 1.5m. The following figures (Figure 10, Figure 11 and Figure 12) illustrate a few of the elements that are present on the culvert.

Figure 10: George V Avenue Culvert – View of Downstream End Looking North-East

Figure 11: George V Avenue Culvert – Handrail, Parapet and Safety Fences

Figure 12: George V Avenue Culvert – View of Carriageway and Footway

5.4.2 Although for the purpose of inventory reporting the elements can be broken down up to level 2c it is recommended that for culverts the condition of individual elements should be marked to Level 1a/2a. For George V Avenue Culvert the following table provides the classification of elements at level2a:

Level 1a	Level 2a
Culvert	1. Primary deck element
	6. Parapet beam or cantilever
	8. Foundations
	9. Abutments (incl. arch springing)
	11. Pier/column
	15. Superstructure drainage
	16. Substructure drainage
	17. Waterproofing
	21. Finishes: parapets/safety fences
	23. Handrail/parapets/safety fences
	24. Carriageway surfacing
	25. Footway/verge/footbridge surfacing
	26. Invert/river bed
	27. Aprons
	30. Revetment/batter paving
	31. Wing walls
	32. Retaining walls
	33. Embankments
	35. Approach rails/barriers/walls
	38. Services

The condition ratings provided in the last inspection report have been used to calculate the BCI values for the culvert. The BCI_{Av} and BCI_{crit} for the culvert were calculated to be 81.0 (see Appendix K).

5.5 Example 4: Retaining Wall

5.5.1 The Widmore Road Retaining Wall owned by the London Borough of Bromley is used as an example to illustrate condition reporting and BCI evaluation for retaining walls. The mass concrete retaining wall consists of seven bays of varying length and height. The total height of the wall is 30.6m and it is supported by six buttresses on the southern side. The following figures (Figure 13 and Figure 14) illustrate a few of the elements that are present on the retaining wall.

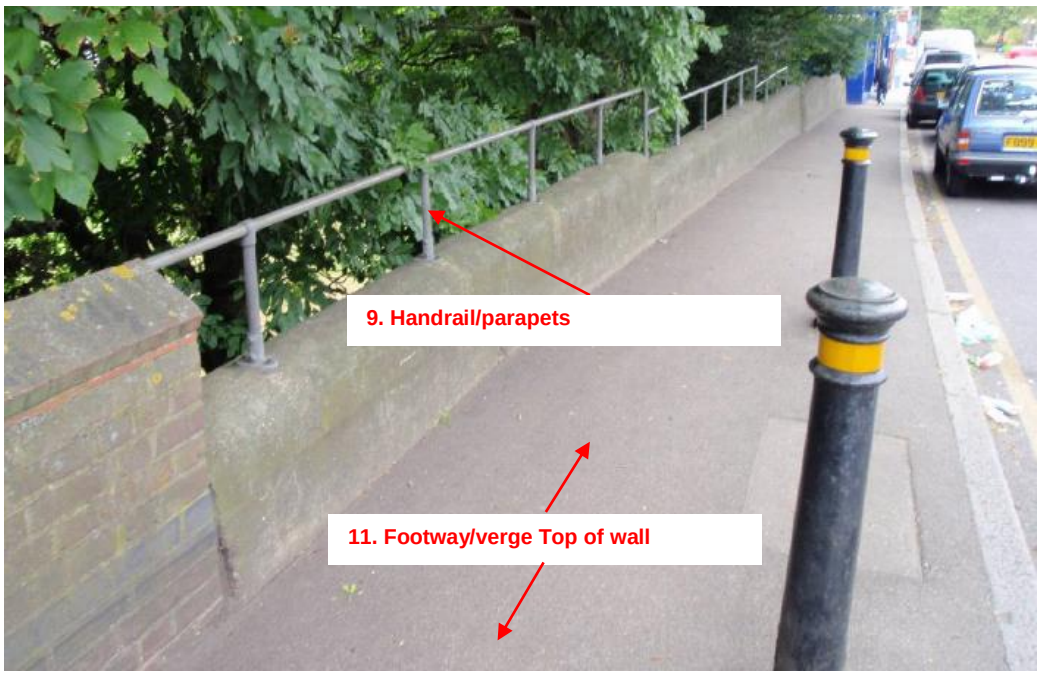

Figure 13: Widmore Road Retaining Wall – General View of Face at Road level

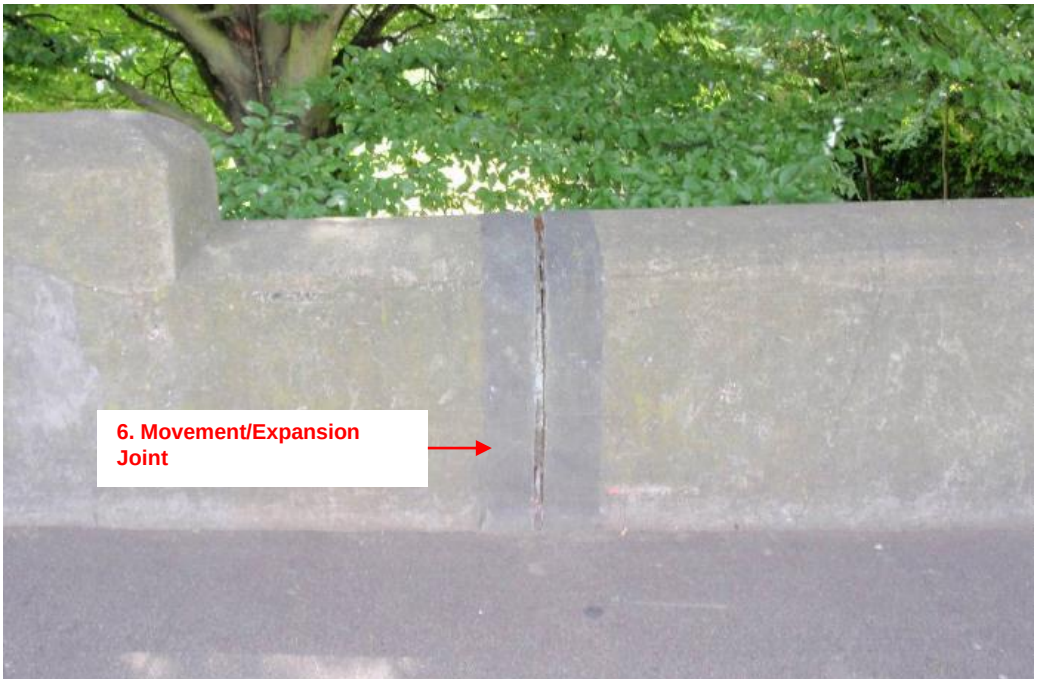

Figure 14: Widmore Road Retaining Wall – Expansion Joint

5.5.2 Although for the purpose of inventory reporting the elements can be broken down to up to level 2c it is recommended that for retaining walls the condition of individual elements should be marked to Level 1a/2a. For Widmore Road Retaining Wall the following table provides the classification of elements at level 2a

Level 1a	Level 2a
Retaining Wall	1.Foundations
	2. Retaining wall - Primary
	3. Retaining wall - Secondary
	5. Drainage
	6. Movement/expansion joints
	7. Surface finishes: wall
	8. Surface finishes: handrail/parapet
	9. Handrail/parapets/safety fences
	10. Carriageway - Top of wall
	12. Footway/verge - Top of wall
	15. Embankment - Foot of wall

5.5.3 The condition ratings provided in the last inspection report have been used to calculate the BCI values for the culvert. The BCI_{Av} and BCI_{Crit} for the retaining wall were calculated to be 85.4 and 78.9 respectively (see Appendix L).

6 References

1. Code of Practice on Transport Infrastructure Assets: Guidance to Support Asset Management, Financial Management and Reporting, Chartered Institute of Public Finance & Accountancy (CIPFA), March 2010.
2. CSS Bridge Condition Indicator, Volume 2: Guidance Note on Bridge Inspection Reporting, April 2002.
3. CSS Bridge Condition Indicator, Volume 2: Guidance Note on Evaluation of Bridge Condition Indicators, August 2002.
4. Addendum to CSS Bridge Condition Indicator, Volume 2: Guidance Note on Bridge Inspection Reporting, August 2004
5. Guidance Document for Performance Measurement of Highway Structures, Part B1: Condition Indicator, 2007
6. Inspection Manual for Highway Structures, Volume 1: Reference Material, TSO, May 2007.

APPENDICES

Appendix A: Standard CSS Element Lists

A1: Bridge Elements

CSS BCI	
ID	**Element Description**
1	Primary deck element (Table 2)
2	Transverse beams
3	Element from Table 3
4	Half joints
5	Tie beam/rod
6	Parapet beam or cantilever
7	Deck bracing
8	Foundations
9	Abutments (inc arch springing)
10	Spandrel wall/head wall
11	Pier/column
12	Cross-head/capping beam
13	Bearings
14	Bearing plinth/shelf
15	Superstructure drainage
16	Substructure drainage
17	Waterproofing
18	Movement/expansion joints
19	Finishes: deck elements
20	Finishes: substructure elements
21	Finishes: parapets/safety fences
22	Access/walkways/gantries
23	Handrail/parapets/safety fences
24	Carriageway surfacing
25	Footway/verge/footbridge surfacing
26	Invert/river bed
27	Aprons
28	Fenders/cutwaters/collision prot.
29	River training works
30	Revetment/batter paving
31	Wing walls
32	Retaining walls
33	Embankments
34	Machinery
35	Approach rails/barriers/walls
36	Signs
37	Lighting
38	Services

A2: Retaining wall Elements

CSS BCI	
ID	**Element Description**
1	Foundations
2	Retaining wall - Primary
3	Retaining wall - Secondary
4	Parapet beam/plinth
5	Drainage
6	Movement/Expansion joints
7	Surface finishes: wall
8	Surfaces finishes: handrail/parapet
9	Handrail/parapets/safety fences
10	Carriageway - Top of wall
11	Carriageway - Foot of wall
12	Footway/verge - Top of wall
13	Footway/verge - Foot of wall
14	Embankment - Top of wall
15	Embankment - Foot of wall
16	Invert/river bed
17	Aprons
18	Signs
19	Lighting
20	Services

A3: Sign/Signal Gantry Elements

CSS BCI ID	Element Description
1	Foundations
2	Truss/beams/cantilever
3	Transverse/horiz. bracing elements
4	Columns/supports/legs
5	Surface Finishes: truss/beams/cantilever
6	Surface Finishes: columns/supports/legs
7	Surface Finishes: other elements
8	Access/walkway/deck
9	Access ladder
10	Handrails/Guard Rails
11	Base connections
12	Support to longitudinal connection
13	Sign and signal supports
14	Signs/Signals
15	Lighting
16	Services
Additional HA Element	Road Restraint System (RRS)

Appendix B: Level 2a Classification

Level 1a	Level 1b	Level 1c	Level 2a	Level 2b	Level 2c
Structure Type	**Super and Substructure**	**Span and/or Construction Form**	**CSS BCI Elements**	**Element Breakdown**	**Further Element Breakdown**
Bridge: Vehicular	Not required	Not required	1.Primary deck element	Not required	Not required
			2. Transverse beams		
			3. Secondary deck element/s		
			4. Half joints		
			5. Tie beam/rod		
			6. Parapet beam or cantilever		
			7. Deck bracing		
			8. Foundations		
			9. Abutments (incl. arch springing)		
			10. Spandrel wall/head wall		
			11. Pier/column		
			12. Cross-head/capping beam		
			13. Bearings		
			14. Bearing plinth/shelf		
			15. Superstructure drainage		
			16. Substructure drainage		
			17. Waterproofing		
			18. Movement/expansion joints		
			19. Finishes: deck elements		
			20. Finishes: substructure elements		
			21. Finishes: parapets/safety fences		
			22. Access/walkways/gantries		
			23. Handrail/parapets/safety fences		
			24. Carriageway surfacing		
			25. Footway/verge/footbridge surfacing		
			26. Invert/river bed		
			27. Aprons		
			28. Fenders/cutwaters/collision prot.		
			29. River training works		
			30. Revetment/batter paving		
			31. Wing walls		
			32. Retaining walls		
			33. Embankments		
			34. Machinery		
			35. Approach rails/barriers/walls		
			36. Signs		
			37. Lighting		
			38. Services		

Appendix C: Level 1b & 1C Classifications

C1: Option 1

Level 1a	Level 1b	Level 1c	Level 2a	Level 2b	Level 2c
Structure Type	**Super and Substructure**	**Span and/or Construction Form**	**CSS BCI Elements**	**Element Breakdown**	**Further Element Breakdown**
Bridge: Vehicular	Superstructure	Span 1	1.Primary deck element	Not required	Not required
			2. Transverse beams		
			3. Secondary deck element/s		
			4. Half joints		
			5. Tie beam/rod		
			6. Parapet beam or cantilever		
			7. Deck bracing		
			10. Spandrel wall/head wall		
			15. Superstructure drainage		
			17. Waterproofing		
			18. Movement/expansion joints		
			19. Finishes: deck elements		
			21. Finishes: parapets/safety fences		
			23. Handrail/parapets/safety fences		
			24. Carriageway surfacing		
			25. Footway/verge/footbridge surfacing		
		Span 2	1.Primary deck element		
			2. Transverse beams		
			3. Secondary deck element/s		
			4. Half joints		
			5. Tie beam/rod		
			6. Parapet beam or cantilever		
			7. Deck bracing		
			10. Spandrel wall/head wall		
			15. Superstructure drainage		
			17. Waterproofing		
			18. Movement/expansion joints		
			19. Finishes: deck elements		
			21. Finishes: parapets/safety fences		
			23. Handrail/parapets/safety fences		
			24. Carriageway surfacing		
			25. Footway/verge/footbridge surfacing		
	Substructure	Not required	8. Foundations		
			9. Abutments (incl. arch springing)		
			11. Pier/column		
			12. Cross-head/capping beam		
			13. Bearings		
			14. Bearing plinth/shelf		
			16. Substructure drainage		
			20. Finishes: substructure elements		
			22. Access/walkways/gantries		
			26. Invert/river bed		
			27. Aprons		
			28. Fenders/cutwaters/collision prot.		
			29. River training works		
			30. Revetment/batter paving		
			31. Wing walls		
			32. Retaining walls		
			33. Embankments		
			34. Machinery		
			35. Approach rails/barriers/walls		
			36. Signs		
			37. Lighting		
			38. Services		
	Whole Structure	Not required	34. Machinery		
			35. Approach rails/barriers/walls		
			36. Signs		
			37. Lighting		
			38. Services		

C2: Option 2

Level 1a	Level 1b	Level 1c	Level 2a	Level 2b	Level 2c
Structure Type	**Super and Substructure**	**Span and/or Construction Form**	**CSS BCI Elements**	**Element Breakdown**	**Further Element Breakdown**
Bridge: Vehicular	Not required	Span 1	1.Primary deck element	Not required	Not required
			2. Transverse beams		
			3. Secondary deck element/s		
			4. Half joints		
			5. Tie beam/rod		
			6. Parapet beam or cantilever		
			7. Deck bracing		
			8. Foundations		
			9. Abutments (incl. arch springing)		
			10. Spandrel wall/head wall		
			11. Pier/column		
			12. Cross-head/capping beam		
			13. Bearings		
			14. Bearing plinth/shelf		
			15. Superstructure drainage		
			16. Substructure drainage		
			17. Waterproofing		
			18. Movement/expansion joints		
			19. Finishes: deck elements		
			20. Finishes: substructure elements		
			21. Finishes: parapets/safety fences		
			22. Access/walkways/gantries		
			23. Handrail/parapets/safety fences		
			24. Carriageway surfacing		
			25. Footway/verge/footbridge surfacing		
			26. Invert/river bed		
			27. Aprons		
			28. Fenders/cutwaters/collision prot.		
			29. River training works		
			30. Revetment/batter paving		
			31. Wing walls		
			32. Retaining walls		
			33. Embankments		
			34. Machinery		
			35. Approach rails/barriers/walls		
			36. Signs		
			37. Lighting		
			38. Services		
		Span 2	1.Primary deck element		
			2. Transverse beams		
			3. Secondary deck element/s		
			4. Half joints		
			5. Tie beam/rod		
			6. Parapet beam or cantilever		
			7. Deck bracing		
			8. Foundations		
			9. Abutments (incl. arch springing)		
			10. Spandrel wall/head wall		
			11. Pier/column		
			12. Cross-head/capping beam		
			13. Bearings		
			14. Bearing plinth/shelf		
			15. Superstructure drainage		
			16. Substructure drainage		
			17. Waterproofing		
			18. Movement/expansion joints		
			19. Finishes: deck elements		
			20. Finishes: substructure elements		
			21. Finishes: parapets/safety fences		
			22. Access/walkways/gantries		
			23. Handrail/parapets/safety fences		
			24. Carriageway surfacing		
			25. Footway/verge/footbridge surfacing		
			26. Invert/river bed		
			27. Aprons		
			28. Fenders/cutwaters/collision prot.		
			29. River training works		
			30. Revetment/batter paving		
			31. Wing walls		
			32. Retaining walls		
			33. Embankments		
			34. Machinery		
			35. Approach rails/barriers/walls		
			36. Signs		
			37. Lighting		
			38. Services		

C3: Option 3

Level 1a	Level 1b	Level 1c		Level 2a	Level 2b	Level 2c
Structure Type	Super and Substructure	Span	Construction Form	CSS BCI Elements	Element Breakdown	Further Element Breakdown
Bridge: Vehicular	Not required	Span 1	Simply Supported - Solid Slab	1.Primary deck element	Not required	Not required
				2. Transverse beams		
				3. Secondary deck element/s		
				4. Half joints		
				5. Tie beam/rod		
				6. Parapet beam or cantilever		
				7. Deck bracing		
				8. Foundations		
				9. Abutments (incl. arch springing)		
				10. Spandrel wall/head wall		
				11. Pier/column		
				12. Cross-head/capping beam		
				13. Bearings		
				14. Bearing plinth/shelf		
				15. Superstructure drainage		
				16. Substructure drainage		
				17. Waterproofing		
				18. Movement/expansion joints		
				19. Finishes: deck elements		
				20. Finishes: substructure elements		
				21. Finishes: parapets/safety fences		
				22. Access/walkways/gantries		
				23. Handrail/parapets/safety fences		
				24. Carriageway surfacing		
				25. Footway/verge/footbridge surfacing		
				26. Invert/river bed		
				27. Aprons		
				28. Fenders/cutwaters/collision prot.		
				29. River training works		
				30. Revetment/batter paving		
				31. Wing walls		
				32. Retaining walls		
				33. Embankments		
				34. Machinery		
				35. Approach rails/barriers/walls		
				36. Signs		
				37. Lighting		
				38. Services		
		Span 2	Cantilever and Suspended Span - Solid Slab	1.Primary deck element		
				2. Transverse beams		
				3. Secondary deck element/s		
				4. Half joints		
				5. Tie beam/rod		
				6. Parapet beam or cantilever		
				7. Deck bracing		
				8. Foundations		
				9. Abutments (incl. arch springing)		
				10. Spandrel wall/head wall		
				11. Pier/column		
				12. Cross-head/capping beam		
				13. Bearings		
				14. Bearing plinth/shelf		
				15. Superstructure drainage		
				16. Substructure drainage		
				17. Waterproofing		
				18. Movement/expansion joints		
				19. Finishes: deck elements		
				20. Finishes: substructure elements		
				21. Finishes: parapets/safety fences		
				22. Access/walkways/gantries		
				23. Handrail/parapets/safety fences		
				24. Carriageway surfacing		
				25. Footway/verge/footbridge surfacing		
				26. Invert/river bed		
				27. Aprons		
				28. Fenders/cutwaters/collision prot.		
				29. River training works		
				30. Revetment/batter paving		
				31. Wing walls		
				32. Retaining walls		
				33. Embankments		
				34. Machinery		
				35. Approach rails/barriers/walls		
				36. Signs		
				37. Lighting		
				38. Services		

Appendix D: Level 2b & 2C Refinements

Level 1a	Level 1b	Level 1c	Level 2a	Level 2b	Level 2c
Structure Type	**Super and Substructure**	**Span and/or Construction Form**	**CSS BCI Elements**	**Element Breakdown**	**Further Element Breakdown**
Bridge: Vehicular	Not required	Not required	1.Primary deck element	Beam 1	End Plate/Stiffner 1
					End Plate/Stiffner 2
					Splice 1
					Splice 2
				Beam 2	
				Beam 3	
				Beam 4	
			2. Transverse beams	and so on….	and so on…
			3. Secondary deck element/s		
			4. Half joints		
			5. Tie beam/rod		
			6. Parapet beam or cantilever		
			7. Deck bracing		
			8. Foundations		
			9. Abutments (incl. arch springing)	Abutment 1 - North	
				Abutment 2 - South	
			10. Spandrel wall/head wall	and so on….	and so on…
			11. Pier/column		
			12. Cross-head/capping beam		
			13. Bearings		
			14. Bearing plinth/shelf		
			15. Superstructure drainage		
			16. Substructure drainage		
			17. Waterproofing		
			18. Movement/expansion joints		
			19. Finishes: deck elements		
			20. Finishes: substructure elements		
			21. Finishes: parapets/safety fences		
			22. Access/walkways/gantries		
			23. Handrail/parapets/safety fences		
			24. Carriageway surfacing		
			25. Footway/verge/footbridge surfacing		
			26. Invert/river bed		
			27. Aprons		
			28. Fenders/cutwaters/collision prot.		
			29. River training works		
			30. Revetment/batter paving		
			31. Wing walls		
			32. Retaining walls		
			33. Embankments		
			34. Machinery		
			35. Approach rails/barriers/walls		
			36. Signs		
			37. Lighting		
			38. Services		

Appendix E: Lea Road Bridge – Level 1a/2a Condition Reporting

Level 1a	Level 2a	Severity	Extent	ECS	EIF	ECF	ECI	ECI x EIF	ECIcrit
Structure Type	**CSS BCI Elements**								
Bridge: Vehicular	1. Primary deck element	2	B	2.0	2.0	0.0	2.0	4.0	2.0
	2. Secondary deck element/s – Transverse beams	2	B	2.0	2.0	0.0	2.0	4.0	2.0
	6. Parapet beam or cantilever	1	A	1.0	2.0	0.0	1.0	2.0	1.0
	8. Foundations	Not Inspected							
	9. Abutments (incl. arch springing)	2	B	2.0	1.5	0.2	1.8	2.7	
	13. Bearings	1	A	1.0	1.2	0.6	1.0	1.2	
	14. Bearing plinth/shelf	1	A	1.0	1.2	0.6	1.0	1.2	
	15. Superstructure drainage	4	E	4.7	1.2	0.0	4.7	5.6	
	16. Substructure drainage	4	B	4.0	1.2	0.2	3.9	4.6	
	17. Waterproofing	1	A	1.0	1.2	0.6	1.0	1.2	
	18. Movement/expansion joints	2	B	2.0	1.5	0.2	1.8	2.7	
	19. Finishes: deck elements	2	C	2.1	1.2	0.4	1.7	2.0	
	21. Finishes: parapets/safety fences	2	B	2.0	1.2	0.5	1.6	1.9	
	23. Handrail/parapets/safety fences	1	A	1.0	1.5	0.3	1.0	1.5	
	24. Carriageway surfacing	2	C	2.1	1.2	0.4	1.7	2.0	
	25. Footway/verge/footbridge surfacing	2	B	2.0	1.0	0.9	1.1	1.1	
	26. Invert/river bed	Not Inspected							
	28. Fenders/cutwaters/collision prot.	1	A	1.0	1.2	0.6	1	1.2	
	32. Retaining walls	2	C	2.1	1.2	0.4	1.7	2.0	
	35. Approach rails/barriers/walls	5	E	5.0					
	38. Services	Not Inspected							
		BCI_{Av}: 86.6				**BCI_{Crit}: 81.0**			

Appendix F: Lea Road Bridge – Level 1b/2a Condition Reporting

Level 1a	Level 1b	Level 2a	Severity	Extent	ECS
Structure Type	Super/Sub Structure	CSS BCI Elements			
Bridge: Vehicular	Superstructure	1. Primary element (Half Through Beams)	2	B	2.0
		2. Transverse Beams	2	B	2.0
		6. Parapet beam or cantilever	1	A	1.0
		15. Superstructure drainage	4	E	4.7
		17. Waterproofing	1	A	1.0
		18. Movement/expansion joints	2	B	2.0
		19. Finishes: deck elements	2	C	2.1
		21. Finishes: parapets/safety fences	2	B	2.0
		23. Handrail/parapets/safety fences	1	A	1.0
		24. Carriageway surfacing	2	C	2.1
		25. Footway/verge/footbridge surfacing	2	B	2.0
	Substructure	8. Foundations	Not Inspected		
		9. Abutments (incl. arch springing)	2	B	2.0
		13. Bearings	1	A	1.0
		14. Bearing plinth/shelf	1	A	1.0
		16. Substructure Drainage	4	B	4.0
		26. Invert/river bed	Not Inspected		
		28. Fenders/cutwaters/collision prot.	1	A	1.0
		32. Retaining walls	2	C	2.1
	Whole Structure	35. Approach rails/barriers/walls	5	E	5.0
		38. Services	Not Inspected		
			BCI_{Av}: 86.6	**BCI_{Crit}: 81.0**	

Appendix G: Lea Road Bridge – Level 1a/2b Condition Reporting

G1: Option 1

Level 1a	Level 2a	Level 2b	Severity	Extent	ECS	EIF	ECF	ECI	ECI x EIF	ECI_{Crit}
Structure Type	**CSS BCI Elements**	**Element Breakdown**								
Bridge: Vehicular	1. Primary deck element	Half Through Beam 1	1	A	1.0	2.0	0.0	2.0	2.0	1.0
		Half Through Beam 2	1	A	1.0	2.0	0.0	2.0	2.0	1.0
		Half Through Beam 3	2	C	2.1	1.2	0.4	1.7	2.0	2.0
	2. Secondary deck element/s – Transverse beams		2	B	2.0	2.0	0.0	2.0	4.0	2.0
	6. Parapet beam or cantilever		1	A	1.0	2.0	0.0	1.0	2.0	1.0
	8. Foundations		Not Inspected							
	9. Abutments (incl. arch springing)		2	B	2.0	1.5	0.2	1.8	2.7	
	13. Bearings		1	A	1.0	1.2	0.6	1.0	1.2	
	14. Bearing plinth/shelf		1	A	1.0	1.2	0.6	1.0	1.2	
	15. Superstructure drainage		4	E	4.7	1.2	0.0	4.7	5.6	
	16. Substructure drainage		4	B	4.0	1.2	0.2	3.9	4.6	
	17. Waterproofing		1	A	1.0	1.2	0.6	1.0	1.2	
	18. Movement/expansion joints		2	B	2.0	1.5	0.2	1.8	2.7	
	19. Finishes: deck elements		2	C	2.1	1.2	0.4	1.7	2.0	
	21. Finishes: parapets/safety fences		2	B	2.0	1.2	0.5	1.6	1.9	
	23. Handrail/parapets/safety fences		1	A	1.0	1.5	0.3	1.0	1.5	
	24. Carriageway surfacing		2	C	2.1	1.2	0.4	1.7	2.0	
	25. Footway/verge/footbridge surfacing		2	B	2.0	1.0	0.9	1.1	1.1	
	26. Invert/river bed		Not Inspected							
	28. Fenders/cutwaters/collision prot.		1	A	1.0	1.2	0.6	1	1.2	
	32. Retaining walls		2	C	2.1	1.2	0.4	1.7	2.0	
	35. Approach rails/barriers/walls		5	E	5.0					
	38. Services		Not Inspected							
			BCI_{Av}: 88.5				**BCI_{Crit}: 78.9**			

G2: Option 2

Level 1a	Level 2a	Level 2b	Sub Element Weighting, W_{SE}	Severity	Extent	Extent Numeric Value	Extent Score for element	ECS	EIF	ECF	ECI	ECI x EIF	ECI_{Crit}
Structure Type	**CSS BCI Elements**	**Element Breakdown**											
Bridge: Vehicular	1. Primary deck element	Half Through Beam 1	1.0	1	A	0.0	0.03	2.03	2.0	0.0	2.0	4.1	2.0
		Half Through Beam 2	1.0	1	A	0.0							
		Half Through Beam 3	1.0	2	C	0.1							
	2. Secondary deck element/s – Transverse beams			2	B			2.0	2.0	0.0	2.0	4.0	2.0
	6. Parapet beam or cantilever			1	A			1.0	2.0	0.0	1.0	2.0	1.0
	8. Foundations		Not Inspected										
	9. Abutments (incl. arch springing)			2	B			2.0	1.5	0.2	1.8	2.7	
	13. Bearings			1	A			1.0	1.2	0.6	1.0	1.2	
	14. Bearing plinth/shelf			1	A			1.0	1.2	0.6	1.0	1.2	
	15. Superstructure drainage			4	E			4.7	1.2	0.0	4.7	5.6	
	16. Substructure drainage			4	B			4.0	1.2	0.2	3.9	4.6	
	17. Waterproofing			1	A			1.0	1.2	0.6	1.0	1.2	
	18. Movement/expansion joints			2	B			2.0	1.5	0.2	1.8	2.7	
	19. Finishes: deck elements			2	C			2.1	1.2	0.4	1.7	2.0	
	21. Finishes: parapets/safety fences			2	B			2.0	1.2	0.5	1.6	1.9	
	23. Handrail/parapets/safety fences			1	A			1.0	1.5	0.3	1.0	1.5	
	24. Carriageway surfacing			2	C			2.1	1.2	0.4	1.7	2.0	
	25. Footway/verge/footbridge surfacing			2	B			2.0	1.0	0.9	1.1	1.1	
	26. Invert/river bed		Not Inspected										
	28. Fenders/cutwaters/collision prot.			1	A			1.0	1.2	0.6	1	1.2	
	32. Retaining walls			2	C			2.1	1.2	0.4	1.7	2.0	
	35. Approach rails/barriers/walls			5	E			5.0					
	38. Services		Not Inspected										
			BCI_{Av}: 86.5					**BCI_{Crit}: 80.3**					

Appendix H: Thundery Hill Bridge – Level 1a/2a Condition Reporting

Level 1a	Level 2a	Severity	Extent	ECS	EIF	ECF	ECI	ECI x EIF	ECI_{Crit}
Structure Type	**CSS BCI Elements**								
Bridge: Vehicular	1. Primary deck element	3	B	3.0	2.0	0.0	3.0	6.0	3.0
	6. Parapet beam or cantilever	2	C	2.1	2.0	0.0	2.1	4.2	2.1
	8. Foundation	1	B	1	1.5	0.3	1.0	1.5	
	9. Abutments (incl. arch springing)	2	C	2.1	1.5	0.2	1.9	2.8	
	11. Pier/column	2	C	2.1	1.5	0.2	1.9	2.8	
	13. Bearings	3	B	3.0	1.5	0.15	2.8	4.3	
	14. Bearing plinth/shelf	Not Inspected							
	15. Superstructure drainage	3	B	3	1.5	0.2	2.8	4.3	
	16. Substructure drainage	Not Inspected							
	17. Waterproofing	Not Inspected							
	18. Movement/expansion joints	3	C	3.1	1.5	1.1	3.0	4.4	
	21. Finishes: parapets/safety fences	Not Inspected							
	23. Handrail/parapets/safety fences	Not Inspected							
	24. Carriageway surfacing	Not Inspected							
	25. Footway/verge/footbridge surfacing	4	E	4.7	1.0	0.1	4.6	4.6	
	30. Revetment/batter paving	2	C	2.1	1.0	0.9	1.1	1.1	
	35. Approach rails/barriers/walls	Not Inspected							
	38. Services	Not Inspected							
		BCI_{Av}: 72.2					**BCI_{Crit}: 58.0**		

Appendix I: Thundery Hill Bridge – Level 1c/2a Condition Reporting

I1: Thundery Hill Bridge – Span 1 (West Span)

Level 1a	Level 2a								
Structure Type	**CSS BCI Elements**	**Severity**	**Extent**	**ECS**	**EIF**	**ECF**	**ECI**	**ECI x EIF**	**ECI_{Crit}**
Bridge: Vehicular – Span 1	1. Primary deck element	2	B	2.0	2.0	0.0	2.0	4.0	2.0
	6. Parapet beam or cantilever	2	B	2.0	2.0	0.0	1.0	2.0	1.0
	8. Foundation	1	B	1	1.5	0.3	1.0	1.5	
	9. Abutments (incl. arch springing)	2	C	2.1	1.5	0.2	1.9	2.8	
	11. Pier/column	2	C	2.1	2.0	0.0	2.1	4.2	
	13. Bearings	3	B	3	1.5	0.2	2.8	4.3	
	14. Bearing plinth/shelf	Not Inspected							
	15. Superstructure drainage	2	C	2.1	1.2	0.5	1.7	2.0	
	16. Substructure drainage	Not Inspected							
	17. Waterproofing	Not Inspected							
	18. Movement/expansion joints	3	C	3.1	1.5	1.1	3.0	4.4	
	21. Finishes: parapets/safety fences	Not Inspected							
	23. Handrail/parapets/safety fences	Not Inspected							
	24. Carriageway surfacing	Not Inspected							
	25. Footway/verge/footbridge surfacing	4	E	4.7	1.0	0.1	4.6	4.6	
	30. Revetment/batter paving	2	C	2.1	1.0	0.9	1.1	1.1	
	35. Approach rails/barriers/walls	Not Inspected							
	38. Services	Not Inspected							
		BCI_{Av}: 77.5				**BCI_{Crit}: 81.0**			

I2: Thundery Hill Bridge – Span 2 (Centre Span)

Level 1a	Level 2a								
Structure Type	**CSS BCI Elements**	**Severity**	**Extent**	**ECS**	**EIF**	**ECF**	**ECI**	**ECI x EIF**	**ECI_{Crit}**
Bridge: Vehicular – Span 2	1. Primary deck element	2	C	2.1	2.0	0.0	2.1	4.0	2.1
	6. Parapet beam or cantilever	2	C	2.1	2.0	0.0	2.1	4.2	2.1
	8. Foundation	1	B	1	1.5	0.3	1.0	1.5	
	11. Pier/column	2	C	2.1	2.0	0.0	2.1	4.2	
	13. Bearings	2	D	2.3	1.5	0.2	2.1	3.1	
	14. Bearing plinth/shelf	Not Inspected							
	15. Superstructure drainage	3	B	3.0	1.2	0.3	2.7	3.2	
	16. Substructure drainage	Not Inspected							
	17. Waterproofing	Not Inspected							
	18. Movement/expansion joints	3	C	3.1	1.5	1.1	3.0	4.4	
	21. Finishes: parapets/safety fences	Not Inspected							
	23. Handrail/parapets/safety fences	Not Inspected							
	24. Carriageway surfacing	Not Inspected							
	25. Footway/verge/footbridge surfacing	4	E	4.7	1.0	0.1	4.6	4.6	
	30. Revetment/batter paving	2	C	2.1	1.0	0.9	1.1	1.1	
	35. Approach rails/barriers/walls	Not Inspected							
	38. Services	Not Inspected							
		BCI_{Av}: 75.7				**BCI_{Crit}: 78.9**			

I3: Thundery Hill Bridge – Span 3 (East Span)

Level 1a	Level 2a								
Structure Type	**CSS BCI Elements**	**Severity**	**Extent**	**ECS**	**EIF**	**ECF**	**ECI**	**ECI x EIF**	**ECI_{Crit}**
Bridge: Vehicular – Span 3	1. Primary deck element	3	B	3.0	2.0	0.0	3.0	6.0	3.0
	6. Parapet beam or cantilever	1	A	1.0	2.0	0.0	1.0	2.0	1.0
	8. Foundation	1	B	1	1.5	0.3	1.0	1.5	
	9. Abutments (incl. arch springing)	2	C	2.1	1.5	0.2	1.9	2.8	
	11. Pier/column	2	C	2.1	2.0	0.0	2.1	4.2	2.1
	13. Bearings	1	A	1	1.5	0.3	1	1.5	
	14. Bearing plinth/shelf	Not Inspected							
	15. Superstructure drainage	2	B	2.0	1.2	0.4	1.6	1.9	
	16. Substructure drainage	Not Inspected							
	17. Waterproofing	Not Inspected							
	18. Movement/expansion joints	3	B	3.1	1.5	1.1	3.0	4.4	
	21. Finishes: parapets/safety fences	Not Inspected							
	23. Handrail/parapets/safety fences	Not Inspected							
	24. Carriageway surfacing	Not Inspected							
	25. Footway/verge/footbridge surfacing	4	E	4.7	1.0	0.1	4.6	4.6	
	30. Revetment/batter paving	2	C	2.1	1.0	0.9	1.1	1.1	
	35. Approach rails/barriers/walls	Not Inspected							
	38. Services	Not Inspected							
		BCI_{Av}: 79.4				**BCI_{Crit}: 58.0**			

Using the following formulae the BCI_{Av} and BCI_{Crit} values for the overall bridge have been calculated as shown in table below:

$$BCI_{Av} = \frac{\sum_{i=1}^{S}(BCI_{Av} \times Span\ Deck\ Area)_i}{Whole\ Bridge\ Deck\ Area}$$

Where S is the total number of spans on a bridge

$$BCI_{Crit} = \text{Minimum } (BCI_{Crit})_i$$

Span No.	BCI_{Av} (Span)	BCI_{Crit} (Span)	Span Length (m)	Span Width (m)	Span Area (m2)
1 (West Span)	77.5	81.0	15	12.3	184.5
2 (Centre Span)	75.7	78.9	26	12.3	319.8
3 (East Span)	79.4	58.0	15	12.3	184.5
				BCIAv (Bridge)	77.2
				BCICrit (Bridge)	58.0

Appendix J: Thundery Hill Bridge – Level 1a/2b Condition Reporting

Level 1a	Level 2a		Level 2b										
Structure Type	**CSS BCI Elements**			**Element Dimension**	**Sub Element Weighting, W_{SE}**	**Severity**	**Extent**	**Extent Score**	**ECS = Severity + Extent Score**	**EIF**	**ECF**	**ECI**	**ECI x EIF**	**ECI_{Crit}**
Bridge: Vehicular	1.Primary deck element	West Span		15m	0.6	2	B	0.0	3.0	2.0	0.0	3.0	6.0	3
		Centre Span		26m	1.0	2	C							
		East Span		15m	0.6	3	B							
	6. Parapet beam or cantilever	West Span		15m	0.6	2	B	0.05	2.0	2.0	0.0	2.0	4.1	2.0
		Centre Span		26m	1.0	2	C							
		East Span		15m	0.6	1	A							
	8. Foundations	West Abutment			1.0	Not Inspected								
		West Pier			1.0	1	B	0.0	1.0	1.5	0.3	1.0	1.5	
		East Pier			1.0	1	B							
		East Abutment			1.0	Not Inspected								
	9. Abutments (incl. arch springing)	West Abutment			1.0	2	C	0.10	2.1	1.5	0.2	1.9	2.8	
		East Abutment			1.0	2	C							
	11. Pier/column	West Pier			1.0	2	B	0.1	2.1	2.0	0.0	2.0	4.0	2
		East Pier			1.0	2	C							
	13. Bearings	West Span			1.0	3	B	0.0	3.0	1.5	0.2	2.9	4.3	
		Centre Span			1.0	2	D							
		East Span			1.0	1	A							
	14. Bearing plinth/shelf	West Abutment			1.0	Not Inspected								
		East Abutment			1.0	Not Inspected								
	15. Superstructure drainage	West Span			1.0	2	C		3.0	1.2	0.3	2.7	3.2	
		East Span			1.0	3	B	0.0						
	17. Waterproofing	West Span			0.6	Not Inspected								
		West Span			1.0	Not Inspected								
		East Span			0.6	Not Inspected								
	18. Movement/expansion joints	West Span			1.0	3	C	0.10	3.1	1.5	0.1	3.0	4.4	
		East Span			1.0	3	C							
	21. Finishes: parapets/safety fences	West Span		15m	0.6	Not Inspected								
		Centre Span		26m	1.0	Not Inspected								
		East Span		15m	0.6	Not Inspected								
	23. Handrail/parapets/safety fences	West Span		15m	0.6	Not Inspected								
		Centre Span		26m	1.0	Not Inspected								
		East Span		15m	0.6	Not Inspected								
	24. Carriageway surfacing	West Span		15m	0.6	Not Inspected								
		Centre Span		26m	1.0	Not Inspected								
		East Span		15m	0.6	Not Inspected								
	25. Footway/verge/footbridge surfacing	West Span		15m	0.6	4	E	0.70	4.7	1.0	0.1	4.6	4.6	
		Centre Span		26m	1.0	4	E							
		East Span		15m	0.6	4	E							
	30. Revetment/batter paving	West Abutment			1.0	2	C	0.1	2.1	1.0	0.9	1.2	1.2	
		East Abutment			1.0	1	A	0.0	1.0	1.0	1.2	1.0	1.0	
	35. Approach rails/barriers/walls					Not Inspected								
	38. Services					Not Inspected								
						BCI_{Av}: 73.8					**BCI_{Crit}: 58.0**			

Appendix K: George V Avenue Culvert – Level 1a/2a Condition Reporting

Level 1a	Level 2a	Severity	Extent	ECS	EIF	ECF	ECI	ECI x EIF	ECI_{Crit}
Structure Type	**CSS BCI Elements**								
Culvert	1. Primary deck element	2	B	2.0	2.0	0.0	2.1	4.0	2.0
	6. Parapet beam or cantilever	1	A	1.0	2.0	0.0	1.0	2.0	1.0
	8. Foundation	1	A	1.0	1.5	0.3	1.0	1.5	
	9. Abutments (incl. arch springing)	2	B	2.0	1.5	0.2	1.8	2.7	2
	11. Pier/column	Not Inspected							
	15. Superstructure drainage	1	A	1	1.2	0.6	1.0	1.2	
	16. Substructure drainage	1	A	1	1.2	0.6	1.0	1.2	
	17. Waterproofing	2	B	2.0	1.2	0.4	1.6	1.9	
	21. Finishes: parapets/safety fences	4	E	4.7	1.2	0.0	4.7	5.6	
	23. Handrail/parapets/safety fences	5	D	5	1.5	0.0	5.0	7.5	
	24. Carriageway surfacing	4	B	4	1.2	0.2	3.8	4.6	
	25. Footway/verge/footbridge surfacing	2	B	2.0	1.0	0.9	1.1	1.1	
	26. Invert/river bed	1	A	1.0	1.2	0.6	1.0	1.2	
	27. Aprons	1	A	1.0	1.2	0.6	1.0	1.2	
	30. Revetment/batter paving	5	C	5.0	1.0	0.0	5.0	5.0	
	31. Wing walls	1	A	1.0	1.5	0.3	1.0	1.5	
	32. Retaining walls	2	B	2.0	1.2	0.4	1.6	1.9	
	33. Embankments	2	B	2.0	1.0	0.9	1.1	1.1	
	35. Approach rails/barriers/walls	Not Inspected							
	38. Services	Not Inspected							
		BCI_{Av}: 81.0				**BCI_{Crit}: 81.0**			

Appendix L: Widmore Road Retaining Wall – Level 1a/2a Condition Reporting

Level 1a	Level 2a	Severity	Extent	ECS	EIF	ECF	ECI	ECI x EIF	ECI_{Crit}
Structure Type	**CSS BCI Elements**								
Retaining Wall	1. Foundation	Not Inspected							
	2. Retaining wall – Primary	2	C	2.1	2.0	0.0	2.1	4.2	2.1
	3. Retaining wall – Primary	2	B	2.0	2.0	0.0	2.0	4.0	2.0
	5. Drainage	Not Inspected							
	6. Movement/expansion joints	4	C	4.1	2.0	0.0	2.1	4.2	2.1
	7. Surface finishes: wall	2	D	2.3	2.0	0.0	2.0	4.0	2
	8. Surface finishes: handrail/parapet	2	B	2.0					
	9. Handrail/parapets/safety fences	1	A	1.0	1.2	0.1	4.0	4.8	
	10. Carriageway - Top of wall	1	A	1.0	1.2	0.4	1.9	2.3	
	12. Footway/verge - Top of wall	1	A	1.0	1.2	0.5	1.6	1.9	
	15. Embankment - Foot of wall	1	A	1.0	1.5	0.3	1.0	1.5	
		BCI_{Av}: 85.4				**BCI_{Crit}: 78.9**			

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