LoBEG Good Practice Guide

Risk-based Inspection of Highway Structures

Objective Risk-based Inspection Planning for the achievement of Effective Risk Management & Targeted Resourcing

Version 1.0

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London Bridges Engineering Group

Notice

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Contents

Glossary

Asset	Physical highway infrastructure and other items that have a distinct value to a highway authority, e.g. carriageway, structures, etc.
General Inspection	The purpose of a General Inspection is to provide information on the physical condition of all visible elements on a highway structure. A General Inspection comprises a visual inspection, usually undertaken from ground level, of all parts of the structure that can be inspected without the need for special access equipment or traffic management arrangements.
Geotechnical Structure	Earth-based structure types such as slopes, retaining structures, embankments, roadways, levees, landfills and other systems that are made of or are supported by soil or rock.
Hidden Elements / Defects	In a structure, a hidden component is an element that would not usually be visually inspected as part of a principal inspection i.e. to within touching distance using normal inspection techniques such as visual techniques and hammer tapping or an element may be inaccessible at the time of inspection. It is necessary to implement appropriate investigations and testing to examine and assess affected elements such as structural arrangement and hidden defects; distortion and movement; material properties; deterioration activity; deterioration rate; deterioration cause or potential.
Inspectability	The Risk-based process subjects any relevant asset to an assessment of its inspectability, this determines if any of its associated elements, or potential defects, are able to be inspected under normal General or Principal Inspection criteria. Should any hidden elements or defects be identified then this is considered in the risk assessment.
Lifecycle Plan	A considered strategy for managing an asset, or group of similar assets, from construction to disposal. It involves the prediction of future performance of an asset, or group of assets, based on investment scenarios and maintenance strategies.
Maintenance	Activities and operations undertaken to manage and maintain an asset, e.g. inspection, assessment, renewal, upgrade, etc.
Principal Inspection	The purpose of a Principal Inspection is to provide information on the physical condition of all inspectable parts of a highway structure. A Principal Inspection is more comprehensive and provides more detailed information than a General Inspection. A Principal Inspection comprises a close examination, within touching distance, of all inspectable parts of a structure. It should utilise as necessary suitable inspection techniques, access equipment and / or traffic management. Where features are not inspectable then appropriate investigations and testing is required to be put in place.

Risk	An event or hazard that has the potential to hinder the achievement of business objectives.
Risk Score	The score or rating assigned to a specific Value Criterion based on an assessment of the likelihood and consequence of the event hazard.
Special Inspection	The purpose of a Special Inspection is to provide detailed information on a particular part, area or defect that is causing concern, or inspection of which is beyond the requirements of the General / Principal Inspection regime. A Special Inspection may comprise a close visual inspection, testing and / or monitoring and may involve a one-off inspection, a series of inspections or ongoing programme of inspection.
Structural Assessment	A process of confirming the adequacy of a structure to support specified loads and determining appropriate remedial actions if necessary. Assessment is carried out in accordance with national standards and involves detailed numerical calculations.
Value Criterion	A measure or principle that is relevant to the delivery of business objectives, for example, safety, functionality, environment and financial.
Value Engineering	Is a refinement of the Value Management process. It is a second stage process that is conducted on an individual scheme, to optimise both the design and construction phases. In principle, it reduces the risk associated with unforeseen issues at the time of scheme development. Value Engineering also provides the authority with a further chance to explore potential opportunities for innovation.
Value Management	A process that may be used to prioritise the competing needs of highway schemes, identified through the condition and economic prioritisation. It provides a structured, consistent and quality-controlled approach for assessing the benefits of undertaking maintenance and the associated risks of not undertaking maintenance. The outcome should be a prioritised programme of schemes.
Whole Life Cost	The cost of all items / activities that need to be considered in a whole life costing analysis, such as the costs of acquiring (includes design and construction costs), operating and maintaining an asset over its whole life through to its eventual disposal.

Abbreviations

AADT	Average Annual Daily Traffic
ADEPT	Association of Directors of Environment, Economy, Planning & Transport
BCI	Bridge Condition Index
BCI_{AV}	The average Bridge Condition Index (the condition of all structural elements in a bridge)
BCI_{CR}	The critical Bridge Condition Index (the condition of those elements deemed to be of very high importance to the bridge)
BPII	Benchmark Principal Inspection Interval
BPRN	Borough Principal Road Network
C_F	Consequence of Failure Score
C_{MF}	Consequence Magnitude Factor
CoP	Code of Practice
CSS	County Surveyors Society (currently known as ADEPT)
DfT	Department for Transport
DLI	Defect Liability Inspection
DoLI	Date of Last Inspection
DSI	Date of Scheduled Inspection
EE_S	Environmental Exposure Score
EC_S	Environmental Consequence Score
FC_S	Functionality Consequence Score
F_{PII}	Principal Inspection Interval Adjustment Factor
FRP	Fibreglass Reinforced Plastic
GI	General Inspection
GPG	Good Practice Guide
GRP	Glass Reinforced Plastic
HE	Highways England (formerly known as Highways Agency)
I_S	Inspectability Score

L_F	Likelihood of Failure Score
L_{F_Aft}	Likelihood After Interval Action Score
$L_{S\text{-}SC}$	Condition Likelihood Score
LoBEG	London Bridge Engineering Group
PI	Principal Inspection
PII	Proposed Inspection Interval
PMT_{MF}	Primary Material Type Modification Factor
POI	Pre Opening Inspection
PPII	Proposed Principal Inspection Interval
PT	Post Tensioned
PTSI	Post-tensioned Special Inspection
RBI	Risk-Based Inspection
SC_S	Safety Consequence Score
$SC_{S\text{-}Base}$	Socio-Economic Importance Score
$SC_{S\text{-}MF}$	Safety Consequence Magnitude Factor
SI	Special Inspection
TfL	Transport for London
TLRN	Transport for London Road Network

1. Executive Summary

Highway structures form essential links in any highway network. A potential failure of any of these links could result in delays to the travelling public, deterioration of the environment and even injuries depending on the severity of the failure event.

The London Bridges Engineering Group (LoBEG) and Transport for London (TfL) have developed a risk-based approach to the planning of inspections of highway structures. This method is appropriate for bridges and other structures and is used to implement a consistent, objective and transparent risk-based approach.

It was developed in order to enable authorities to:

- Identify needs and provide justification for inspection activities by formalising the assessment of benefits and risks.
- Allocate resources efficiently to the relevant assets.
- Enable consistent comparison of different needs between different assets.
- Realise the benefits from appropriate utilisation of resources.

The risk-based methodology uses data, such as inventory, condition, primary materials, structure dimensions, construction forms, annual average daily traffic, inspections, with the aim of:

- Assessing the current level of risk associated with the structure(s).
- Calculating appropriate inspection intervals.
- Developing long term inspection programming.

2. Introduction

2.1. General

This Good Practice Guide describes the methodology jointly developed by the London Bridges Engineering Group (LoBEG) and Transport for London (TfL) for the risk-based inspection planning process for highway structures.

This framework can be used to implement a consistent, objective and transparent risk-based approach for the inspection of all highway structures.

2.2. Purpose

The purpose of this document is to provide a step-by-step guide to risk-based inspection planning for highway structures explaining how and when the methodology should be used.

2.3. The Need for Risk-based Inspection Planning

Well-managed Highways Infrastructure: A Code of Practice (2016) replaced the previous suite of UK highway's codes of practice: Well Maintained Highways, Management of Highway Structures, Well-lit highways and Management of Electronic Traffic Equipment.

The code of practice was developed by the Department of Transport through its Roads, Bridges and Lighting boards with the UK Road Liaison Group as a single document to emphasis the integrated asset management approach to highway network infrastructure assets.

The CoP was published in 2016 and there was an agreed period of two years where all the codes of practice would be valid as best practice to aid in the transition to the required full implementation.

Along with condensing the previous suite of codes, the main change between the old and new is the requirement that all highway management activities are delivered on a risk-based approach.

The intention of the CoP is that authorities will develop their own levels of service and the CoP, therefore, provides guidance for authorities to consider when developing their approach in accordance with local needs, levels of service, inspections, programmes, responses, priorities and affordability.

As stipulated in the CoP, a risk-based approach requires highway authorities to fully document their practices and the evidence, analysis and / or rationale that support those practices.

Highway structures were subject to a time-based regime of General Inspections (GIs) and Principal Inspections (PIs) every two and six years respectively (and to

Special Inspections (SIs) as and when required). These inspection regimes are defined in:

- Inspection Manual for Highway Structures (2007)
- BD63: Inspection of Highway Structures (2017)

However, BD63 also advises that structure owners are able to increase or decrease the Principal Inspection intervals based on a robust and fully documented risk assessment, i.e. risk-based inspection. The aforementioned documents do not describe the specific details of the risk assessment that should be undertaken, as such, the majority of highway structures owners had tended to retain the standard cycles.

Based on the CoP, organisations are required, where practicable, to apply appropriately tailored inspection regimes using risk assessment in order to improve the risk profile, minimise the liability to the owners of the structures and utilise inspection resources as effectively as possible.

2.4. Dependencies

In order to deliver a reliable risk-based inspection regime, there are certain fundamental prerequisites that need to be in place in order to ensure that the process is robust and can provide an authority with confidence in their informed decision making.

These requirements ultimately need to be determined by the authority proposing to deliver a risk-based approach, however inclusion of, but not limited to, the following fundamentals are recommended to be considered as essential:

- Personnel involved in conducting risk assessments, developing risk-based inspection programmes and inspections delivery are suitably competent and qualified.
- Highway safety and service inspections and / or other relevant processes are in place, that includes for the affected structures, are in place and appropriately managed. This is vital to ensure that the network is monitored in line with current standards and change and issues are identified, managed and risk assessments informed and updated where applicable.
- Consistent and sufficiently comprehensive asset inventory.
- Condition data is sufficient and quality assured.
- Asset specific knowledge and / or issues are considered.

2.5. The Layout of the Good Practice Guide

The layout of the good practice guide is summarised in Table 1.

Section		Description
1.	Executive Summary	A brief but comprehensive synopsis of this document.
2.	Introduction	The current section that serves as a general overview of this document.
3.	The Evolution of Risk-based Asset Management	Describes how risk-based methodologies are utilised to support objective and optimum management of Highway Structures.
4.	Framework for Risk-based Inspections	Defines the approach used in the framework to determine the Risk-based Inspection intervals in a step-by-step manner.
5.	Conclusion	A summing up of the benefits of implementing the framework as well as defining the dependencies and limitations of the overall process.
6.	References	Relevant documents referred to for the purpose of this study.
A to E	Appendices	Provision of supporting information and evidence based material.

Table 1: The Layout of the Guide

3. The Evolution of Risk-based Asset Management

3.1. Overview

Asset Management is defined in the Framework for Highway Asset Management as:

> *'Asset management is a strategic approach that identifies the optimal allocation of resources for the management, operation, preservation and enhancement of the highway infrastructure to meet the needs of current and future customers.'*

There is appetite across the industry to develop methodologies that support formal asset management of highway structures. The publication of the Code of Practice in 2016 has given further impetus to this, in order that authorities adopt and meet these requirements.

An important component of Risk-based Asset Management is the categorisation of assets by level of risk which enables asset owners to objectively assess asset condition, evaluate maintenance and inspection programmes, study operating protocols and estimate the remaining life of assets – in relation to / or considering the likelihood and consequences of structural and / or other failure. This information is then used to modify and optimise inspection and maintenance programmes, audit procedures, operating limits and other risk mitigation measures.

3.2. Why use a risk-based approach?

Previously, the structural safety of most highway structures had been assured by two factors:

- Design, assessment and maintenance in accordance with codes or rules incorporating empirical safety factors.

- Regular inspections to provide assurance that no accidental damage or unanticipated deterioration has occurred.

However, it is prudent to accept that operational loads may vary beyond design levels and that material degradation may be greater than anticipated. The safety factors used at the design stage may not, therefore, guarantee through-life structural safety. Hence periodic inspection is also carried out to determine the actual levels of deterioration and to check the adequacy of the design loads (e.g. inspection for assessment) and identify appropriate maintenance actions.

Both inspection and maintenance strategies should take account of the risk of structural failure. Using traditional approaches to inspection planning, risk tended only to be considered implicitly and was not assessed in an auditable manner. This can lead to 'high-risk' and 'low-risk' assets not being clearly identified and distinguished for management purposes. This may also mean that 'low-risk' assets are inspected more frequently than is necessary which leads to needless inspection costs, while 'high-risk' assets may not all be afforded sufficient attention and priority. Without the explicit consideration of risk, resources may not be appropriately targeted.

An inspection strategy based on risk overcomes the limitations of the time-based approach and ensures that resources are appropriately targeted. The concept of risk takes into account, not only the probability of failure, but also the consequences of failure. These may encompass consequences in terms of lost profits, repair and re-justification costs, casualties, reduced level of service and environmental costs. Such a strategy ensures that inspection effort is targeted appropriately to optimise costs and benefits while providing an auditable demonstration that this has been done with due diligence.

Maintenance and inspection strategies have evolved, as shown in Figure 1.

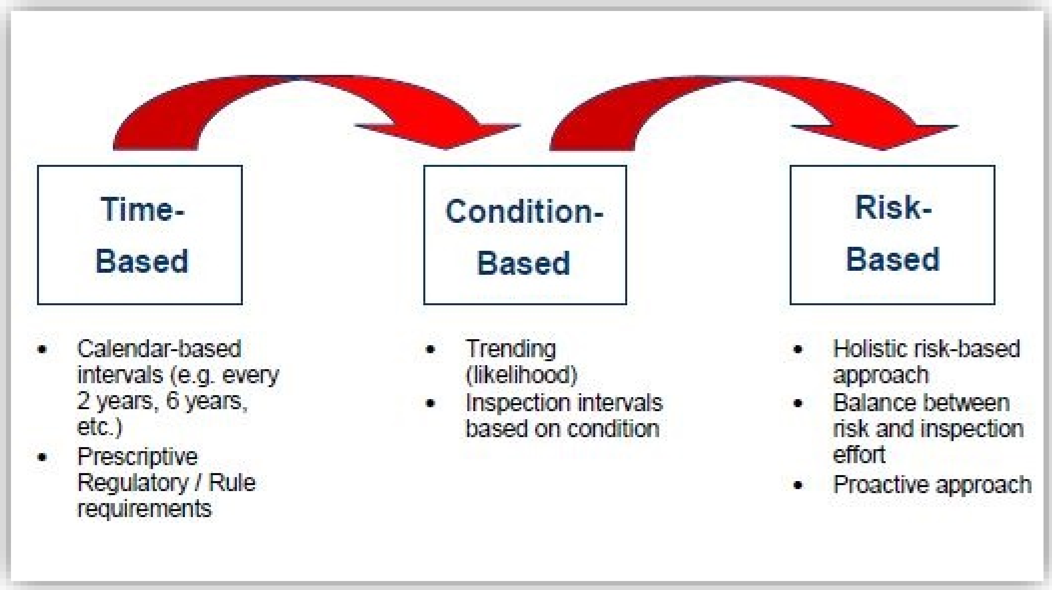

Figure 1: Evolution of Inspection and Maintenance Planning Strategies

Clearly, risk is an important consideration in the asset management of highway structures. Available guidance for the principal areas of application is reviewed in the following.

3.3. Risk-based Inspection

The intervals for General and Principal Inspections are mandated in BD63 and they are largely the same for all structures regardless of their strategic importance and risk of failure. The introduction of the CoP, requires that a risk-based approach is applied to activities that highway authorities deliver, including inspections.

The London Bridges Engineering Group (LoBEG) and Transport for London (TfL) have developed and utilise a risk-based approach to the delivery of the Principal

Inspection regimes that they are responsible for, this has realised benefits of improved risk management and reduced liabilities.

The Well-managed Highway Infrastructure CoP provides some basic guidance for varying inspection intervals based on risk considerations.

Network Rail and Welsh Assembly also introduced flexibility in their inspection regimes to alter the inspection intervals based on the qualitative estimate of risk.

3.4. Risk-based Maintenance

Risk-based maintenance is widely used in numerous sectors, historically its application to highway structures has been limited; however, there are increasing numbers of authorities implementing maintenance regimes of this nature.

LoBEG, in collaboration with TfL and Atkins, has developed and adopted the Risk-based Prioritisation & Value for Money tool which enables the implementation of an objective risk-based approach to the prioritisation of planned maintenance works.

Highways England applies risk-based methods for developing maintenance regimes for Midland Links Viaducts and for half joints and hinge joints.

Highways England commissioned Atkins to develop optimum maintenance strategies and plans (i.e. lifecycle plans) based on risk and whole life cost approaches. These lifecycle plans are utilised to develop a long term Asset Management Plan for the entire stock of highway structures that Highways England is responsible for. This also provides guidance for use by associated maintaining agents to apply risk and whole life cost approaches to individual bridges to determine optimal maintenance interventions.

3.5. Prioritisation and Value Management

LoBEG implements the Risk-based Prioritisation & Value for Money tool, referenced in section 3.4, which is a value management process that enables objective risk-based prioritisation of planned maintenance work for the achievement of value for money. This methodology is appropriate for bridges and other structures and is used to implement a consistent, objective and transparent prioritisation approach.

TfL also implements a cross-asset value management process for all highway asset types which incorporates the application of the above LoBEG process.

Highway England's value management process takes account of risk in prioritising maintenance needs. A simple risk scoring procedure is given for scoring a range of maintenance and upgrade works.

Following the road / rail incident at Great Heck, Selby, on 28th February 2001, the DfT issued a risk ranking procedure for road / rail intersections. A similar system was developed by the UK Bridges Board for prioritising road over rail bridges for strengthening.

4. Framework for Risk-based Inspections

4.1. Overview

The aim of the framework is to provide a practical approach for authorities and guidance for readily and objectively determining risk-based inspection intervals for highway structures in order to identify and adopt an inspection regime that minimises liability. In developing the framework, a risk approach has been adopted whereby the risk of an event (e.g. defect occurring and / or progressively getting worse over a period of time) is assessed through Likelihood and Consequence of the event, i.e.:

$$Risk\ = f\ (Likelihood\ of\ Event, Consequence\ of\ Event)$$

Equation 1: Assessed Risk Constituents

Where:

- **Likelihood of Event:**
  The probability of rapid deterioration, damage or failure given the current condition, i.e. the condition at the last recorded General or Principal Inspection, the rate of deterioration, the Inspectability, etc., what is the likelihood that a structure or part of a structure will deteriorate further or even fail?

- **Consequence of Event:**
  Given that deterioration or damage remains undetected, what are the likely consequences of damage or failure in terms of network disruption, casualties and other socio-economic impacts.

4.2. Assumptions

The risk-based inspection framework has been developed to aid in establishing current risk profile (i.e. for instance where a time-based inspection regime is in place) and to allow comparisons to be made with the risk profile that would result from the application of this framework. It is anticipated that by using the risk-based inspections framework, the overall level of risk exposure would be reduced and hence minimise liability.

It is considered that the framework can be applied at any time to assist in the identification of the level of risk that may be posed by different assets including parts of a structure, e.g. very high importance elements (as defined by the CSS inspection procedure), individual structures or a group of structures with similar characteristics. Subsequently, this can be used to determine appropriate inspection intervals, thus focussing effort and resources where these are most needed to ensure that any risks identified can be managed appropriately.

It has been assumed that as a baseline, there will be sufficient condition data, inventory and other relevant available data, e.g. structure dimensions, exposure conditions, etc., that can be used to inform the risk-based inspections framework. It is essential that all structures within the stock have undergone at least one General or Principal Inspection and that the data from the inspection has been recorded and is readily available.

Acceptance inspections, i.e. Pre Opening Inspections (POI), Defects Liability Inspections (DLI), Transfer Inspections and Handback Inspections, should be carried out in accordance with Section 5 of BD63 to ensure adequate inspection data is available for new structures and elements.

The delivery of both General and Principal Inspection types are deemed to be required within the life cycle of all structure types to ensure that all associated elements are assessed at the determined intervals. For example, a retaining wall (regardless of associated risk, dimensional size, etc.) may have elements that are not observable from accessible footing points or where visibility is obstructed by the presence of vegetation, i.e. issues that to overcome would require measures not practicable and / or beyond the scope of a General Inspection.

It is noted that inspection alone is not sufficient to mitigate risk even when it is undertaken at the intervals identified under this framework. Appropriate action(s) arising from inspection findings is also required.

The following were excluded when formulating the risk-based inspection framework for the reasons outlined below:

- **Live loading capacity:**
  The inspection intervals that will be identified under the proposed framework will enable significant deterioration to be identified at an optimum time. As such it is likely that the appropriate maintenance needs will be identified and the relevant maintenance activities undertaken so that the structural integrity and the live loading capacity of the structure will remain unaffected during the service life of a structure. Where a structure had undergone structural assessment and was found to be substandard, it is assumed that it would be managed in accordance with BD79, i.e. its risk is managed through interim measures, e.g. weight / width restrictions or monitoring, as appropriate. Any reserve capacity above the assessment live load would clearly have an influence on risk and could, in principle, be taken into account in setting inspection intervals. However, information on reserve capacities of major structural elements is typically not recorded. Hence it was decided not to consider ‘capacity’ as a factor in developing the RBI methodology.

- **Monitoring systems:**
  Where a monitoring system is present on a structure, the level of monitoring applied is commensurate with the level of risk posed by the

critical element in accordance with BD79. Where a monitoring system may be required for a structure and / or element of a structure but is not present and the structure is analysed under the risk-based inspection framework, it should yield ‘very high’ likelihood and consequence values indicating ‘very high’ levels of risk which would suggest that inspection intervals should be of a reduced period.

- **Impact and / or vandalism damage:**
  Safety inspections will identify obvious deficiencies which represent, or might lead to, a danger or may pose a safety risk to the public.

- **Specific known structural risks:**
  Activities to manage specific risks such as PTSI programmes, half joints, assessments for scour and other hydraulic actions, inspection of complex structures, etc. are requirements to ensure the safe operation of affected structures and are the responsibility of an authority to deliver where is relevant.

4.3. Steps in Determining the Risk-based Inspection Intervals & Programme

An overview of the process for determining the risk-based inspection intervals and the inspection programme is shown in Figure 2.

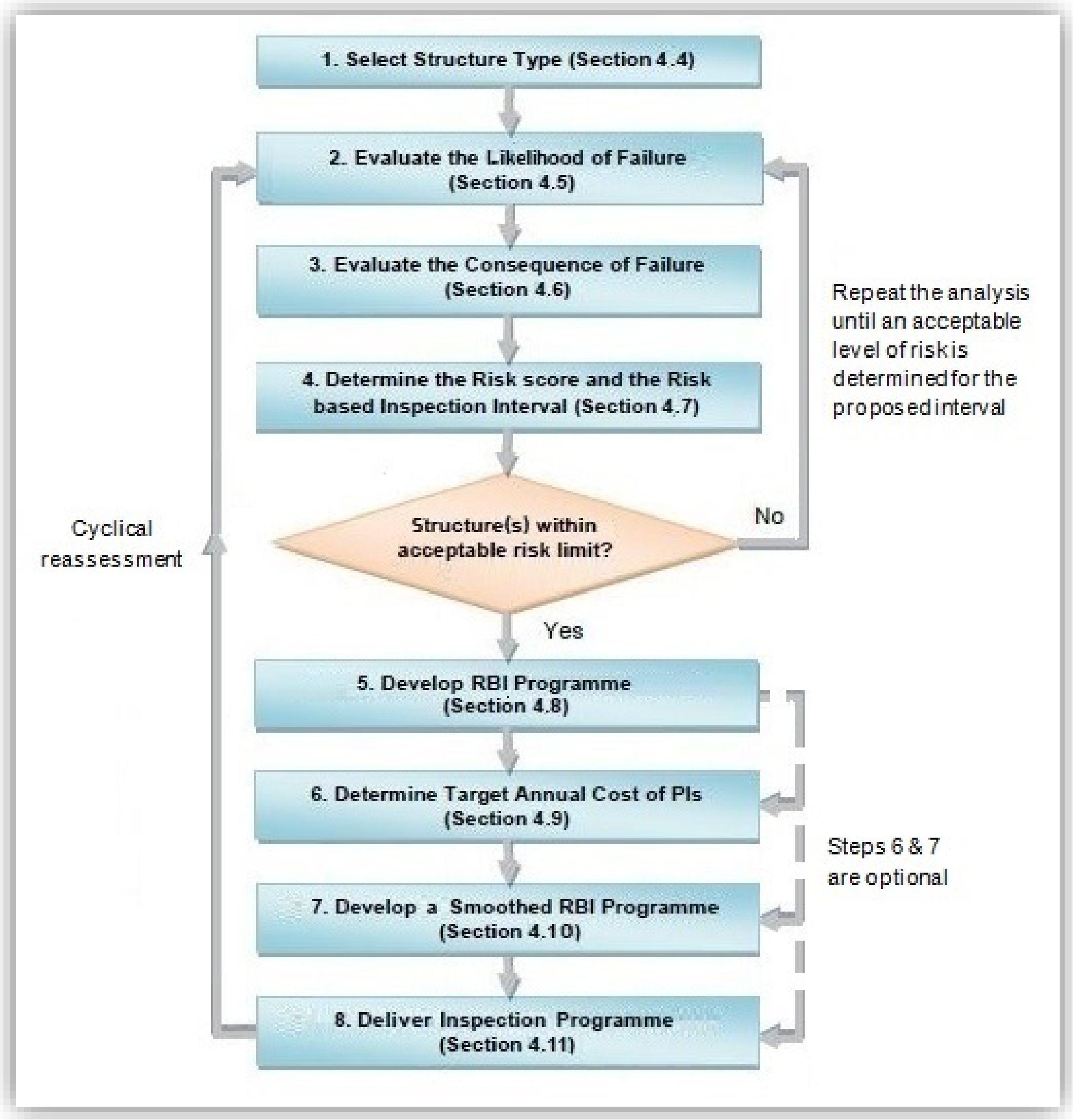

Figure 2: Flowchart for Determining the Risk-based Inspection Intervals

Step 1: Select Structure(s) Type
The risk-based inspections framework can be adopted to determine the appropriate inspection intervals for parts of a structure, i.e. very high importance elements (defined by the CSS inspection procedure), individual structures or groups of structures with similar characteristics. In all cases, the structure type under evaluation is initially selected from Table 2 in Section 4.4.

Step 2: Evaluate the Likelihood of Failure
The likelihood of rapid deterioration, damage or failure is a function of the structure type as well as current condition of a structure and / or element of a structure, rate of deterioration, potential failure mode and inspectability.

Step 3: Evaluate the Consequence of Failure
The consequence of failure is based on the magnitude of failure associated with the structure, the safety impact which considers the overall effects on the end user, including fatalities and injuries that would be caused, the functionality impact of a loss or reduction in service, the socio-economic impact to businesses and communities and environmental impacts, such as pollution caused through traffic delay, sensitivity of route, etc.

Step 4: Determine the Risk Score and the Risk-based Inspection Interval
The analysis is initially undertaken for the time-based inspection interval and the Risk Rating for this scenario is selected from the Risk Rating Matrix in Section 4.6 (Table 18) by combining the outcomes from Steps 2 and 3 above. The inspection interval is then altered if deemed appropriate; by using the Risk-based Intervals matrix in Section 4.6 (Table 19). An analysis is then undertaken for the proposed Principal Inspection Interval until an acceptable risk score and inspection interval is obtained. Acceptable risk is defined in this framework as equal to, or better than the 'moderate' category (Table 18).

Step 5: Develop RBI Programme
The inspection interval, derived from Step 4, is used in combination with the last known General and Principal inspection dates to produce an inspection programme. This requires adding the proposed inspection interval to the last inspection date to determine when the next PI and GI should be conducted.

Step 6: Determine the Target Annual Cost of Inspections
The resulting programme from Step 5 can be estimated for cost and assessed against target budgets. The programme can be expected to produce uneven inspection cost distribution over time, i.e. more resources being required in some years than others, and if deemed significant budget fluctuation then an authority at their discretion, can apply a smoothing process.

Step 7: Develop a Smoothed RBI Programme
A smoothed inspection programme can be developed by an authority by comparing the cost of the programme and target budget in Step 6 and any significant resource fluctuation can be managed through risk assessed deferral or advancement of inspections.

Step 8: Deliver Inspection Programme
Delivery of the inspections identified in the programme, including the completion of inspection data updates, in accordance with the authority's inspection and reporting requirements. The updated inspection data is then reassessed in in a cyclical manner in Steps 2 through to 5.

4.4. Identification of Structure Type

Part of the framework risk assessment is undertaken using the criteria contained in Table 2 to identify the appropriate generic structure types. This enables the risk analysis required for the structure types to be readily identified.

Structure Category	Construction Form	Dimensional Element
Bridge	Any	Span Width
Subway	Box / Pipe Construction of in-situ or precast concrete	Span Width
	Other	
Culvert	Any	Span Width
Retaining Wall / River Wall / Geotechnical	Any	Height
Tunnel	Any	Global
Mast / Sign / Signal Gantry	Any	Global
Other	Any	Global

Table 2: Identification of Structure Type

The risk assessment criteria covers consequences associated with structure types, i.e. assessing whether there are any significant safety and / or service consequences and identifying those with low consequences to inform what appropriate intervals are considered.

4.5. Likelihood of Failure

4.5.1. Overview

The likelihood of rapid deterioration, damage or failure is a function of the following:

- The current condition of a structure and / or element of a structure, i.e. the condition at the last recorded GI or PI (Section 4.5.2).
- Rate of deterioration, which is dependent on the structure-specific characteristics, material types and potential failure mode, e.g. brittle or ductile mechanisms (Section 4.5.3).
- Inspectability, i.e. the ability to adequately inspect all critical parts of the structure (Section 4.5.4).

The likelihood of rapid deterioration, damage or failure score is calculated using Equation 2:

$$L_F = (L_{S-SC} + PMT_{MF}) \times I_S$$

Equation 2: Likelihood of Failure

Where:

L_F	=	Likelihood of failure score
L_{S-SC}	=	Condition Likelihood Score (lowest BCI for entire structure and / or critical elements)
PMT_{MF}	=	Primary Material Type Modification Factor
I_S	=	Inspectability Score

4.5.2. Structure Condition Likelihood Score, L_{S-SC}

The Structure Condition Likelihood Score, L_{S-SC} is selected from Table 3, based on the condition performance indicators (BCI) for an individual structure, i.e. BCI_{AV} (all structure elements) and related score $L_{S-BCI-Av}$ or BCI_{CR} (worst critical element) and its related score $L_{S-BCI-Cr}$, whichever is lower, established during the most recent inspection. The analysis can also be undertaken for a group of structures with similar characteristics, for which the current condition score is based on the BCI of the structure in the worse condition in the group.

In the case of structures with BCI values of less than 40, it is recommended that the maintenance needs of the structure should be identified (if not already known) and duly addressed.

Unknown BCI values are not permissible under this RBI framework. In these cases, it is recommended that an appropriate inspection is scheduled and undertaken as soon as reasonably practicable so that the relevant information may be obtained prior to carrying out an analysis of any structure(s) with unknown BCI values.

The interpretation of the BCI range shown in Table 3 was adopted from the Guidance Document for Performance Measurement of Highway Structures, Part B1: Condition Performance Indicator and is contained in Appendix A.

BCI_{AV} and BCI_{CR} Score Range	Condition Likelihood Score, L_{S-SC}
	Category
$90 \leq BCI \leq 100$	Very Good
$80 \leq BCI < 90$	Good
$65 \leq BCI < 80$	Fair
$40 \leq BCI < 65$	Poor
$0 \leq BCI < 40$	Very Poor

Table 3: Structure Condition Likelihood Score

4.5.3. Primary Material Type Modification Factor, PMT_{MF}

Many defects are known to take many years to develop to the point where they require maintenance or present a risk to the structural integrity or public safety. However, the structure-specific characteristics, i.e. construction form, details susceptible to deterioration, geometry and the overall material types are significant considerations in determining the rate of deterioration and failure modes.

Table 4 provides the anticipated deterioration rates and failure mechanisms for typical construction forms for associated structure types and their respective primary material types. The potential failure mode is accounted for within the scores where sudden or ductile failure mechanisms are considered based on:

- **Brittle:**
  Or non-ductile, materials will not undergo significant plastic deformation before breaking. Failure of a brittle material occurs suddenly, with little or no warning. Structural materials that are generally brittle include concrete, cast iron, stone and timber.

- **Ductility:**
  Is the measure of plastic (permanent) strain that a material can endure. A ductile material will undergo a large amount of plastic deformation before breaking. It will also have a greatly reduced cross-sectional area before breaking. Structural materials that are generally ductile include steel and aluminium.

Structure Type	Construction Form				
Bridge	Truss	Slab	Beam & Slab	Arch	
Culvert	Slab	Portal	Box	Pipe	Arch
Subway	Walls	Slab	Box	Pipe	
Retaining Wall / Geotechnical	Embedded / Tied Back / Propped / Hybrid	Gravity			
Gantry	Cantilever Beam	Cantilever Truss	Beam & Slab	Truss	
Chamber					
Mast					

Primary Material Type	Failure Mode
Reinforced concrete	Brittle
Plain/Mass concrete	Brittle
Post-tensioned concrete	Brittle
Pre-tensioned concrete	Brittle
Steel	Ductile
Cast Iron	Brittle
Wrought Iron	Brittle
Aluminium	Ductile
Corrugated steel	Ductile
Corrugated aluminium	Ductile
Masonry	Ductile
FRP / GRP / Composite	Ductile
Timber	Brittle
Other / Unknown	(worst case)

Table 4: Deterioration Factors of Structure Characteristics

4.5.4. Inspectability Score, I_S

The Inspectability Score, I_S takes account of the capability of the inspector to adequately inspect all the elements that are significant to structural integrity during a General Inspection, i.e. can the necessary information about the condition of the structure(s) and any significant safety concerns be readily obtained without any access difficulties. Table 5 distinguishes between structures where elements that are significant to structural integrity can be adequately inspected and those that cannot be adequately inspected. The resulting score applies a weighting in order to account for risks associated with inspectability.

It should be noted that where a structure is deemed to have issues in terms of its elements being inspected, such as access issues, hidden elements or defects, then appropriate measures to manage these cases are required in line with current guidelines and standards.

Table 6 provides a list of elements that are significant to the structural integrity of different structure types.

Inspectability Considerations	Inspectable
All elements significant to structural integrity (except foundations) are visible (not hidden) and can be adequately inspected during a General Inspection.	Yes
One or more element(s) significant to structural integrity (except foundations) are not visible or hidden and / or cannot be adequately inspected during a General Inspection.	No

Table 5: Inspectability Score, I_S

Structure Type	Elements Significant to Structural Integrity (excludes foundations)
Bridge **Chamber** **Culvert** **Footbridge** **Pedestrian Subway** **Pipe Subway** **Tunnel** **Vault**	• Primary deck element • Transverse Beams • Secondary deck element • Half joints • Tie beam / rod • Parapet beam or cantilever • Deck bracing • Abutments (incl. arch springing) • Spandrel wall / headwall • Pier / column • Cross-head / capping beam • Bearings
Sign / Signal Gantry	• Truss / beams / cantilever • Transverse / horizontal bracing elements • Columns / supports / legs • Base connections • Support to longitudinal connection
Catenary Lighting **Mast**	• Mast • Base Connection
Retaining Wall **River Wall**	• Retaining wall (Primary / Secondary) • Parapet beam / plinth • Anchoring system

Table 6: Elements Significant to Structural Integrity

4.6. Consequence of Failure

4.6.1. Overview

The consequence of failure is evaluated as a combination of the:

- The magnitude of the failure of the structure or its elements (Section 4.6.2).
- Safety consequences based on the total number of users affected and the socio-economic importance assessed by the route carried / obstacle crossed, to establish which parts of the community it services and the number of vehicles (Section 4.6.3).
- Functionality consequences in terms of the amount of delay caused both in terms of additional length of time to complete the journey and the number of vehicles affected (Section 4.6.4).
- Environmental consequences based on the importance of the structure's location and the effect on the environment (Section 4.6.5).
- The environmental exposure to which the structure is subjected, this is based on the severity of the conditions (Section 4.6.6).

The scores for each of these criteria are combined using Equation 3 below:

$$C_F = C_{MF}\,(SC_S + FC_S + EC_S + EE_S)$$

Equation 3: Consequence of Failure

Where:

C_F	=	Consequence of Failure
C_{MF}	=	Consequence of Magnitude of Failure Score
SC_S	=	Safety Consequence Score
FC_S	=	Functionality Consequence Score
EC_S	=	Environmental Consequence Score
EE_S	=	Environmental Exposure Score

4.6.2. Consequence of Magnitude of Failure Score, C_{MF}

The consequence of the failure of a structure and / or its element(s) depends on a wide range of factors; significant criteria where data is readily available are the condition and dimensions of the structure and / or the elements of a structure.

Failure is not necessarily the collapse of the element / structure, but maybe the failure of drainage elements or expansion joints which affect the function and durability of the structure.

As such, the Magnitude of Failure Score of a structure is based on:

- The size of the structure, i.e. span length for a bridge, footbridge, culvert, gantry, chamber, pipe subway, subway, tunnel and vault; and the height for a retaining wall river wall, mast and catenary lighting.

- The potential extent of the failure, e.g. localised damage or full / global collapse.

The Magnitude of Failure is shown in Table 7.

When the analysis is undertaken for groups of structures with similar characteristics, the structure size and potential extent of the failure of the structure that has the worse condition in the group should be used.

Structure Type	Dimensional Extent	
Bridge	Span Length	< 10m
		≥ 10m to ≤ 50m
		≥ 50m to ≤ 100m
		> 100m
Subway	Span Length	< 3m
		≥ 3m to ≤ 10m
		> 10m
Culvert	Span Length	< 3m
		≥ 3m to ≤ 10m
		> 10m
Retaining / River Wall / Geotechnical	Height	< 1.5m
		≥ 1.5m to ≤ 5m
		> 5m
Tunnel	Global	Full Extent (effective)
Sign / Signal Gantry	Global	Full Extent
Other	Global	Full Extent

Table 7: Magnitude of Failure Score, C_{MF}

4.6.3. Safety Consequence Score, SC_S

The safety consequence score is based on two factors:

$$SC_S = SC_{S-Base} + SC_{S-MF}$$

Equation 4: Consequence of Failure

Where:

SC_S	=	Safety Consequence Score
$SC_{S\text{-}Base}$	=	Socio-Economic Importance Score
$SC_{S\text{-}MF}$	=	Safety Consequence Magnitude Factor

4.6.3.1. Socio-Economic Importance Score, $SC_{S\text{-}Base}$

If deterioration or damage remains undetected and subsequent appropriate maintenance activities are not identified and undertaken, a failure event has the potential to impact on social and economic factors relating to the local and wider community, e.g. accessibility to community services, business deliveries, access to leisure facilities, etc. These are important considerations and can lead to adverse public opinion and reputational detriment, if not managed accordingly.

The Socio-Economic Importance Score, $SC_{S\text{-}Base}$ is used to evaluate consequence in terms of inconvenience to the community and businesses due to diversions, delays and restrictions.

These effects can be difficult to quantify but it is considered that there is a close relationship between these and the route supported by or crossed by the structure.

The Socio-Economic Importance Score is therefore selected from Table 10 based on the route supported or adjacent to and the obstacle crossed by a structure (see Tables 8 and 9).

When the analysis is undertaken for groups of structures with similar characteristics, the route supported by and obstacle crossed by the structure that has the worse condition in the group should be used.

Primary route supported by or is adjacent to the structure	Route Description	Ref.
	No primary route supported / Disused	A
	Unclassified, Cyclist and Pedestrian	B
	B and C Class (local access / distributor)	C
	A Class	D
	BPRN road (Non-strategic) / Primary road	E
	TLRN road / Strategic Borough road	F

Table 8: Route Supported

Obstacle crossed by or is adjacent to the structure	Obstacle Description	Ref.
	No obstacle / Waste ground / Disused / Non-navigable watercourse	G
	Unclassified, Cyclist and Pedestrian	H
	B and C Class (local access / distributor) road and Business premises	I
	Navigable watercourse and A Class road	J
	BPRN road (Non-strategic) / Primary road	K
	TLRN road / Strategic Borough road	L
	Operational railway / Gas installation / Storage facility of hazardous chemicals	M

Table 9: Obstacle Crossed

		Primary route supported by or is adjacent to the structure reference					
	Ref.	A	B	C	D	E	F
Obstacle crossed by or is adjacent to the structure reference	G	Very Low	Very Low	Low	Medium	High	Very High
	H	Very Low	Very Low	Low	Medium	High	Very High
	I	Low	Low	Medium	High	High	Very High
	J	Medium	Medium	High	High	High	Very High
	K	High	High	High	High	High	Very High
	L	Very High	Very High	Very High	Very High	Very High	Very High
	M	Very High	Very High	Very High	Very High	Very High	Very High

Table 10: Route Supported & Obstacle Crossed Impact Factor, $SC_{S\text{-}Base}$

4.6.3.2. Safety Consequence Magnitude Factor, $SC_{S\text{-}MF}$

Safety consequence is the overall effect on the end-user, including fatalities and injuries that would be caused by a failure.

Traffic flow is a key element in considering the impact of a failure event in terms of total users affected.

Average Annual Daily Traffic (AADT) values are utilised and these should be taken for the affected route(s).

The ranges of traffic flows are assessed and scored as detailed in Table 11. The traffic flow ranges in Table 11 are indicative for the typically highly trafficked network that LoBEG manage and as such an authority can allocate flow categories that they may deem relevant to a given network, at their own discretion.

Flow Category	AADT	Ref.
No vehicular traffic	0	A
Very Low	AADT < 10000	B
Low	10000 ≤ AADT < 25000	C
Moderate	25000 ≤ AADT < 50000	D
High	50000 ≤ AADT < 75000	E
Very High	75000 ≤ AADT < 100000	F
Extremely High	AADT ≥ 100000	G

Table 11: Traffic Flow Factor, $SC_{S\text{-}MF}$

4.6.4. Functionality Consequence Score, FC_S

Functionality consequence is the impact of a loss or reduction in service.

The magnitude of the delays due to the implementation of a diversion route in the event of a failure is assessed based on the anticipated additional time required in order for users to complete their journey. This is based on the classifications described in Table 12 and is measured against the Traffic Flow data (see section 4.6.3.2) to establish an impact assessment factor for the total number of users affected (see Table 13). This informs the value of the Functionality Consequence Score, FC_S.

Delay Classification		
Description	**Journey Time Delay**	**Ref.**
None	0 minutes	H
Slight	up to 10 minutes	I
Moderate	10 to 30 minutes	J
Severe	30 to 50 minutes	K
Very Severe	over 50 minutes	L

Table 12: Delay Classifications

		Delay Classification				
	Ref.	**H**	**I**	**J**	**K**	**L**
Traffic Flow	**A**	Very Low	Very Low	Very Low	Very Low	Very Low
	B	Very Low	Low	Low	Medium	High
	C	Very Low	Low	Medium	High	High
	D	Low	Medium	High	High	Very High
	E	Medium	Medium	High	Very High	Very High
	F	Medium	High	Very High	Very High	Very High
	G	High	High	Very High	Very High	Very High

Table 13: Traffic Flow to Delay Classification Impact Factor, FC_S

4.6.5. Environmental Consequence Score, EC_S

The impact to the environment in the event of failure is based upon the level of exposure to pollutants as well as the structures environmental importance in terms of where it is located, i.e. within a conservation area. These criteria are applied to structures on the classifications described in Tables 14 and 15 and are assessed together as described in Table 16 in order to establish the Environmental Consequence Score, EC_S.

Environmental Exposure Effect	Example
Unacceptable	Structural collapse or element failure could result in the pollution or contamination of land or watercourse, e.g. due to damage to a carried utility / supply line or from damage to a storage facility for hazardous chemicals.
Significant	Structural collapse or element failure could result in pollution or contamination of land or watercourse due to damage to a carried utility / supply line.
Some	Structural collapse or element failure where the period to repair / replacement would involve significant traffic delay and hence increased air pollution / environmental impact.
Limited	Structural collapse or element failure where the period to repair / replacement would involve some traffic delay and hence increased air pollution / environmental impact.
Negligible	Structural collapse or element failure where the period to repair / replacement would negligible environmental impact.

Table 14: Environmental Exposure Effects

Structure Importance	Scenario
High	Structures located in a conservation area or area of biological or other special scientific interest, or listed structures, or both.
Medium	Structures at a prominent location.
Low	All other structures.

Table 15: Structure Importance Scenarios

Environmental Effect	Structure Importance		
	Low	Medium	High
Unacceptable	High	Very High	Very High
Significant	Medium	High	Very High
Some	Low	Medium	High
Limited	Very Low	Low	Medium
Negligible	Very Low	Very Low	Low

Table 16: Environmental Consequence Impact Factor, EC_S

4.6.6. Environmental Exposure Score, EE_S

The rate of deterioration of a structure and / or its elements can be influenced by the environmental conditions that it is exposed to, i.e. external influences that may cause rapid or progressive deterioration, damage or failure. Four classifications are used to distinguish between the different severities, i.e. mild, moderate, severe and very severe. A description of these, along with assessed scoring, is provided in Table 17.

During the design process of a structure, solutions that consider the environmental conditions that it would be exposed to, is a requirement, therefore its construction would consist of appropriate materials, protection systems, etc. as well as any dedicated inspection regimes for specific issues such as scouring, to manage safe operation throughout the life cycle. However, assessment in consideration of an asset's proximity to coastal environments and impacts of microclimates must be conducted in line with current standards to manage any change.

As described in Section 3.2, although the construction and management processes incorporate empirical risk (including environmental factors), it is considered at this stage of the framework in order that the potential for any accelerated deterioration of structure(s) and / or elements due to exposure to the environment, is established.

Exposure Severity	Exposure Description	Examples
Mild / Protected	Structure and / or elements of structure: Generally exposed to mild weather conditions, i.e. maybe sheltered or in an environment that results in little or no exposure to severe weather conditions; Not exposed to aggressive agents, e.g. no exposure to road de-icing salts or 10m away from traffic spray, aggressive soil agents, contaminated water, etc.; With no ventilation or condensation problems or where it is unlikely to increase the rate of deterioration.	Elements protected from salt spray with cladding or by a protective enclosure. Deck soffit and piers of integral bridges where the obstacle crossed is not a road, i.e. elements are not subjected to spray from salted roads. Tenanted arch bridges. Half-joints or hinge joints overlaid with functional expansion joints.

Exposure Severity	Exposure Description	Examples
Moderate	Structure and / or elements of a structure exposed to: Moderate (normal) weather conditions, e.g. direct rain, moderate humidity or condensation, some freeze-thaw action etc.; and / or Moderate de-icing salt spray and airborne chlorides; e.g. within 3 to 10m of traffic spray-on routes with de-icing salts; and / or Low to moderate river flow. But elements are not exposed to or buried in aggressive soils that are contaminated with acidic water or water containing sulphates.	Top of roadside bridge pier or abutment subject to light vehicle spray from the salted road. Bridge deck soffit subject to light vehicle spray from the salted road. Structural elements, e.g. piers, subjected to abrasion / erosion.
Severe	Structure and / or elements of a structure exposed to: Continuous or regular severe / extreme weather conditions, e.g. hot and cold extremes, high freeze-thaw action, severe humidity or condensation, etc.; and / or Severe de-icing salt spray, e.g. within 3m of traffic spray-on routes with de-icing salts; and / or Run-off and/or ponding on routes with de-icing salts; and / or Aggressive soils, i.e. completely or partially buried in aggressive soils that are contaminated with acidic water or water containing sulphates. Medium to rapid river flow and flooding.	Roadside bridge abutment, Parapet upstand or deck edge beam subject to heavy vehicle spray from the salted road. Section of bridge deck near a leaking expansion joint or gutter, e.g. deck end or crosshead. Half joints or hinge joints overlaid with non-functional expansion joints. Top surfaces with non-waterproofed bridge decks. Areas where corrosion or spalling of surface concrete is evident. Structural elements, e.g. piers, susceptible to scour.
Very Severe	Structure and / or elements of a structure exposed to: Marine environment and / or abrasive action of seawater or completely immersed in seawater; and / or Tidal splash and spray zone; and / or Airborne salt but not in direct contact with seawater; and / or Corrosive fumes in industrial areas.	Surfaces directly affected by seawater spray, e.g. surfaces adjacent to the sea. Surfaces directly affected by airborne salts, e.g. deck, walls, parapet edge beams, etc. Completely / partially submerged marine structures. Structures near to or on coastal areas. Structures in industrial areas with high humidity and aggressive atmosphere.

Table 17: Environmental Exposure Score, EE_S

4.7. Determine Risk Score & Risk-based Inspection Intervals

The risk posed by a group of structures, an individual structure and / or an element of very high importance (as defined by the CSS inspection procedure) due to deterioration or damage is evaluated as a function of the likelihood and consequence of rapid deterioration, damage or failure. The risk score and associated rating is obtained from Table 18.

A risk rating of 'Very Low', 'Low' and 'Moderate' is considered to represent structures that have inspection intervals which are broadly acceptable or negligible in terms of risk mitigation. This does not preclude the analysis being repeated for structures with 'Very Low' and 'Low' risk ratings with an appropriately increased inspection interval so that the associated resulting risk rating would be 'Moderate'.

A risk rating of 'High' and 'Very High' represents structures that pose critical risk(s) and are considered to have inappropriate inspection intervals. For these structures the analysis should be repeated with an appropriately decreased inspection interval where the resulting risk score is at least 'Moderate'.

Consequence of Failure, C_F	**Likelihood of Failure, L_F**				
	Very Low **< 30**	**Low** **≥ 30 - < 50**	**Moderate** **≥ 50 - < 70**	**High** **≥ 70 - < 90**	**Very High** **≥ 90**
Very Low **< 10**	Very Low	Very Low	Low	Moderate	Moderate
Low **≥ 10 - < 30**	Very Low	Low	Moderate	Moderate	High
Moderate **≥ 30 - < 50**	Low	Low	Moderate	High	High
High **≥ 50 - < 70**	Low	Moderate	Moderate	High	Very High
Very High **≥ 70**	Moderate	Moderate	High	Very High	Very High

Table 18: Risk Rating Matrix

The next stage of the analysis is undertaken against the original time-based regime of GIs and PIs every two and six years respectively to set a benchmark measure of the current level of risk. Based on the outcome of this analysis the inspection interval should be increased, decreased or maintained as appropriate (see Table 19), and the resulting level of risk for the next run of the analysis can be calculated accordingly.

Risk Rating	Action
Very Low	Increase the inspection interval
Low	Increase the inspection interval
Moderate	Maintain the inspection interval
High	Reduce the inspection interval
Very High	Reduce the inspection interval (if not already at minimum interval otherwise is considered as BD79 Interim Measures)

Table 19: Risk Rating Based Interval Actions

Interval adjustment actions are described in Table 20. This also enables risk profiling to be undertaken that compares the time-based inspection intervals to the risk-based intervals (see Section 4.7.3).

Consequence of Failure, C_F	Likelihood of Failure, L_F				
	Very Low < 30	**Low** ≥ 30 - < 50	**Moderate** ≥ 50 - < 70	**High** ≥ 70 - < 90	**Very High** ≥ 90
Very Low < 10	Increase	Increase	Increase	Maintain	Maintain
Low ≥ 10 - < 30	Increase	Increase	Maintain	Maintain	Reduce
Moderate ≥ 30 - < 50	Increase	Increase	Maintain	Reduce	Reduce
High ≥ 50 - < 70	Increase	Maintain	Maintain	Reduce	Reduce
Very High ≥ 70	Maintain	Maintain	Reduce	Reduce	Reduce

Table 20: Interval Actions

When the actions are determined for a structure, the effective likelihood of failure score is required to be amended in order to reflect the scenario whereby a less frequent regime would increase the likelihood of failure occurrence, due to early signs of defect mechanisms not being identified at a stage where early interventions could be implemented. Conversely, a reduced inspection interval would decrease the likelihood due to more observations of any developing defects being conducted. The resulting likelihood scores after the interval action is implemented are described in Table 21.

Consequence of Failure, C_F	Likelihood of Failure After Action, L_{F-Aft}				
	Very Low < 30	**Low ≥ 30 - < 50**	**Moderate ≥ 50 - < 70**	**High ≥ 70 - < 90**	**Very High ≥ 90**
Very Low < 10	Very Low	Very Low	Low	Maintain	Maintain
Low ≥ 10 - < 30	Very Low	Low	Maintain	Maintain	High
Moderate ≥ 30 - < 50	Low	Low	Maintain	High	High
High ≥ 50 - < 70	Low	Maintain	Maintain	High	Very High
Very High ≥ 70	Maintain	Maintain	High	Very High	Very High

Table 21: Likelihood of Failure After Action Scores, L_{F-Aft}

From the resulting likelihood score, the Principal Inspection Interval adjustment factor, F_{PII} is established for the PIs, which takes account of the current and proposed interval action likelihood scores (detailed in Equation 5).

$$F_{PII} = L_{F-Aft} \div L_F$$

Equation 5: Consequence of Failure

Where:

F_{PII}	=	Principal Inspection Interval Factor
L_F	=	Likelihood of Failure Score
L_{F-Aft}	=	Likelihood After Interval Action Score

Utilising the Principal Inspection Interval factor, initial interval periods are calculated by analysis against the benchmark regime (detailed in Equation 6)

$$PPII = F_{PII} \times BPII$$

Equation 6: Consequence of Failure

Where:

PPII	=	Proposed Principal Inspection Interval
F_{PII}	=	Principal Inspection Interval Factor
BPII	=	Benchmark Principal Inspection Interval, based on the standard 6 year interval

With the Proposed Principal Inspection Interval, PPII established, a Proposed Inspection Interval, PII is then set for the regime, which also includes the interval for the associated General Inspection. The PII intervals associated with the PPII values are obtained from Table 22.

This ratifies manageable periods within a programme and limits the maximum length of time possible for intervals at 12 years for the PI and 4 years for the GI, or double the period in which a standard time-based PI and GI would be conducted.

A summary of the formulae to process the proposed inspection programme is provided in Appendix B and Appendix C provides a programme plan of the regimes detailed in Table 22.

Proposed Principal Inspection Interval, PPII (years)	Standard Interval (years)		RBI Interval, PII (years)		
	PI	GI	PI	GI	Regime Rationale
11 ≤ PPII	6	2	12	4	Very low-risk structures that permit the maximum proposed interval period, reflecting half the frequency of the standard regime. This typically reflects structures that are exposed to low consequences and are in very good condition that would not be expected to deteriorate to any significant extent within the proposed interval period.
9 ≤ PPII < 11	6	2	10	4 then 3	Typically consist of structures in very good or good condition that may have elements or construction forms that carry higher inherent consequential risk(s). The initial 4-year interval for the GI reflects the period in which deterioration would be at its least within the 10 year PI schedule, followed by a reduced 3-year interval, to establish if deterioration has occurred or accelerated at an earlier stage.
7 ≤ PPII < 9	6	2	8	3	Reflects structures that are typically in good or fair condition that are not exposed to high inherent consequential risk(s), or very good to good condition structures with higher inherent risk(s).
5 ≤ PPII < 7	6	2	6	2	Framework risk assessment deems the standard regime is sufficient to manage the current status of the structure.
0 ≤ PPII < 5	6	2	4	2	Applicable to structures with critical risks, where the standard regime is deemed inadequate. Increased regime enables deterioration of elements to be more closely monitored and enhances the opportunities for defects to be identified at an optimum time. These defects may require further measures to then manage risk(s) at the discretion of the authority, such as further inspection, monitoring, assessment, etc. Any further interval reduction would require an asset to be considered for BD79 Interim Measures.

Table 22: Proposed Inspection Intervals, PII

4.7.1. Interval Rationale

As detailed in BD63; the maximum interval period of 12 years for a PI regime is permitted for cases where there is very low-risk exposure. A review of the risk shall be carried out following each subsequent GI. This is in order to ensure that the assumptions on the risk levels remain valid, e.g. unexpected deterioration of defects, change in usage or functionality or other risks which may become apparent. As such the 12 year PI and 4 year GI intervals are deemed within this framework to be the maximum periods between inspections.

This framework can propose interval periods that are less than the minimum stipulated in BD63. This is due to the risk-based approach of structures meeting this category receiving a more frequent inspection regime which enables associated defects to be effectively monitored more regularly. As such any developments in those defects will be more likely to be identified at an earlier or more optimal stage in order for mitigation actions to be delivered.

This is applicable to all structures including those such as retaining walls where the value of the limited additional information provided by a PI to that of a GI may not be deemed significant, however it is still necessary to ensure that any accessibility issues are managed and all elements are assessed.

Deterioration rates of structural elements are influenced by construction type, materials and condition, the inspection interval periods proposed within this framework enable the identification of developing defects and the subsequent adjustment of interval actions to appropriately manage associated risks. This is demonstrated based on evidence from existing structures whereby deterioration is shown to be progressive across numerous annual periods in which this framework is able to identify and respond to within its proposals. Examples of the extracts of existing structure condition profiles are provided in Appendix D.

The dynamic nature of the framework whereby inspection intervals are adapted based on the most up to date information available which is also supported by the recommended annual reassessment of risks enables risks to be managed in a sufficient targeted manner.

4.7.2. Inspection Interval Review

A formal risk assessment of known risks associated with structures must be conducted by suitably competent personnel and based on the finding of the risk assessment it may be required to extend the inspection scope or introduce additional special inspection(s) where required. The risk assessment shall factor in all known structural risks and vulnerable details including but not limited to: scour susceptibility, half-joints, hinged deck, segmental post-tensioning, severe (marine environment) exposure and suspension and cable-stayed bridges. This also must include for developments and recommendations within the industry as well as any locally considered issues.

It is assumed that engineering judgement will be used throughout any risk assessment and proposed intervals must be approved and / or subsequently adjusted where deemed necessary by competent persons nominated by the authority.

Where 4-year interval periods are determined for the PI regime of a given structure, then it is recommended that consideration is pursued to determine whether further actions are required, such as BD79 Interim Measures.

4.7.3. Framework Sensitivity Testing

The framework has been analysed as part of the study in order to ensure the intervals generated are accurate and appropriate. A comprehensive sensitivity testing process was implemented where the methodology consisted of two main phases:

Phase 1: Accuracy

- Testing of data ranges and results with iterative analysis.

- Full ranges of contributory likelihood and consequence factors were assessed by setting up a series of test scenarios for each structure type. By utilising hypothetical structures, it was possible simulate the full range of scenarios including the most extreme possibilities to identify if any abnormal results were generated.

Phase 2: Proportionality

- Testing the appropriateness of intervals with comparative technical assessment.

- When the first phase of scenario testing substantiated the accuracy of the framework, then the next testing phase was conducted. This phase is to assess whether any disproportionate interval periods could be generated within the framework by directly comparing results of the full range of scenarios across each of the relevant structure types. This was delivered by setting up the summarised results of Phase 1 into a grouping of key comparators alongside all structure types which were then presented for full technical review to ensure appropriateness and consistency.

Appendix E provides an extract of Phase 1 (Appendix E - E1) and Phase 2 (Appendix E – E2) testing results. This is not a fully comprehensive compilation of all the testing that was conducted.

4.7.4. Risk Profiling

It is anticipated that by using the risk-based inspections framework the overall level of risk and hence incumbent liability on the organisation can be minimised.

The risk profile for the time-based and the risk-based inspection regimes can be evaluated as follows:

- Determine the risk score for each individual structure and / or group(s) of structures with similar characteristics. A histogram, such as in Figure 3, could then be plotted to analyse risk profiles.

- Calculate the Cumulative Risk Score = Sum of ((Risk Score x Number of Structures) with Risk Score) for both the time-based and the risk-based inspection regimes.

- Evaluate the "Risk Change" = Cumulative Risk Score (Time-based – Risk-based).

The risk profiles of a sample data set are compared in Figure 3.

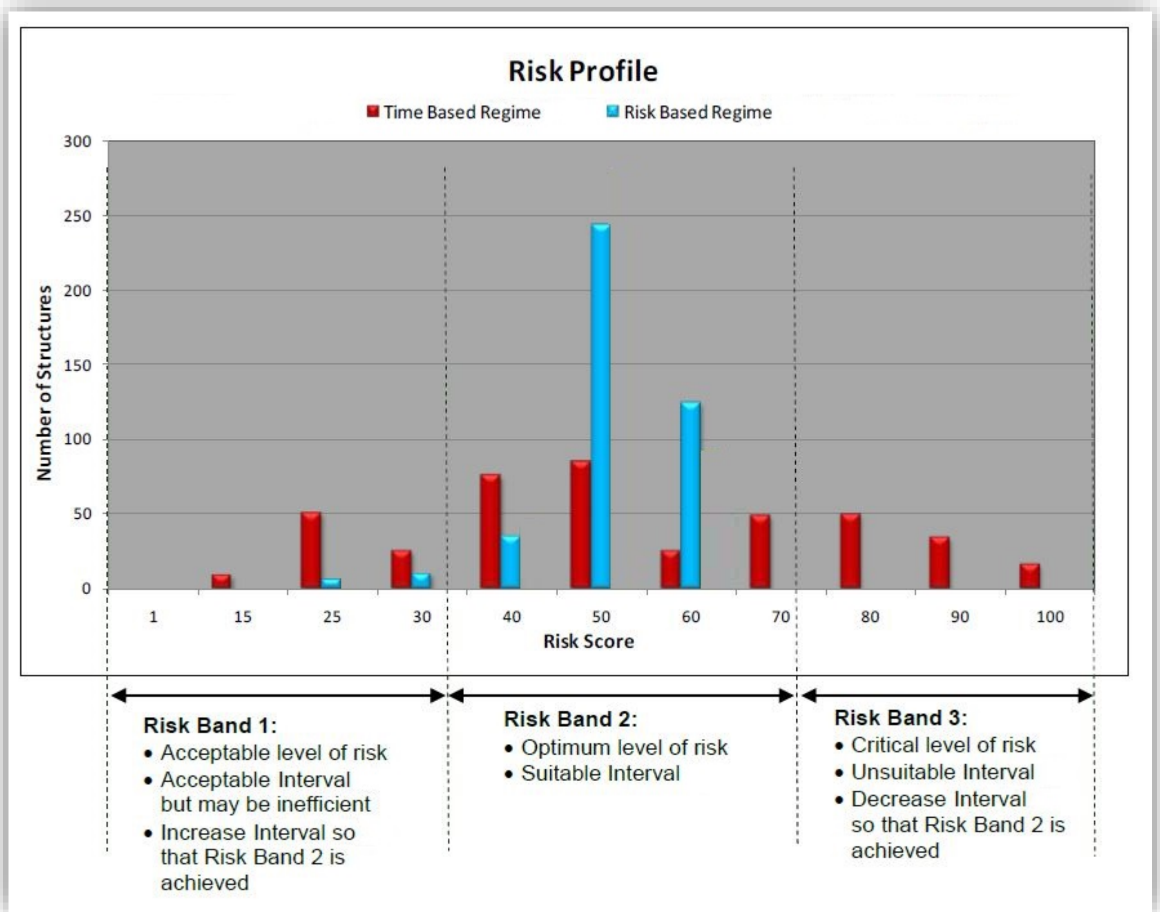

Figure 3: Example showing risk profiles for time-based and RBI approaches

4.8. Develop Inspection Programme

The inspection interval, derived from the risk-based approach, is used in combination with the last known structure inspection date to produce an inspection programme, i.e., by adding the proposed inspection interval to the last inspection date in order to determine when the next inspection should be conducted (see Equation 7).

$$DSI = DoLI + PII$$

Equation 7: Inspection Schedule

Where:

DSI	=	Date of Scheduled Inspection
DoLI	=	Date of Last Inspection
PII	=	Proposed Inspection Interval (calculated through Sections 4.4 to 4.7)

If a structure's Date of Last Inspection is unknown, then the Date of Scheduled Inspection is set as the next financial year. In addition, if the DSI calculated from the above equation indicates a date in the past, then also the structure is set to undergo an inspection in the next financial year.

An authority should determine if an earlier date, i.e. within a current financial year, is deemed necessary to deliver any overdue inspection activities.

4.9. Determine Target Annual Cost of Inspections

The average cost required to undertake inspections over the programme period (for example, a 30-year programme) is set as the initial target annual cost of inspections for each financial year (see Equation 8).

$$Target\ Annual\ Cost\ of\ Inspections = \frac{Total\ cost\ of\ inspections\ required\ for\ the\ stock}{Programme\ period\ (years)}$$

Equation 8: Annual Inspection Cost

Where:

A 30-year programme period is considered to get a reasonable estimate for the annual average cost of inspections. However, the inspection planning can be done for a shorter time frame (e.g. 12 years) using this target value, if preferred.

4.10. Developing a Smoothed Inspection Programme

The RBI process described through Sections 4.4 to 4.7 can result in an uneven distribution of inspection costs over time, i.e. more resources being required in some years than others. This can potentially lead to difficulties in resource management and budget planning for the inspection programme, particularly where significant fluctuations occur from one year to the next.

At the discretion of an authority, a smoothing process can be introduced in order to more evenly distribute the inspection cost profile of the programme over a given period of time. This can minimise variations in resource requirements and enable a more manageable budget profile.

A smoothed programme can be developed by considering the initial requirements for the financial year. These are determined by comparing the cost of inspections due in that financial year, including any inspections moved forward from previous years, against the initial target cost. If the initial programme cost of inspections is higher than the target annual cost, then the structures with lower risk scores (calculated from Step 4 in Figure 2) could be deferred to the following financial year. If the initial programme cost is lower than the target annual cost, then structures with the higher risk scores in future financial years can be advanced to the current financial year.

For each structure, the interval between the last inspection year and the proposed inspection year from the programme is taken as the smoothed inspection programme. If the risk score is outside the acceptable range, i.e. in a high or very high-risk category in Table 19, then structures will undergo Step 4 in Figure 2 (i.e. determine risk score and inspection interval). This process will be repeated until all structures fall within the acceptable risk range.

If it is not possible to maintain the target annual average cost without exceeding the acceptable risk level in a particular year, then all the structures, which are identified as requiring an inspection in that year, are recommended to be inspected within that current year (or in earlier years). This ensures that the methodology gives higher priority to safety over the cost revised inspection interval and the risk score is recalculated.

4.11. Deliver Inspection Programme

The determined inspection programme should be delivered in accordance with the authority's inspection and reporting requirements. Completion of inspection reporting is crucial to enable the risk-based process to be implemented accurately and in a continuous manner.

When the latest inspection data is updated in the relevant asset management system, this will potentially change the values of a structure's variables that are assessed within this framework. This essentially informs the process dynamically, and reassessment can be conducted cyclically, recommended on an annual frequency, in order to manage ongoing change to the asset stock.

Cyclical reassessment and delivery of this risk-based regime ensures that appropriate resourcing is applied to the inspection programme, the risk is managed and associated benefits are realised throughout the duration of its implementation.

5. Conclusion

The process described in the previous sections depends greatly on the accuracy of the data used at each step. It is recommended to review all the data thoroughly in order to avoid false indications as much as reasonably practical.

Where this risk-based regime is adopted, it will inform a dynamic inspection programme that will be based, and reliant upon, the last iterations of inspection information. As such it is recommended that as a minimum the programme is reassessed at least on an annual basis or more frequently where an authority deems it necessary.

It is the intention of this framework that full flexibility is available to an authority to adopt any of the standards or proposed risk-based regime options either fully or in part, at their discretion.

Enhancements to this framework will be developed where improvements are identified that provide further refinement(s) where currently unknown factors that have not been considered may arise or where there are major improvements and / or change made available within the industry.

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Appendix A

Interpretation of the Condition Performance Indicator for Individual Structures

Condition Score Range	BCI_{AV}, $L_{S\text{-}BCI\text{-}Av}$ (All Structure Elements)	BCI_{CR}, $L_{S\text{-}BCI\text{-}Cr}$ (Worst Critical Element)
90 ≤ x ≤ 100	• Likely to be no significant defects in any elements. • The structure is in a "Very Good" condition overall	• Insignificant defects / damage • Capacity unaffected
80 ≤ x < 90	• Mostly minor defects / damage, but may also be some moderate defects. • The structure is in a "Good" condition overall	• Minor defects / damage. • Capacity unlikely to be unaffected
65 ≤ x < 80	• Minor-to-Moderate defects / damage • Structure is in a “Fair” condition overall • One or more functions of the structure may be significantly affected	• Minor to moderate defects / damage • Capacity may be slightly affected
40 ≤ x < 65	• Moderate-to-Severe defects / damage. • The structure is in a "Poor" condition overall. • One or more functions of the bridge may be severely affected	• Moderate to severe defects / damage • Capacity may be significantly affected
0 ≤ x < 40	• Severe defects / damage on a number of elements. • One or more elements may have failed. • The structure is in a "Very Poor" condition overall. • The structure may be unserviceable	• Severe defects / damage • Failure or possible failure of the critical element • Capacity may be severely affected • The structure may need to be weight restricted or closed to traffic

Table A1: Condition Performance Indicators

Appendix B

Systems Application

Proposed Principal Inspection Interval, PPII (years)	Interval Periods (years)	
	PI	GI
11 ≤ PPII	12	4
9 ≤ PPII < 11	10	4 then 3
7 ≤ PPII < 9	8	3
5 ≤ PPII < 7	6	2
0 ≤ PPII < 5	4	2

Table B1: Inspection Intervals

Appendix C

Programme Plan of Risk-based Structure Inspection Regime Options

Layout of an example 36-year programme period to demonstrate regime cycles and quantities of inspections.

Interval Setting	Inspection Type	Proposed Interval (years)	Year																																			Inspection Totals	
			01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
Structure is deemed to be within Interim Measure Requirements (determined by Authority)	GI	<2																																					-	-
	PI	<4																																					-	
GI every 2 years	GI	2		GI				GI				GI				GI				GI				GI				GI				GI				GI			9	18
PI every 4 years	PI	4				PI				PI				PI				PI				PI				PI				PI				PI				PI	9	
GI every 2 years	GI	2		GI		GI				GI		GI				GI		GI				GI		GI				GI		GI				GI		GI			12	18
PI every 6 years	PI	6						PI						PI						PI						PI						PI						PI	6	
GI every 3 years	GI	3			GI			GI					GI			GI					GI			GI					GI			GI					GI		9	13
PI every 8 years	PI	8								PI								PI								PI								PI					4	
GI every 4 then 3 years	GI	4 then 3				GI			GI							GI			GI							GI			GI							GI			7	10
PI every 10 years	PI	10										PI										PI										PI							3	
GI every 4 years	GI	4				GI				GI								GI				GI								GI				GI					6	9
PI every 12 years	PI	12												PI												PI												PI	3	
Typical PI Interval Reference Periods	4-year cycle					▲																																		
	6-year cycle							▲																																
	8-year cycle									▲																														
	10-year cycle											▲																												
	12-year cycle													▲																										

Table C1: Programme Plan of Inspection Regime Options

Appendix D

Condition Profile Evidence

This appendix provides an example extract of the condition profiles of existing structures which was used as an empirical evidence base to support the proposed inspection interval periods as well as the maximum acceptable period within this framework.

Where financial year cells do not contain condition values in the following tables, this is due to the data being in a non-compatible format, such as hard copy inspection reports, or being unavailable.

Structure Reference	Structure Type	BCI Type	Financial Year Period															Comments
			2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	
Bridge Example 1	Bridge	BCI Average				98.28	98.28	95.61	95.61	95.99	95.99	95.99	96.42	96.42	96.9	96.9	95.76	A bridge in very good condition with a slow rate of deterioration.
		BCI Critical				100	100	100	100	100	100	100	100	100	100	100	100	
Bridge Example 2	Bridge	BCI Average				93.93	93.93	97.35	97.35	97.87	97.21	94.03	94.03	92.97	92.97	92.97	92.97	A bridge in very good condition with a slow rate of deterioration. The initial good condition scores for BCI_{AV} in 2007/08 and 2009/10 are likely due to inconsistent inspector assessment.
		BCI Critical				81	81	100	100	100	100	100	100	100	100	100	100	
Bridge Example 3	Bridge	BCI Average	88.71	88.71	88.71	88.71	88.71	90.54	90.54	91.06	87.47	77.02	77.02	90.6	90.6	87.83	87.83	A bridge in good condition with a slow rate of deterioration over a 15 year period. The fluctuation in values from very good to fair between 2009/10 to 2016/17 is due to inconsistent inspector assessment.
		BCI Critical	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	
Bridge Example 4	Bridge	BCI Average				89.57	89.57	89.57	89.57	83.32	83.32	84.96	84.96	84.24	80.2	80.2	80.2	A bridge in good condition with a slow rate of deterioration remaining within condition band throughout a 12 year period.
		BCI Critical				81	81	81	81	81	81	81	81	81	81	81	81	
Bridge Example 5	Bridge	BCI Average	70.23	70.23	91.91	91.91	91.91	91.91	91.91	77.72	77.72	70.26	70.26	75.19	75.19	78.54	78.54	A bridge with fair BCI_{AV} and BCI_{CR} of poor transitioning to very poor condition scores. This demonstrates the rate of deterioration of poorer condition structures are manageable within the framework as intervals would adapt to change. The condition change during 2006/07 is due to completion of targeted maintenance.
		BCI Critical	9.72	9.72	58	58	58	58	58	55.48	55.48	28.08	28.08	28.08	28.08	22.12	22.12	
Bridge Example 6	Bridge	BCI Average					60.4	60.4	65.45	71.32	71.32	72.16	70.51	70.51	70.51	70.51	70.51	A bridge with very poor BCI_{CR} condition and fair BCI_{AV} condition the deterioration of which is within inspection interval and reassessment periods of the framework.
		BCI Critical					39.52	39.52	31	31	31	31	31	31	31	31	31	

Table D1: Condition Profiles of Example Existing Bridge Structures

Structure Reference	Structure Type	BCI Type	Financial Year Period															Comments
			2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	
Retaining Wall Example 1	Retaining Wall	BCI Average				100	100	97.07	97.07	97.07	94.7	94.7	95.89	95.89	95.83	95.83	95.83	Retaining wall in very good condition with a slow rate of deterioration.
		BCI Critical				100	100	100	100	100	100	100	100	100	100	100	100	
Retaining Wall Example 2	Retaining Wall	BCI Average				94.14	94.14	94.14	90.07	96.33	96.33	96.33	94.12	94.12	94.43	94.43	93.53	Retaining wall in very good condition with a slow rate of deterioration.
		BCI Critical				100	100	100	100	100	100	100	100	100	100	100	100	
Retaining Wall Example 3	Retaining Wall	BCI Average				93.45	93.45	93.45	96.26	98.19	98.19	98.19	88.98	88.98	84.29	84.29	85.2	Retaining wall with BCI_{AV} in very good condition transitioning to good condition. The framework would manage this transition within the maximum GI interval period of this framework.
		BCI Critical				100	100	100	100	100	100	100	100	100	100	100	100	
Retaining Wall Example 4	Retaining Wall	BCI Average				80.63	82.13	82.13	82.13	82.13	86.43	86.43	82.71	82.71	80.17	80.17	80.17	Retaining wall in initial poor condition that post targeted works transitioned to fair condition. The framework would reassess the risk score when the condition records are updated to reflect the maintenance works.
		BCI Critical				55.48	58	58	58	58	58	58	78.88	78.88	78.88	78.88	78.88	
Retaining Wall Example 5	Retaining Wall	BCI Average					83.98	83.98	84.52	77.71	77.71	72.83	76.93	76.93	66.94	66.94	66.94	Retaining wall with poor transitioning to very poor BCI_{CR} condition and good transitioning to fair BCI_{AV} condition. The deterioration of which is protracted over numerous years and is within the inspection interval and reassessment periods of the framework.
		BCI Critical					58	58	58	58	58	31	31	31	31	31	31	

Table D2: Condition Profiles of Example Existing Retaining Wall Structures

Structure Reference	Structure Type	BCI Type	Financial Year Period 2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	Comments
Culvert Example 1	Culvert	BCI Average						92.86	92.86	92.86	94	94	93.04	93.04	93.31	93.31	93.31	A culvert in very good condition with a slow rate of deterioration.
		BCI Critical						100	100	100	100	100	100	100	100	100	100	
Culvert Example 2	Culvert	BCI Average				97.77	97.77	97.77	96.03	96.03	95.95	86.4	86.4	86.01	86.01	83.51	83.51	Retaining wall with BCI$_{AV}$ in very good condition transitioning to good condition. The framework would manage this transition within the maximum GI interval period of this framework.
		BCI Critical				100	100	100	100	100	100	100	100	100	100	100	100	
Culvert Example 3	Culvert	BCI Average						90.23	90.23	88.37	88.37	78.33	78.33	87.52	87.52	88.05	88.05	Culvert with good condition showing a slow deterioration rate. The fluctuations in the BCI$_{AV}$ condition scores are due to inconsistent inspector assessments.
		BCI Critical						81	81	81	81	81	81	81	81	81	81	
Culvert Example 4	Culvert	BCI Average					89.73	89.73	89.73	89.73	87.87	87.87	81.74	79.75	79.75	79.75	79.75	A culvert with BCI$_{AV}$ transitioning from good to fair condition and BCI$_{CR}$ transitioning from good to poor, both change scenarios of which would be identified within framework and reassessed in a reasonable time period.
		BCI Critical					81	81	81	81	81	81	55.48	55.48	55.48	55.48	55.48	
Culvert Example 5	Culvert	BCI Average					89.33	89.33	89.33	87.68	87.68	87.68	86.58	86.58	85.45	85.45	86.26	Culvert with BCI$_{AV}$ as good condition and BCI$_{CR}$ as poor condition with a demonstrated slow rate of deterioration within both condition bands.
		BCI Critical					55.48	55.48	55.48	55.48	55.48	55.48	55.48	55.48	55.48	55.48	55.48	
Culvert Example 6	Culvert	BCI Average						74.89	74.89	74.89	85.12	85.12	74.71	74.71	70.36	70.36	80.91	Culvert with fair BCI$_{AV}$ and very poor BCI$_{CR}$ condition demonstrating deterioration rate that would be suitably managed within the framework reassessments. Fluctuations in 2018/19 due to interim maintenance.
		BCI Critical						58	58	58	31	31	31	31	31	31	55.48	

Table D3: Condition Profiles of Example Existing Culvert Structures

Structure Reference	Structure Type	BCI Type	Financial Year Period															Comments
			2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	
Subway Example 1	Pipe Subway	BCI Average						95.08	95.08	96.71	96.71	98.61	98.61	98.61	88.62	88.62	84.51	A subway in very good condition with a slow rate of deterioration transitioning to good condition.
		BCI Critical						100	100	100	100	100	100	100	81	81	81	
Subway Example 2	Pipe Subway	BCI Average						88.36	88.36	94.59	94.59	94.59	94.59	94.59	83.39	83.39	83.39	Subway with BCI_{AV} in very good condition transitioning to good condition and BCI_{CR} of poor condition with slow rate of deterioration.
		BCI Critical						58	58	58	58	58	58	58	50.32	50.32	50.32	
Subway Example 3	Pipe Subway	BCI Average						81.09	81.09	81.09	81.09	81.09	81.09	81.09	81.09	81.09	81.09	Subway with good BCI_{AV} condition and fair BCI_{CR} condition showing a slow deterioration rate.
		BCI Critical						65.32	65.32	65.32	65.32	65.32	65.32	65.32	65.32	65.32	65.32	
Subway Example 4	Pipe Subway	BCI Average						85.43	85.43	85.85	85.85	85.85	85.85	85.85	74.17	74.17	74.17	A subway with BCI_{AV} transitioning from good to fair condition and BCI_{CR} transitioning form good to poor, both change scenarios of which would be identified within the framework and reassessed in a reasonable time period.
		BCI Critical						74.52	74.52	74.52	74.52	74.52	74.52	74.52	55.48	55.48	55.48	
Subway Example 5	Pipe Subway	BCI Average			69.58	69.58	69.58	69.58	69.58	78.2	78.2	80.71	80.71	80.71	65.57	65.57	65.57	Subway with BCI_{AV} as fair condition and BCI_{CR} transitioning from fair to very poor condition where the primary deck element was graded from 2D to 3E. Framework would identify and manage change in risk score and implement revised inspection schedule.
		BCI Critical			74.52	74.52	74.52	74.52	74.52	39.52	39.52	39.52	39.52	39.52	39.52	39.52	39.52	
Subway Example 6	Pipe Subway	BCI Average						74.56	74.56	80	80	65.67	65.67	65.67	65.67	65.67	65.67	Subway with fair BCI_{AV} and very poor BCI_{CR} condition demonstrating deterioration rate that would be suitably managed within the framework reassessments. Fluctuations in 2018/19 due to interim maintenance.
		BCI Critical						39.52	39.52	50.32	50.32	39.52	39.52	39.52	39.52	39.52	39.52	

Table D4: Condition Profiles of Example Existing Subway Structures

Appendix E

Framework Sensitivity Testing

This appendix provides an extract of the testing results generated, it is not fully comprehensive of the testing conducted but illustrates the methodology of approach taken as described in Section 4.7.2.

E1. Phase 1 - Accuracy

Testing of data ranges and results with iterative analysis.

Structure Data																Proposed Intervals		Monetised Risk (values @ 2019 rates)				
Structure Type	**BCI_{AV}**	**BCI_{CR}**	**Primary Material Type**	**Bridge / Footbridge Length (m)**	**Subway / Culvert Width (m)**	**Wall Height (m)**	**Other Structure Type Extent**	**Inspectable**	**Environmental Exposure**	**Obstacle Crossed**	**Route Carried**	**Traffic Flow (AADT)**	**Delay Classification**	**Environmental Effect**	**Structure Importance**	**Principal Inspection**	**General Inspection**	**Annual Total Safety Risk (£/year)**	**Annual Safety Risk (£/year)**	**Annual Functionality Risk (£/year)**	**Annual Environmental Risk (£/year)**	**Risk Category**
Bridge	Very Good	Very Good	Reinforced concrete	<10m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	12	4	**£5**	£0	£4	£0	No Action Required
Bridge	Good	Good	Reinforced concrete	<10m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	10	4 & 3	**£124**	£4	£118	£1	No Action Required
Bridge	Fair	Fair	Reinforced concrete	<10m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	6	2	**£18,528**	£638	£17,717	£173	Moderate
Bridge	Poor	Poor	Reinforced concrete	<10m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	6	2	**£463,195**	£15,962	£442,913	£4,319	High
Bridge	Very Poor	Very Poor	Reinforced concrete	<10m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	4	2	**£9,263,901**	£319,245	£8,858,268	£86,389	Critical
Bridge	Very Good	Very Good	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	12	4	**£5**	£0	£4	£0	No Action Required
Bridge	Good	Good	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	10	4 & 3	**£126**	£6	£118	£1	No Action Required
Bridge	Fair	Fair	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	6	2	**£18,828**	£938	£17,717	£173	Moderate
Bridge	Poor	Poor	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	4	2	**£470,689**	£23,456	£442,913	£4,319	High
Bridge	Very Poor	Very Poor	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	4	2	**£9,413,781**	£469,125	£8,858,268	£86,389	Critical

Table E1.01: Test Scenario – Bridge Structure Type up to 50m Span with Average Consequences for all condition bands assessed

Structure Data																Proposed Intervals		Monetised Risk (values @ 2019 rates)				
Structure Type	BCI_{AV}	BCI_{CR}	Primary Material Type	Bridge / Footbridge Length (m)	Subway / Culvert Width (m)	Wall Height (m)	Other Structure Type Extent	Inspectable	Environmental Exposure	Obstacle Crossed	Route Carried	Traffic Flow (AADT)	Delay Classification	Environmental Effect	Structure Importance	Principal Inspection	General Inspection	Annual Total Safety Risk (£/year)	Annual Safety Risk (£/year)	Annual Functionality Risk (£/year)	Annual Environmental Risk (£/year)	Risk Category
Bridge	Very Good	Very Good	Reinforced concrete	>50 to ≤100m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	12	4	**£5**	£0	£4	£0	No Action Required
Bridge	Good	Good	Reinforced concrete	>50 to ≤100m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	10	4 & 3	**£131**	£11	£118	£1	No Action Required
Bridge	Fair	Fair	Reinforced concrete	>50 to ≤100m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	6	2	**£19,577**	£1,688	£17,717	£173	Moderate
Bridge	Poor	Poor	Reinforced concrete	>50 to ≤100m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	4	2	**£489,424**	£42,191	£442,913	£4,319	High
Bridge	Very Poor	Very Poor	Reinforced concrete	>50 to ≤100m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	4	2	**£9,788,482**	£843,825	£8,858,268	£86,389	Critical
Bridge	Very Good	Very Good	Reinforced concrete	>100m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	12	4	**£5**	£1	£4	£0	No Action Required
Bridge	Good	Good	Reinforced concrete	>100m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	6	2	**£134**	£15	£118	£1	No Action Required
Bridge	Fair	Fair	Reinforced concrete	>100m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	6	2	**£20,102**	£2,212	£17,717	£173	Moderate
Bridge	Poor	Poor	Reinforced concrete	>100m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	4	2	**£502,539**	£55,306	£442,913	£4,319	High
Bridge	Very Poor	Very Poor	Reinforced concrete	>100m			0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	4	2	**£10,050,772**	£1,106,116	£8,858,268	£86,389	Critical

Table E1.02: Test Scenario – Bridge Structure Type up to 50m Span with Average Consequences for all condition bands assessed

Structure Data																Proposed Intervals		Monetised Risk (values @ 2019 rates)				
Structure Type	BCI_{AV}	BCI_{CR}	Primary Material Type	Bridge / Footbridge Length (m)	Subway / Culvert Width (m)	Wall Height (m)	Other Structure Type Extent	Inspectable	Environmental Exposure	Obstacle Crossed	Route Carried	Traffic Flow (AADT)	Delay Classification	Environmental Effect	Structure Importance	Principal Inspection	General Inspection	Annual Total Safety Risk (£/year)	Annual Safety Risk (£/year)	Annual Functionality Risk (£/year)	Annual Environmental Risk (£/year)	Risk Category
Bridge	Very Good	Very Good	Reinforced concrete	<10m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	12	4	**£32**	£3	£29	£-	No Action Required
Bridge	Good	Good	Reinforced concrete	<10m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	10	4 & 3	**£866**	£85	£773	£8	No Action Required
Bridge	Fair	Fair	Reinforced concrete	<10m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	6	2	**£129,911**	£12,818	£115,963	£1,131	High
Bridge	Poor	Poor	Reinforced concrete	<10m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	4	2	**£3,247,781**	£320,438	£2,899,069	£28,273	Very High
Bridge	Very Poor	Very Poor	Reinforced concrete	<10m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	4	2	**£64,955,611**	£6,408,768	£57,981,389	£565,454	Critical
Bridge	Very Good	Very Good	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	12	4	**£33**	£3	£29	£0	No Action Required
Bridge	Good	Good	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	6	2	**£871**	£91	£773	£8	No Action Required
Bridge	Fair	Fair	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	6	2	**£130,711**	£13,617	£115,963	£1,131	High
Bridge	Poor	Poor	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	4	2	**£3,267,765**	£340,422	£2,899,069	£28,273	Very High
Bridge	Very Poor	Very Poor	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	4	2	**£65,355,292**	£6,808,449	£57,981,389	£565,454	Critical

Table E1.03: Test Scenario – Bridge Structure Type up to 50m Span with Highest Consequences for all condition bands assessed

Structure Data																Proposed Intervals		Monetised Risk (values @ 2019 rates)				
Structure Type	BCI_{AV}	BCI_{CR}	Primary Material Type	Bridge / Footbridge Length (m)	Subway / Culvert Width (m)	Wall Height (m)	Other Structure Type Extent	Inspectable	Environmental Exposure	Obstacle Crossed	Route Carried	Traffic Flow (AADT)	Delay Classification	Environmental Effect	Structure Importance	Principal Inspection	General Inspection	Annual Total Safety Risk (£/year)	Annual Safety Risk (£/year)	Annual Functionality Risk (£/year)	Annual Environmental Risk (£/year)	Risk Category
Bridge	Very Good	Very Good	Reinforced concrete	>50 to ≤100m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	6	2	**£33**	£4	£29	£0	No Action Required
Bridge	Good	Good	Reinforced concrete	>50 to ≤100m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	6	2	**£885**	£104	£773	£8	No Action Required
Bridge	Fair	Fair	Reinforced concrete	>50 to ≤100m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	4	2	**£132,709**	£15,615	£115,963	£1,131	High
Bridge	Poor	Poor	Reinforced concrete	>50 to ≤100m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	4	2	**£3,317,725**	£390,382	£2,899,069	£28,273	Very High
Bridge	Very Poor	Very Poor	Reinforced concrete	>50 to ≤100m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	4	2	**£66,354,493**	£7,807,650	£57,981,389	£565,454	Critical
Bridge	Very Good	Very Good	Reinforced concrete	>100m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	6	2	**£34**	£4	£29	£0	No Action Required
Bridge	Good	Good	Reinforced concrete	>100m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	6	2	**£894**	£113	£773	£8	No Action Required
Bridge	Fair	Fair	Reinforced concrete	>100m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	4	2	**£134,108**	£17,014	£115,963	£1,131	High
Bridge	Poor	Poor	Reinforced concrete	>100m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	4	2	**£3,352,697**	£425,355	£2,899,069	£28,273	Very High
Bridge	Very Poor	Very Poor	Reinforced concrete	>100m			0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	4	2	**£67,053,933**	£8,507,090	£57,981,389	£565,454	Critical

Table E1.04: Test Scenario – Bridge Structure Type over 50m Span with Highest Consequences for all condition bands assessed

Structure Data																Proposed Intervals		Monetised Risk (values @ 2019 rates)				
Structure Type	**BCI$_{AV}$**	**BCI$_{CR}$**	**Primary Material Type**	**Bridge / Footbridge Length (m)**	**Subway / Culvert Width (m)**	**Wall Height (m)**	**Other Structure Type Extent**	**Inspectable**	**Environmental Exposure**	**Obstacle Crossed**	**Route Carried**	**Traffic Flow (AADT)**	**Delay Classification**	**Environmental Effect**	**Structure Importance**	**Principal Inspection**	**General Inspection**	**Annual Total Safety Risk (£/year)**	**Annual Safety Risk (£/year)**	**Annual Functionality Risk (£/year)**	**Annual Environmental Risk (£/year)**	**Risk Category**
Bridge	Very Good	Very Good	Reinforced concrete	<10m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Bridge	Good	Good	Reinforced concrete	<10m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Bridge	Fair	Fair	Reinforced concrete	<10m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Bridge	Poor	Poor	Reinforced concrete	<10m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Bridge	Very Poor	Very Poor	Reinforced concrete	<10m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Bridge	Very Good	Very Good	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Bridge	Good	Good	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Bridge	Fair	Fair	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Bridge	Poor	Poor	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Bridge	Very Poor	Very Poor	Reinforced concrete	≥10 to ≤50m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required

Table E1.05: Test Scenario – Bridge Structure Type up to 50m Span with Lowest Consequences for all condition bands assessed

Structure Data																Proposed Intervals		Monetised Risk (values @ 2019 rates)				
Structure Type	**BCI_{AV}**	**BCI_{CR}**	**Primary Material Type**	**Bridge / Footbridge Length (m)**	**Subway / Culvert Width (m)**	**Wall Height (m)**	**Other Structure Type Extent**	**Inspectable**	**Environmental Exposure**	**Obstacle Crossed**	**Route Carried**	**Traffic Flow (AADT)**	**Delay Classification**	**Environmental Effect**	**Structure Importance**	**Principal Inspection**	**General Inspection**	**Annual Total Safety Risk (£/year)**	**Annual Safety Risk (£/year)**	**Annual Functionality Risk (£/year)**	**Annual Environmental Risk (£/year)**	**Risk Category**
Bridge	Very Good	Very Good	Reinforced concrete	>50 to ≤100m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Bridge	Good	Good	Reinforced concrete	>50 to ≤100m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Bridge	Fair	Fair	Reinforced concrete	>50 to ≤100m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Bridge	Poor	Poor	Reinforced concrete	>50 to ≤100m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Bridge	Very Poor	Very Poor	Reinforced concrete	>50 to ≤100m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Bridge	Very Good	Very Good	Reinforced concrete	>100m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Bridge	Good	Good	Reinforced concrete	>100m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Bridge	Fair	Fair	Reinforced concrete	>100m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Bridge	Poor	Poor	Reinforced concrete	>100m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Bridge	Very Poor	Very Poor	Reinforced concrete	>100m			0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required

Table E1.06: Test Scenario – Bridge Structure Type over 50m Span with Lowest Consequences for all condition bands assessed

Structure Data																Proposed Intervals		Monetised Risk (values @ 2019 rates)				
Structure Type	**BCI_{AV}**	**BCI_{CR}**	**Primary Material Type**	**Bridge / Footbridge Length (m)**	**Subway / Culvert Width (m)**	**Wall Height (m)**	**Other Structure Type Extent**	**Inspectable**	**Environmental Exposure**	**Obstacle Crossed**	**Route Carried**	**Traffic Flow (AADT)**	**Delay Classification**	**Environmental Effect**	**Structure Importance**	**Principal Inspection**	**General Inspection**	**Annual Total Safety Risk (£/year)**	**Annual Safety Risk (£/year)**	**Annual Functionality Risk (£/year)**	**Annual Environmental Risk (£/year)**	**Risk Category**
Retaining Wall	Very Good	Very Good	Masonry			<1.5m	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	12	4	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Good	Good	Masonry			<1.5m	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	12	4	**£7**	£1	£7	£0	No Action Required
Retaining Wall	Fair	Fair	Masonry			<1.5m	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	6	2	**£1,086**	£92	£984	£10	Low
Retaining Wall	Poor	Poor	Masonry			<1.5m	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	6	2	**£27,158**	£2,312	£24,606	£240	Moderate
Retaining Wall	Very Poor	Very Poor	Masonry			<1.5m	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	6	2	**£543,165**	£46,240	£492,126	£4,799	High
Retaining Wall	Very Good	Very Good	Masonry			≥1.5 to ≤5m	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	12	4	**£1**	£0	£0	£0	No Action Required
Retaining Wall	Good	Good	Masonry			≥1.5 to ≤5m	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	12	4	**£16**	£3	£13	£0	No Action Required
Retaining Wall	Fair	Fair	Masonry			≥1.5 to ≤5m	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	6	2	**£2,450**	£462	£1,969	£19	Low
Retaining Wall	Poor	Poor	Masonry			≥1.5 to ≤5m	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	6	2	**£61,253**	£11,560	£49,213	£480	High
Retaining Wall	Very Poor	Very Poor	Masonry			≥1.5 to ≤5m	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	4	2	**£1,225,051**	£231,200	£984,252	£9,599	Very High

Table E1.07: Test Scenario – Retaining Wall Structure Type up to 5m Height with Average Consequence for all condition bands assessed

Structure Data																Proposed Intervals		Monetised Risk (values @ 2019 rates)				
Structure Type	BCI_{AV}	BCI_{CR}	Primary Material Type	Bridge / Footbridge Length (m)	Subway / Culvert Width (m)	Wall Height (m)	Other Structure Type Extent	Inspectable	Environmental Exposure	Obstacle Crossed	Route Carried	Traffic Flow (AADT)	Delay Classification	Environmental Effect	Structure Importance	Principal Inspection	General Inspection	Annual Total Safety Risk (£/year)	Annual Safety Risk (£/year)	Annual Functionality Risk (£/year)	Annual Environmental Risk (£/year)	Risk Category
Retaining Wall	Very Good	Very Good	Masonry			>5	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	12	4	**£2**	£0	£1	£0	No Action Required
Retaining Wall	Good	Good	Masonry			>5	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	12	4	**£44**	£5	£39	£0	No Action Required
Retaining Wall	Fair	Fair	Masonry			>5	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	6	2	**£6,657**	£694	£5,906	£58	Moderate
Retaining Wall	Poor	Poor	Masonry			>5	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	4	2	**£166,418**	£17,340	£147,638	£1,440	High
Retaining Wall	Very Poor	Very Poor	Masonry			>5	0	No	Moderate	Navigable watercourse and A Class road	TLRN road/Strategic Borough road	Moderate (25000≤AADT<50000)	Moderate (10 to 30 minutes)	Some	Medium	4	2	**£3,328,352**	£346,800	£2,952,756	£28,796	Very High

Table E1.08: Test Scenario – Retaining Wall Structure Type over 5m Height with Average Consequence for all condition bands assessed

Structure Data																Proposed Intervals		Monetised Risk (values @ 2019 rates)				
Structure Type	**BCI_{AV}**	**BCI_{CR}**	**Primary Material Type**	**Bridge / Footbridge Length (m)**	**Subway / Culvert Width (m)**	**Wall Height (m)**	**Other Structure Type Extent**	**Inspectable**	**Environmental Exposure**	**Obstacle Crossed**	**Route Carried**	**Traffic Flow (AADT)**	**Delay Classification**	**Environmental Effect**	**Structure Importance**	**Principal Inspection**	**General Inspection**	**Annual Total Safety Risk (£/year)**	**Annual Safety Risk (£/year)**	**Annual Functionality Risk (£/year)**	**Annual Environmental Risk (£/year)**	**Risk Category**
Retaining Wall	Very Good	Very Good	Masonry			<1.5m	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	12	4	**£2**	£0	£2	£0	No Action Required
Retaining Wall	Good	Good	Masonry			<1.5m	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	12	4	**£45**	£1	£43	£0	No Action Required
Retaining Wall	Fair	Fair	Masonry			<1.5m	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	6	2	**£6,690**	£185	£6,442	£63	Moderate
Retaining Wall	Poor	Poor	Masonry			<1.5m	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	6	2	**£167,254**	£4,624	£161,059	£1,571	High
Retaining Wall	Very Poor	Very Poor	Masonry			<1.5m	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	6	2	**£3,345,082**	£92,480	£3,221,188	£31,414	Very High
Retaining Wall	Very Good	Very Good	Masonry			≥1.5 to ≤5m	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	12	4	**£2**	£0	£2	£0	No Action Required
Retaining Wall	Good	Good	Masonry			≥1.5 to ≤5m	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	12	4	**£50**	£6	£43	£0	No Action Required
Retaining Wall	Fair	Fair	Masonry			≥1.5 to ≤5m	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	6	2	**£7,430**	£925	£6,442	£63	Moderate
Retaining Wall	Poor	Poor	Masonry			≥1.5 to ≤5m	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	6	2	**£185,750**	£23,120	£161,059	£1,571	High
Retaining Wall	Very Poor	Very Poor	Masonry			≥1.5 to ≤5m	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	4	2	**£3,715,002**	£462,400	£3,221,188	£31,414	Very High

Table E1.09: Test Scenario – Retaining Wall Structure Type up to 5m Height with Highest Consequence for all condition bands assessed

Structure Data																Proposed Intervals		Monetised Risk (values @ 2019 rates)				
Structure Type	BCI_{AV}	BCI_{CR}	Primary Material Type	Bridge / Footbridge Length (m)	Subway / Culvert Width (m)	Wall Height (m)	Other Structure Type Extent	Inspectable	Environmental Exposure	Obstacle Crossed	Route Carried	Traffic Flow (AADT)	Delay Classification	Environmental Effect	Structure Importance	Principal Inspection	General Inspection	Annual Total Safety Risk (£/year)	Annual Safety Risk (£/year)	Annual Functionality Risk (£/year)	Annual Environmental Risk (£/year)	Risk Category
Retaining Wall	Very Good	Very Good	Masonry			>5	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	12	4	**£2**	£0	£2	£0	No Action Required
Retaining Wall	Good	Good	Masonry			>5	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	8	3	**£53**	£9	£43	£0	No Action Required
Retaining Wall	Fair	Fair	Masonry			>5	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	6	2	**£7,892**	£1,387	£6,442	£63	Moderate
Retaining Wall	Poor	Poor	Masonry			>5	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	4	2	**£197,310**	£34,680	£161,059	£1,571	High
Retaining Wall	Very Poor	Very Poor	Masonry			>5	0	No	Moderate	Operational railway/Gas installation/Storage facility of hazardous chemicals	TLRN road/Strategic Borough road	Extremely High (AADT≥100000)	Very Severe (over 50 minutes)	Unacceptable	High	4	2	**£3,946,202**	£693,600	£3,221,188	£31,414	Very High

Table E1.10: Test Scenario – Retaining Wall Structure Type over 5m Height with Highest Consequence for all condition bands assessed

Structure Data																Proposed Intervals		Monetised Risk (values @ 2019 rates)				
Structure Type	BCI_{AV}	BCI_{CR}	Primary Material Type	Bridge / Footbridge Length (m)	Subway / Culvert Width (m)	Wall Height (m)	Other Structure Type Extent	Inspectable	Environmental Exposure	Obstacle Crossed	Route Carried	Traffic Flow (AADT)	Delay Classification	Environmental Effect	Structure Importance	Principal Inspection	General Inspection	Annual Total Safety Risk (£/year)	Annual Safety Risk (£/year)	Annual Functionality Risk (£/year)	Annual Environmental Risk (£/year)	Risk Category
Retaining Wall	Very Good	Very Good	Masonry			<1.5m	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Good	Good	Masonry			<1.5m	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Fair	Fair	Masonry			<1.5m	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Poor	Poor	Masonry			<1.5m	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Very Poor	Very Poor	Masonry			<1.5m	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Very Good	Very Good	Masonry			≥1.5 to ≤5m	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Good	Good	Masonry			≥1.5 to ≤5m	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Fair	Fair	Masonry			≥1.5 to ≤5m	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Poor	Poor	Masonry			≥1.5 to ≤5m	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Very Poor	Very Poor	Masonry			≥1.5 to ≤5m	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required

Table E1.11: Test Scenario – Retaining Wall Structure Type up to 5m Height with Lowest Consequence for all condition bands assessed

Structure Data																Proposed Intervals		Monetised Risk (values @ 2019 rates)				
Structure Type	BCI_{AV}	BCI_{CR}	Primary Material Type	Bridge / Footbridge Length (m)	Subway / Culvert Width (m)	Wall Height (m)	Other Structure Type Extent	Inspectable	Environmental Exposure	Obstacle Crossed	Route Carried	Traffic Flow (AADT)	Delay Classification	Environmental Effect	Structure Importance	Principal Inspection	General Inspection	Annual Total Safety Risk (£/year)	Annual Safety Risk (£/year)	Annual Functionality Risk (£/year)	Annual Environmental Risk (£/year)	Risk Category
Retaining Wall	Very Good	Very Good	Masonry			>5	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Good	Good	Masonry			>5	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	12	4	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Fair	Fair	Masonry			>5	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Poor	Poor	Masonry			>5	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required
Retaining Wall	Very Poor	Very Poor	Masonry			>5	0	No	Moderate	No obstacle/Waste ground/Disused/Non-navigable watercourse	No primary route supported / Disused	No vehicular traffic	None	Negligible	Low	6	2	**£0**	£0	£0	£0	No Action Required

Table E1.12: Test Scenario – Retaining Wall Structure Type over 5m Height with Lowest Consequence for all condition bands assessed

E2. Phase 2 – Proportionality

Testing of the appropriateness of intervals with a comparative technical assessment.

Test Details	Base Scenario [Average Consequences]		Comparator Scenarios											
			Highest Consequences			Lowest Consequences			Very Severe Environmental Exposure			Structure is Inspectable		
Structure Description	PI Proposed Interval	GI Proposed Interval	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration
Bridge: Very Good Condition Reinforced Concrete Spanning < 10m	12	4	12	4	No Change	12	4	No Change	12	4	No Change	12	4	No Change
Bridge: Good Condition Reinforced Concrete Spanning < 10m	10	4 then 3	10	4 & 3	No Change	12	4	Increased	10	4 & 3	No Change	12	4	Increased
Bridge: Fair Condition Reinforced Concrete Spanning < 10m	6	2	6	2	No Change	6	2	No Change	6	2	No Change	6	2	No Change
Bridge: Poor Condition Reinforced Concrete Spanning < 10m	6	2	4	2	Reduced	6	2	No Change	4	2	Reduced	6	2	No Change
Bridge: Very Poor Condition Reinforced Concrete Spanning < 10m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	6	2	Increased

Table E2.01: Test Comparison – Comparators of Structure Type Bridge up to 10m Span all condition bands assessed

Test Details	Base Scenario [Average Consequences]		Comparator Scenarios											
			Highest Consequences			Lowest Consequences			Very Severe Environmental Exposure			Structure is Inspectable		
Structure Description	PI Proposed Interval	GI Proposed Interval	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration
Bridge: Very Good Condition Reinforced Concrete Spanning ≥10m to ≤50m	12	4	12	4	No Change	12	4	No Change	12	4	No Change	12	4	No Change
Bridge: Good Condition Reinforced Concrete Spanning ≥10m to ≤50m	10	4 then 3	6	2	Reduced	12	4	Increased	10	4 & 3	No Change	12	4	Increased
Bridge: Fair Condition Reinforced Concrete Spanning ≥10m to ≤50m	6	2	6	2	No Change	6	2	No Change	6	2	No Change	6	2	No Change
Bridge: Poor Condition Reinforced Concrete Spanning ≥10m to ≤50m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	4	2	No Change
Bridge: Very Poor Condition Reinforced Concrete Spanning ≥10m to ≤50m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	4	2	No Change

Table E2.02: Test Comparison – Comparators of Structure Type Bridge with 10m to 50m Span all condition bands assessed

Test Details	Base Scenario [Average Consequences]		Comparator Scenarios											
			Highest Consequences			Lowest Consequences			Very Severe Environmental Exposure			Structure is Inspectable		
Structure Description	PI Proposed Interval	GI Proposed Interval	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration
Bridge: Very Good Condition Reinforced Concrete Spanning >50m to ≤100m	12	4	6	2	Reduced	12	4	No Change	12	4	No Change	12	4	No Change
Bridge: Good Condition Reinforced Concrete Spanning >50m to ≤100m	10	4 then 3	6	2	Reduced	12	4	Increased	6	2	Reduced	12	4	Increased
Bridge: Fair Condition Reinforced Concrete Spanning >50m to ≤100m	6	2	4	2	Reduced	6	2	No Change	6	2	No Change	6	2	No Change
Bridge: Poor Condition Reinforced Concrete Spanning >50m to ≤100m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	4	2	No Change
Bridge: Very Poor Condition Reinforced Concrete Spanning >50m to ≤100m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	4	2	No Change

Table E2.03: Test Comparison – Comparators of Structure Type Bridge with 50m to 100m Span all condition bands assessed

Test Details	Base Scenario [Average Consequences]		Comparator Scenarios											
			Highest Consequences			Lowest Consequences			Very Severe Environmental Exposure			Structure is Inspectable		
Structure Description	PI Proposed Interval	GI Proposed Interval	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration
Bridge: Very Good Condition Reinforced Concrete Spanning > 100m	12	4	6	2	Reduced	12	4	No Change	12	4	No Change	12	4	No Change
Bridge: Good Condition Reinforced Concrete Spanning > 100m	6	2	6	2	No Change	12	4	Increased	6	2	No Change	8	3	Increased
Bridge: Fair Condition Reinforced Concrete Spanning > 100m	6	2	4	2	Reduced	6	2	No Change	6	2	No Change	6	2	No Change
Bridge: Poor Condition Reinforced Concrete Spanning > 100m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	4	2	No Change
Bridge: Very Poor Condition Reinforced Concrete Spanning > 100m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	4	2	No Change

Table E2.04: Test Comparison – Comparators of Structure Type Bridge over 100m Span all condition bands assessed

Test Details	Base Scenario [Average Consequences]		Comparator Scenarios											
			Highest Consequences			Lowest Consequences			Very Severe Environmental Exposure			Structure is Inspectable		
Structure Description	PI Proposed Interval	GI Proposed Interval	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration
Bridge: Very Good Condition PT Concrete Spanning < 10m	12	4	12	4	No Change	12	4	No Change	12	4	No Change	12	4	No Change
Bridge: Good Condition PT Concrete Spanning < 10m	8	3	8	3	No Change	12	4	Increased	8	3	No Change	10	4 & 3	Increased
Bridge: Fair Condition PT Concrete Spanning < 10m	6	2	4	2	Reduced	6	2	No Change	4	2	Reduced	6	2	No Change
Bridge: Poor Condition PT Concrete Spanning < 10m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	6	2	Increased
Bridge: Very Poor Condition PT Concrete Spanning < 10m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	6	2	Increased

Table E2.05: Test Comparison – Comparators of Structure Type PT Bridge up to 10m Span all condition bands assessed

Test Details	Base Scenario [Average Consequences]		Comparator Scenarios											
			Highest Consequences			Lowest Consequences			Very Severe Environmental Exposure			Structure is Inspectable		
Structure Description	PI Proposed Interval	GI Proposed Interval	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration
Bridge: Very Good Condition PT Concrete Spanning ≥10 to ≤50m	12	4	10	4 & 3	Reduced	12	4	No Change	12	4	No Change	12	4	No Change
Bridge: Good Condition PT Concrete Spanning ≥10 to ≤50m	8	3	6	2	Reduced	12	4	Increased	8	3	No Change	10	4 & 3	Increased
Bridge: Fair Condition PT Concrete Spanning ≥10 to ≤50m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	6	2	Increased
Bridge: Poor Condition PT Concrete Spanning ≥10 to ≤50m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	4	2	No Change
Bridge: Very Poor Condition PT Concrete Spanning ≥10 to ≤50m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	4	2	No Change

Table E2.06: Test Comparison – Comparators of Structure Type PT Bridge with 10m to 50m Span all condition bands assessed

Test Details	Base Scenario [Average Consequences]		Comparator Scenarios											
			Highest Consequences			Lowest Consequences			Very Severe Environmental Exposure			Structure is Inspectable		
Structure Description	PI Proposed Interval	GI Proposed Interval	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration
Bridge: Very Good Condition PT Concrete Spanning>50 to ≤100m	12	4	6	2	Reduced	12	4	No Change	10	4 & 3	Reduced	12	4	No Change
Bridge: Good Condition PT Concrete Spanning >50 to ≤100m	8	3	6	2	Reduced	12	4	Increased	6	2	Reduced	10	4 & 3	Increased
Bridge: Fair Condition PT Concrete Spanning>50 to ≤100m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	6	2	Increased
Bridge: Poor Condition PT Concrete Spanning >50 to ≤100m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	4	2	No Change
Bridge: Very Poor Condition PT Concrete Spanning >50 to ≤100m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	4	2	No Change

Table E2.07: Test Comparison – Comparators of Structure Type PT Bridge with 50m to 100m Span all condition bands assessed

Test Details	Base Scenario [Average Consequences]		Comparator Scenarios											
			Highest Consequences			Lowest Consequences			Very Severe Environmental Exposure			Structure is Inspectable		
Structure Description	PI Proposed Interval	GI Proposed Interval	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration
Bridge: Very Good Condition PT Concrete Spanning > 100m	10	4 then 3	6	2	Reduced	12	4	Increased	10	4 & 3	No Change	12	4	Increased
Bridge: Good Condition PT Concrete Spanning > 100m	6	2	6	2	No Change	12	4	Increased	6	2	No Change	6	2	No Change
Bridge: Fair Condition PT Concrete Spanning > 100m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	6	2	Increased
Bridge: Poor Condition PT Concrete Spanning > 100m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	4	2	No Change
Bridge: Very Poor Condition PT Concrete Spanning > 100m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	4	2	No Change

Table E2.08: Test Comparison – Comparators of Structure Type PT Bridge over 100m Span all condition bands assessed

Test Details	Base Scenario [Average Consequences]		Comparator Scenarios: Highest Consequences			Comparator Scenarios: Lowest Consequences			Comparator Scenarios: Very Severe Environmental Exposure			Comparator Scenarios: Structure is Inspectable		
Structure Description	**PI Proposed Interval**	**GI Proposed Interval**	**PI Proposed Interval**	**GI Proposed Interval**	**Base Scenario Interval Alteration**	**PI Proposed Interval**	**GI Proposed Interval**	**Base Scenario Interval Alteration**	**PI Proposed Interval**	**GI Proposed Interval**	**Base Scenario Interval Alteration**	**PI Proposed Interval**	**GI Proposed Interval**	**Base Scenario Interval Alteration**
Retaining Wall: Very Good Condition Masonry Height < 1.5m	12	4	12	4	No Change	12	4	No Change	12	4	No Change	12	4	No Change
Retaining Wall: Good Condition Masonry Height < 1.5m	12	4	12	4	No Change	12	4	No Change	12	4	No Change	12	4	No Change
Retaining Wall: Fair Condition Masonry Height < 1.5m	6	2	6	2	No Change	6	2	No Change	6	2	No Change	8	3	Increased
Retaining Wall: Poor Condition Masonry Height < 1.5m	6	2	6	2	No Change	6	2	No Change	6	2	No Change	6	2	No Change
Retaining Wall: Very Poor Condition Masonry Height < 1.5m	6	2	6	2	No Change	6	2	No Change	6	2	No Change	6	2	No Change

Table E2.09: Test Comparison – Comparators of Structure Type Retaining Wall up to 1.5m Height all condition bands assessed

Test Details	Base Scenario [Average Consequences]		Comparator Scenarios											
			Highest Consequences			Lowest Consequences			Very Severe Environmental Exposure			Structure is Inspectable		
Structure Description	PI Proposed Interval	GI Proposed Interval	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration
Retaining Wall: Very Good Condition Masonry Height ≥1.5 to ≤5m	12	4	12	4	No Change	12	4	No Change	12	4	No Change	12	4	No Change
Retaining Wall: Good Condition Masonry Height ≥1.5 to ≤5m	12	4	12	4	No Change	12	4	No Change	12	4	No Change	12	4	No Change
Retaining Wall: Fair Condition Masonry Height ≥1.5 to ≤5m	6	2	6	2	No Change	6	2	No Change	6	2	No Change	6	2	No Change
Retaining Wall: Poor Condition Masonry Height ≥1.5 to ≤5m	6	2	6	2	No Change	6	2	No Change	6	2	No Change	6	2	No Change
Retaining Wall: Very Poor Condition Masonry Height ≥1.5 to ≤5m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	6	2	Increased

Table E2.10: Test Comparison – Comparators of Structure Type Retaining Wall with 1.5m to 5m Height all condition bands assessed

Test Details	Base Scenario [Average Consequences]		Comparator Scenarios												
			Highest Consequences			Lowest Consequences			Very Severe Environmental Exposure			Structure is Inspectable		
Structure Description	PI Proposed Interval	GI Proposed Interval	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration	PI Proposed Interval	GI Proposed Interval	Base Scenario Interval Alteration
Retaining Wall: Very Good Condition Masonry Height >5m	12	4	12	4	No Change	12	4	No Change	12	4	No Change	12	4	No Change
Retaining Wall: Good Condition Masonry Height >5m	12	4	8	3	Reduced	12	4	No Change	12	4	No Change	12	4	No Change
Retaining Wall: Fair Condition Masonry Height >5m	6	2	6	2	No Change	6	2	No Change	6	2	No Change	6	2	No Change
Retaining Wall: Poor Condition Masonry Height >5m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	6	2	Increased
Retaining Wall: Very Poor Condition Masonry Height >5m	4	2	4	2	No Change	6	2	Increased	4	2	No Change	4	2	No Change

Table E2.10: Test Comparison – Comparators of Structure Type Retaining Wall over 5m Height all condition bands assessed

Appendix F

Framework Comparative Testing

This appendix provides an extract of the testing results generated from the comparative analysis of risk assessment processes existing within the industry.

Test Details			Structure Description					Proposed Intervals (years)		Commentary
Reference	**Highways England Structure Type**	**LoBEG Structure Name**	**Structure Type**	**Environment**	**Inspection / Assessment**	**Condition**	**Consequences**	**Highways England Principal Inspection Interval / PII**	**LoBEG Principal Inspection Interval / PII**	**Rationale summary for discrepancies**
1	A - Bridges & Large Culverts	Example Bridge 1	A1 Structure Type - Bridge A1.1 Structural Form - Arched A1.2 Constituent Material - Masonry A1.3 Age of Structure - > 25 years A1.4 Headroom - > min A1.5 Span - < 10m	A2 Environment A.2.1 Exposure - Moderate A.2.2 Scour - No Risk A.2.3 Flooding - No Risk	A3 Inspection / Assessment A.3.1 Accessible / Inspectable - No A.3.2 Latent Defect Likelihood - Low A.3.3 Assessment - Low Priority	A4 Condition A.4.1 Inspector opinion - Fair A.4.2 Indicator Average Score - Fair A.4.3 Indicator Critical Score - Not Known (Very Poor) A.4.4 Concrete Deterioration - Yes	A5 Consequences A.5.1 Applied Loading - Full Highway A.5.2 Route Supported - A Road A.5.3 Obstacle Crossed - Other (Railway) A.5.4 Failure Mode - Brittle	6	4	The Condition (Very Poor for critical elements) and relatively high Consequence factors are primary drivers that are generating an intensive interval regime in both cases. The proposed LoBEG interval is reduced further in comparison to the HE proposal due to the availability of a reduced interval period in order to monitor deterioration / defects in a more intensive manner. HE process does not reduce inspection frequency below that of 6 years.
2	A - Bridges & Large Culverts	Example Bridge 2	A1 Structure Type - Bridge A1.1 Structural Form - Framed Span A1.2 Constituent Material - Reinforced Concrete A1.3 Age of Structure - > 25 years A1.4 Headroom - > min A1.5 Span - 10m to 25m	A2 Environment A.2.1 Exposure - Moderate A.2.2 Scour - Low A.2.3 Flooding - Low	A3 Inspection / Assessment A.3.1 Accessible / Inspectable - Yes A.3.2 Latent Defect Likelihood - Low A.3.3 Assessment - No Concerns	A4 Condition A.4.1 Inspector opinion - Good A.4.2 Indicator Average Score - V Good A.4.3 Indicator Critical Score - V Good A.4.4 Concrete Deterioration - No	A5 Consequences A.5.1 Applied Loading - Full Highway A.5.2 Route Supported - A Road A.5.3 Obstacle Crossed - River / Canal A.5.4 Failure Mode - Brittle	8	12	The Condition (Very Good for average and critical elements) factors are primarily driving a less frequent inspection regime in both cases however the Age factor is also driving a more intensive interval period for the HE results compared to that of the LoBEG proposal. LoBEG process considers the asset condition irrespective of age when assessing risk.
3	A - Bridges & Large Culverts	Example Bridge 3	A1 Structure Type - Bridge A1.1 Structural Form - Framed Span A1.2 Constituent Material - Prestressed Concrete A1.3 Age of Structure - > 25 years A1.4 Headroom - > min A1.5 Span - < 10m	A2 Environment A.2.1 Exposure - Moderate A.2.2 Scour - No Risk A.2.3 Flooding - No Risk	A3 Inspection / Assessment A.3.1 Accessible / Inspectable - No A.3.2 Latent Defect Likelihood - Low A.3.3 Assessment - Low Priority	A4 Condition A.4.1 Inspector opinion - Fair A.4.2 Indicator Average Score - Good A.4.3 Indicator Critical Score - Fair A.4.4 Concrete Deterioration - No	A5 Consequences A.5.1 Applied Loading - Full Highway A.5.2 Route Supported - A Road A.5.3 Obstacle Crossed - Other (Railway) A.5.4 Failure Mode - Brittle	6	4	Constituent material (Prestressed Concrete) factor is identifying underlying risks associated with pre/post stressed nature of materials, with a Fair condition of critical elements in combination with onerous consequences (crosses Railway) is producing an intensive inspection regime in both cases, however the LoBEG proposals differ due to the availability of a further reduced period to monitor deterioration / defects in a more intensive manner. HE process does not reduce inspection frequency below that of 6 years.
4	A - Bridges & Large Culverts	Example Bridge 4	A1 Structure Type - Bridge A1.1 Structural Form - Framed Span A1.2 Constituent Material - Prestressed Concrete A1.3 Age of Structure - > 25 years A1.4 Headroom - > min A1.5 Span - < 10m	A2 Environment A.2.1 Exposure - Moderate A.2.2 Scour - No Risk A.2.3 Flooding - No Risk	A3 Inspection / Assessment A.3.1 Accessible / Inspectable - No A.3.2 Latent Defect Likelihood - Low A.3.3 Assessment - Low Priority	A4 Condition A.4.1 Inspector opinion - Good A.4.2 Indicator Average Score - Good A.4.3 Indicator Critical Score - Good A.4.4 Concrete Deterioration - No	A5 Consequences A.5.1 Applied Loading - Full Highway + Heavy Load A.5.2 Route Supported - A Road A.5.3 Obstacle Crossed - Motorway A.5.4 Failure Mode - Brittle	6	8	Constituent material (Presstressed Concrete) factor is identifying underlying risks associated with pre/post stressed nature of materials in combination with onerous consequences (crosses Motorway) is producing a relatively intensive regime in both cases. However, in the case of the HE process the Age of Structure factor (over 25 years) is driving a reduced interval period whereas the condition factor (Good for both average and critical elements) is driving the LoBEG proposals to propose an increased period of 8 years.

Table F1: Comparison Risk Assessment Scenario – Bridges & Large Culverts

Test Details			Structure Description					Proposed Intervals (years)		Commentary
Reference	Highways England Structure Type	LoBEG Structure Name	Structure Type	Environment	Inspection / Assessment	Condition	Consequences	Highways England Principal Inspection Interval / PII	LoBEG Principal Inspection Interval / PII	Rationale summary for discrepancies
5	B - Small Span Structures	Example Small Span Bridge 1	B1 Structure Type - Small Span Structures B.1.1 Structural Form - Uniform Box B.1.2 Constituent Material - Reinforced Concrete B.1.3 Age of Structure - > 25 years B.1.4 Approximate Cover - Unknown (N/A) B.1.5 Structure Length - < 10m	B2 Environment B.2.1 Exposure - Wet B.2.2 Scour - Very Low Risk B.2.3 Flooding - Low Risk	B3 Inspection / Assessment B.3.1 Accessible / Inspectable - No B.3.2 Assessment - No Concern	B4 Condition B.4.1 Inspector opinion - Good B.4.2 Indicator Average Score - V Good B.4.3 Indicator Critical Score - V Good B.4.4 Concrete Deterioration - No	B5 Consequences B.5.1 Applied Loading - Full Highway B.5.2 Feature Affected by Collapse - A Road & River / Canal	10	12	Due to relatively low Consequences and Condition (Very Good average and critical elements) an increased inspection period is proposed in both cases. The HE proposal has a reduced frequency, in comparison to the LoBEG proposal, primarily due to the influence of the Age Factor (Greater than 25 years) whereas the LoBEG process utilises condition for assessment.
6	B - Small Span Structures	Example Small Span Bridge 2	B1 Structure Type - Small Span Structures B.1.1 Structural Form - Uniform Box B.1.2 Constituent Material - Reinforced Concrete B.1.3 Age of Structure - > 25 years B.1.4 Approximate Cover - Unknown (N/A) B.1.5 Structure Length - < 10m	B2 Environment B.2.1 Exposure - Wet B.2.2 Scour - Very Low Risk B.2.3 Flooding - Low Risk	B3 Inspection / Assessment B.3.1 Accessible / Inspectable - No B.3.2 Assessment - Low Priority	B4 Condition B.4.1 Inspector opinion - Fair B.4.2 Indicator Average Score - Fair B.4.3 Indicator Critical Score - Poor B.4.4 Concrete Deterioration - No	B5 Consequences B.5.1 Applied Loading - Full Highway B.5.2 Feature Affected by Collapse - A Road & River / Canal	6	6	Equal intervals proposed.
7	B - Small Span Structures	Example Culvert 1	B1 Structure Type - Small Span Structures B.1.1 Structural Form - Uniform Box B.1.2 Constituent Material - Reinforced Concrete B.1.3 Age of Structure - > 25 years B.1.4 Approximate Cover - Unknown (N/A) B.1.5 Structure Length - < 10m	B2 Environment B.2.1 Exposure - Wet B.2.2 Scour - Very Low Risk B.2.3 Flooding - Low Risk	B3 Inspection / Assessment B.3.1 Accessible / Inspectable - No B.3.2 Assessment - No Concern	B4 Condition B.4.1 Inspector opinion - Good B.4.2 Indicator Average Score - V Good B.4.3 Indicator Critical Score - Good B.4.4 Concrete Deterioration - No	B5 Consequences B.5.1 Applied Loading - Full Highway B.5.2 Feature Affected by Collapse - A Road & River / Canal	10	10	Equal intervals proposed.
8	B - Small Span Structures	Example Culvert 2	B1 Structure Type - Small Span Structures B.1.1 Structural Form - Arched B.1.2 Constituent Material - Masonry B.1.3 Age of Structure - > 25 years B.1.4 Approximate Cover - Unknown (N/A) B.1.5 Structure Length - < 10m	B2 Environment B.2.1 Exposure - Wet B.2.2 Scour - Very Low Risk B.2.3 Flooding - Low Risk	B3 Inspection / Assessment B.3.1 Accessible/ Inspectable - No B.3.2 Assessment - No Concern	B4 Condition B.4.1 Inspector opinion - Good B.4.2 Indicator Average Score - Good B.4.3 Indicator Critical Score - Good B.4.4 Concrete Deterioration - No	B5 Consequences B.5.1 Applied Loading - Full Highway B.5.2 Feature Affected by Collapse - A Road & River / Canal	8	12	The Condition (Good for average and critical elements), Structural Form (Arched), Constituent Material (Masonry) and relatively low Consequence factors are driving a generally reduced frequency proposal in both cases. However, Age Factor is driving a lesser interval period for the HE proposal.

Table F2: Comparison Risk Assessment Scenario – Small Span Structures

Test Details			Structure Description					Proposed Intervals (years)		Commentary
Reference	Highways England Structure Type	LoBEG Structure Name	Structure Type	Environment	Inspection / Assessment	Condition	Consequences	Highways England Principal Inspection Interval / PII	LoBEG Principal Inspection Interval / PII	Rationale summary for discrepancies
9	C - Retaining Wall	Example Retaining Wall 1	C1 Structure Type - Retaining Walls C.1.1 Structural Form - Diaphram Wall C.1.2 Constituent Material - Reinforced Concrete C.1.3 Age of Structure - > 25 years C.1.4 Max Retained Height - > 6m C.1.5 Wall Length - < 10m	C2 Environment C.2.1 Exposure - Moderate C.2.2 - Scour - No Risk C.2.3 Flooding - No Risk	C3 Inspection / Assessment C.3.1 Deterioration Since Last Inspection - No C.3.2 Accessible / Inspectable - Yes C.3.3 Assessment - Not Known (N/A)	C4 Condition C.4.1 Inspector opinion - Good C.4.2 Indicator Average Score - V Good C.4.3 Indicator Critical Score - V Good C.4.4 Concrete Deterioration - No	C5 Consequences C.5.1 Applied Loading - No Live Loading C.5.2 Feature Affected by Collapse - A Road	10	12	The Condition (Very Good for average and critical elements) and relatively low Consequence factors are driving a generally reduced frequency proposal in both cases. However, Age Factor is driving a lesser interval period for the HE proposal.
10	C - Retaining Wall	Example Retaining Wall 2	C1 Structure Type - Retaining Walls C.1.1 Structural Form - Cantilever C.1.2 Constituent Material - Reinforced Concrete C.1.3 Age of Structure - > 25 years C.1.4 Max Retained Height - > 6m C.1.5 Wall Length - 10m to 50m	C2 Environment C.2.1 Exposure - Moderate C.2.2 Scour - No Risk C.2.3 Flooding - No Risk	C3 Inspection / Assessment C.3.1 Deterioration Since Last Inspection - Yes C.3.2 Accessible / Inspectable - Yes C.3.3 Assessment - Not Known (N/A)	C4 Condition C.4.1 Inspector opinion - Fair C.4.2 Indicator Average Score - V Good C.4.3 Indicator Critical Score - Fair C.4.4 Concrete Deterioration - No	C5 Consequences C.5.1 Applied Loading - Full Highway C.5.2 Feature Affected by Collapse - A Road	6	6	Equal intervals proposed.
11	C - Retaining Wall	Example Retaining Wall 3	C1 Structure Type - Retaining Walls C.1.1 Structural Form - Cantilever C.1.2 Constituent Material - Reinforced Concrete C.1.3 Age of Structure - > 25 years C.1.4 Max Retained Height - > 6m C.1.5 Wall Length - > 50m	C2 Environment C.2.1 Exposure - Moderate C.2.2 Scour - No Risk C.2.3 Flooding - No Risk	C3 Inspection / Assessment C.3.1 Deterioration Since Last Inspection - No C.3.2 Accessible / Inspectable - Yes C.3.3 Assessment - Not Known (N/A)	C4 Condition C.4.1 Inspector opinion - Not Known (Poor) C.4.2 Indicator Average Score - Fair C.4.3 Indicator Critical Score - Poor C.4.4 Concrete Deterioration - Yes	C5 Consequences C.5.1 Applied Loading - Full Highway C.5.2 Feature Affected by Collapse - A Road	6	6	Equal intervals proposed.
12	C - Retaining Wall	Example Retaining Wall 4	C1 Structure Type - Retaining Walls C.1.1 Structural Form - Cantilever C.1.2 Constituent Material - Reinforced Concrete C.1.3 Age of Structure - > 25 years C.1.4 Max Retained Height - > 3m & < 4.5m C.1.5 Wall Length - > 50m	C2 Environment C.2.1 Exposure - Moderate C.2.2 Scour - No Risk C.2.3 Flooding - No Risk	C3 Inspection / Assessment C.3.1 Deterioration Since Last Inspection - No C.3.2 Accessible / Inspectable - Yes C.3.3 Assessment - Not Known (N/A)	C4 Condition C.4.1 Inspector opinion - Good C.4.2 Indicator Average Score - V Good C.4.3 Indicator Critical Score - V Good C.4.4 Concrete Deterioration - No	C5 Consequences C.5.1 Applied Loading - No Live Loading C.5.2 Feature Affected by Collapse - A Road	10	12	The Condition (Very Good for average and critical elements) and relatively low Consequence factors are driving a generally reduced frequency proposal in both cases. However, Age Factor is driving a lesser interval period for the HE proposal.
13	C - Retaining Wall	Example Retaining Wall 5	C1 Structure Type - Retaining Walls C.1.1 Structural Form - Cantilever C.1.2 Constituent Material - Reinforced Concrete C.1.3 Age of Structure - > 25 years C.1.4 Max Retained Height - > 3m & < 4.5m C.1.5 Wall Length - > 50m	C2 Environment C.2.1 Exposure - Moderate C.2.2 Scour - No Risk C.2.3 Flooding - No Risk	C3 Inspection / Assessment C.3.1 Deterioration Since Last Inspection - No C.3.2 Accessible / Inspectable - Yes C.3.3 Assessment - Not Known (N/A)	C4 Condition C.4.1 Inspector opinion - Good C.4.2 Indicator Average Score - Good C.4.3 Indicator Critical Score - Fair C.4.4 Concrete Deterioration - No	C5 Consequences C.5.1 Applied Loading - Full Highway C.5.2 Feature Affected by Collapse - A Road	8	6	The Condition (Good for average and Fair for critical elements) and relatively low Consequence factors are driving a generally reduced frequency proposal in the HE process. However, the Fair condition of the Critical Structural element is driving a lesser interval period for the LoBEG proposal.

Table F3: Comparison Risk Assessment Scenario – Retaining Walls

Test Details			Structure Description					Proposed Intervals (years)		Commentary
Reference	Highways England Structure Type	LoBEG Structure Name	Structure Type	Environment	Inspection / Assessment	Condition	Consequences	Highways England Principal Inspection Interval / PII	LoBEG Principal Inspection Interval / PII	Rationale summary for discrepancies
14	C - Retaining Wall	Example Retaining Wall 6	C1 Structure Type - Retaining Walls C.1.1 Structural Form - Cantilever C.1.2 Constituent Material - Reinforced Concrete C.1.3 Age of Structure - > 25 years C.1.4 Max Retained Height - > 3m & < 4.5m C.1.5 Wall Length - > 50m	C2 Environment C.2.1 Exposure - Moderate C.2.2 Scour - No Risk C.2.3 Flooding - No Risk	C3 Inspection / Assessment C.3.1 Deterioration Since Last Inspection - No C.3.2 Accessible / Inspectable - Yes C.3.3 Assessment - Not Known (N/A)	C4 Condition C.4.1 Inspector opinion - Not Known (Poor) C.4.2 Indicator Average Score - Poor C.4.3 Indicator Critical Score - Poor C.4.4 Concrete Deterioration - Yes	C5 Consequences C.5.1 Applied Loading - Full Highway C.5.2 Feature Affected by Collapse - A Road	6	6	Equal intervals proposed.
15	C - Retaining Wall	Example Retaining Wall 7	C1 Structure Type - Retaining Walls C.1.1 Structural Form - Cantilever C.1.2 Constituent Material - Reinforced Concrete C.1.3 Age of Structure - > 25 years C.1.4 Max Retained Height - < 3m C.1.5 Wall Length - 10m to 50m	C2 Environment C.2.1 Exposure - Moderate C.2.2 - Scour - No Risk C.2.3 Flooding - No Risk	C3 Inspection / Assessment C.3.1 Deterioration Since Last Inspection - No C.3.2 Accessible / Inspectable - Yes C.3.3 Assessment - Not Known (N/A)	C4 Condition C.4.1 Inspector opinion - Good C.4.2 Indicator Average Score - V Good C.4.3 Indicator Critical Score - Good C.4.4 Concrete Deterioration - No	C5 Consequences C.5.1 Applied Loading - No Live Loading C.5.2 Feature Affected by Collapse - A Road	10	12	The Condition (Very Good for average and Good for critical elements) and relatively low Consequence factors are driving a reduced frequency proposal in both cases. However, Age Factor is driving a lesser interval period for the HE proposal.
16	C - Retaining Wall	Example Retaining Wall 8	C1 Structure Type - Retaining Walls C.1.1 Structural Form - Cantilever C.1.2 Constituent Material - Reinforced Concrete C.1.3 Age of Structure - Not Known C.1.4 Max Retained Height - < 3m C.1.5 Wall Length - > 50m	C2 Environment C.2.1 Exposure - Moderate C.2.2 Scour - No Risk C.2.3 Flooding - No Risk	C3 Inspection / Assessment C.3.1 Deterioration Since Last Inspection - No C.3.2 Accessible / Inspectable - Yes C.3.3 Assessment - Not Known (N/A)	C4 Condition C.4.1 Inspector opinion - Fair C.4.2 Indicator Average Score - Good C.4.3 Indicator Critical Score - Fair C.4.4 Concrete Deterioration - No	C5 Consequences C.5.1 Applied Loading - Full Highway C.5.2 Feature Affected by Collapse - A Road	8	8	Equal intervals proposed.
17	C - Retaining Wall	Example Retaining Wall 9	C1 Structure Type - Retaining Walls C.1.1 Structural Form - Cantilever C.1.2 Constituent Material - Reinforced Concrete C.1.3 Age of Structure - > 25 years C.1.4 Max Retained Height - < 3m C.1.5 Wall Length - > 50m	C2 Environment C.2.1 Exposure - Moderate C.2.2 Scour - No Risk C.2.3 Flooding - No Risk	C3 Inspection / Assessment C.3.1 Deterioration Since Last Inspection - No C.3.2 Accessible / Inspectable - Yes C.3.3 Assessment - Not Known (N/A)	C4 Condition C.4.1 Inspector opinion - Not Known (Poor) C.4.2 Indicator Average Score - Poor C.4.3 Indicator Critical Score - Poor C.4.4 Concrete Deterioration - No	C5 Consequences C.5.1 Applied Loading - Full Highway C.5.2 Feature Affected by Collapse - A Road	6	6	Equal intervals proposed.

Table F3 [continued]: Comparison Risk Assessment Scenario – Retaining Walls

Test Details			Structure Description					Proposed Intervals (years)		Commentary
Reference	**Highways England Structure Type**	**LoBEG Structure Name**	**Structure Type**	**Environment**	**Inspection / Assessment**	**Condition**	**Consequences**	**Highways England Principal Inspection Interval / PII**	**LoBEG Principal Inspection Interval / PII**	**Rationale summary for discrepancies**
18	D - Masts & Mast Schemes	Example Mast 1	D1 Structure - Masts / Masts Schemes D.1.1 Primary Material - Steel D.1.2 Age of Mast - > 20 years D.1.3 Height of Mast - > 15m	D2 Environment D.2.1 Exposure - Moderate	D3 Inspection D.3.1 Deterioration Since Last Inspection - No D.3.2 Defects Affecting Structural Integrity - No D.3.3 - Accessible / Inspectable - Yes	D4 Condition C.4.1 Inspector opinion - Good D.4.2 Indicator Average Score - Good D.4.3 Indicator Critical Score - Good	D5 Consequences D.5.1 Feature Affected by Collapse - A Road	10	12	The Condition (Good for average and critical elements) and relatively low Consequence factors are driving a reduced frequency proposal in both cases. However, Age Factor is driving a lesser interval period for the HE proposal.
19	D - Masts & Mast Schemes	Example Mast 2	D1 Structure - Masts / Masts Schemes D.1.1 Primary Material - Steel D.1.2 Age of Mast - > 20 years D.1.3 Height of Mast - > 15m	D2 Environment D.2.1 Exposure - Moderate	D3 Inspection D.3.1 Deterioration Since Last Inspection - No D.3.2 Defects Affecting Structural Integrity - No D.3.3 - Accessible / Inspectable - Yes	D4 Condition C.4.1 Inspector opinion - Not Known (Poor) D.4.2 Indicator Average Score - Fair D.4.3 Indicator Critical Score - Poor	D5 Consequences D.5.1 Feature Affected by Collapse - A Road	6	6	Equal intervals proposed.

Table F4: Comparison Risk Assessment Scenario – Masts & Mast Schemes

Test Details			Structure Description					Proposed Intervals (years)		Commentary
Reference	Highways England Structure Type	LoBEG Structure Name	Structure Type	Environment	Inspection / Assessment	Condition	Consequences	Highways England Principal Inspection Interval / PII	LoBEG Principal Inspection Interval / PII	Rationale summary for discrepancies
20	E - Sign / Signal Gantries	Example Gantry 1	E1 Structure Type - Sign / Signal Gantries E.1.1 Structural Form - Cantilever Gantry E.1.2 Primary Material - Steel E.1.3 Age of Gantry - 20-80 years E.1.4 Headroom - > 5.7m E.1.5 Span - > 20m	E2 Environment E.2.1 Exposure - Moderate	E3 Inspection E.3.1 Deterioration Since Last Inspection - No E.3.2 Defects Affecting Structural Integrity - No E.3.3 - Accessible / Inspectable - Yes	E4 Condition E.4.1 Inspector opinion - Good E.4.2 Indicator Average Score - Good E.4.3 Indicator Critical Score - Good	E5 Consequences E.5.1 Gantry Displays - Yes E.5.2 Feature Affected by Collapse - A Road	12	12	Equal intervals proposed.
21	E - Sign / Signal Gantries	Example Gantry 2	E1 Structure Type - Sign / Signal Gantries E.1.1 Structural Form - Cantilever Gantry E.1.2 Primary Material - Steel E.1.3 Age of Gantry - 20-80 years E.1.4 Headroom - > 5.7m E.1.5 Span - > 20m	E2 Environment E.2.1 Exposure - Moderate	E3 Inspection E.3.1 Deterioration Since Last Inspection - Yes E.3.2 Defects Affecting Structural Integrity - No E.3.3 - Accessible / Inspectable - Yes	E4 Condition E.4.1 Inspector opinion - Fair E.4.2 Indicator Average Score - Good E.4.3 Indicator Critical Score - Fair	E5 Consequences E.5.1 Gantry Displays - Yes E.5.2 Feature Affected by Collapse - A Road	8	6	The Condition (Good for average and Fair for critical elements) and relatively low Consequence factors are driving a generally reduced frequency proposal in the HE process. However, the Fair condition of the Critical Structural element is driving a lesser interval period for the LoBEG proposal.
22	E - Sign / Signal Gantries	Example Gantry 3	E1 Structure Type - Sign / Signal Gantries E.1.1 Structural Form - Cantilever Gantry E.1.2 Primary Material - Steel E.1.3 Age of Gantry - 20-80 years E.1.4 Headroom - > 5.7m E.1.5 Span - > 20m	E2 Environment E.2.1 Exposure - Moderate	E3 Inspection E.3.1 Deterioration Since Last Inspection - Yes E.3.2 Defects Affecting Structural Integrity - Yes E.3.3 - Accessible / Inspectable - Yes	E4 Condition E.4.1 Inspector opinion - Not Known (Poor) E.4.2 Indicator Average Score - Good E.4.3 Indicator Critical Score - Poor	E5 Consequences E.5.1 Gantry Displays - Yes E.5.2 Feature Affected by Collapse - A Road	6	6	Equal intervals proposed.
23	E - Sign / Signal Gantries	Example Gantry 4	E1 Structure Type - Sign / Signal Gantries E.1.1 Structural Form - Cantilever Gantry E.1.2 Primary Material - Steel E.1.3 Age of Gantry - 20-80 years E.1.4 Headroom -< 5.7m E.1.5 Span - > 20m	E2 Environment E.2.1 Exposure - Moderate	E3 Inspection E.3.1 Deterioration Since Last Inspection - No E.3.2 Defects Affecting Structural Integrity - Yes E.3.3 - Accessible / Inspectable - Yes	E4 Condition E.4.1 Inspector opinion - Not Known (V Poor) E.4.2 Indicator Average Score - Good E.4.3 Indicator Critical Score - V Poor	E5 Consequences E.5.1 Gantry Displays - Yes E.5.2 Feature Affected by Collapse - A Road	6	4	The Condition factor (Very Poor Critical elements) is producing an intensive inspection regime in both cases, however the LoBEG proposals differ due to the availability of a further reduced period to monitor deterioration / defects in a more intensive manner. HE process does not reduce inspection frequency below that of 6 years.

Table F5: Comparison Risk Assessment Scenario – Sign / Signal Gantries

Test Details			Structure Description					Proposed Intervals (years)		Commentary
Reference	Highways England Structure Type	LoBEG Structure Name	Structure Type	Environment	Inspection / Assessment	Condition	Consequences	Highways England Principal Inspection Interval / PII	LoBEG Principal Inspection Interval / PII	Rationale summary for discrepancies
24	F - Service Crossings & Other Structures	Example Service Crossing 1	F1 Structure - Service Crossings & Other Structures F.1.1 Structure Type - Other (Bridge) F.1.2 Age Of Structure - 0-5 years	F2 Environment F.2.1 Exposure - Mild F.2.2 - Scour - No Risk F.2.3 Flooding - No Risk	F3 Inspection F.3.1 Deterioration Since Last Inspection - No F.3.2 Defects Affecting Structural Integrity - No F.3.3 - Accessible / Inspectable - No	F4 Condition F.4.1 Inspector opinion - Good	F5 Consequences F.5.1 Feature Affected by Collapse - Railway	10	12	The Condition (Very Good for average and Good for critical elements) is driving a reduced frequency proposal in both cases. However, the Structure Type factor is driving a lesser interval period for the HE proposal.
25	F - Service Crossings & Other Structures	Example Service Crossing 2	F1 Structure - Service Crossings & Other Structures F.1.1 Structure Type - Other (Bridge) F.1.2 Age Of Structure - > 20 years	F2 Environment F.2.1 Exposure - Mild F.2.2 - Scour - No Risk F.2.3 Flooding - No Risk	F3 Inspection F.3.1 Deterioration Since Last Inspection - No F.3.2 Defects Affecting Structural Integrity - Yes F.3.3 - Accessible / Inspectable - No	F4 Condition F.4.1 Inspector opinion - Poor	F5 Consequences F.5.1 Feature Affected by Collapse - Railway	6	6	Equal intervals proposed.

Table F6: Comparison Risk Assessment Scenario – Service Crossing & Other Structures

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