Task No: YY86731

Guidance Document for Performance Measurement of Highway Structures

Part B2: Availability Performance Indicator

Report prepared by:

ATKINS

Report prepared on behalf of:

Highways Agency

CSS Bridges Group

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1. Introduction

1.1 Availability Performance Indicator Definition

The Availability PI is defined as:

> *A measure of the reduction in the Level of Service provided, on a highway network, due to restrictions placed on highway structures.*

This includes any weight, height or width restrictions that were in place during the last 12 month period and had a duration of greater than one month. This excludes restrictions caused during maintenance work because the purpose of maintenance work is to repair the structure and therefore should not be used to penalise the Availability PI. However, if a structure has an interim restriction in place while awaiting work, for example strengthening, then its Availability PI should be penalised for the duration of the waiting period.

1.2 Background, Objectives and Scope

The background, objectives and scope are discussed in *Part A: Framework for Performance Measurement*.

1.3 Terminology

The following terminology is used by the Availability PI procedure:

- **Interaction** – refers to the interaction between a structure and an individual route, e.g. a route crossing a bridge or a route under a bridge.
- **Network** – the complete highway network managed/owned by an authority.

2. Overview of the Availability PI Procedure

2.1 General Approach

The aim of the Availability PI is to provide scores that are meaningful, beneficial and where possible comparable. This cannot be effectively achieved by simply counting the number of structures with restrictions. Instead, a more rigorous approach that takes into account the wider economic, network, traveller and community implications is required in order to provide a suitably robust basis for comparison, decision making and possibly prioritisation. Relevant criteria that an Availability PI procedure should include are:

1. Types of vehicle restricted and their associated economics.
2. Actual number of vehicles restricted.
3. Length and characteristics of the preferred diversion.
4. Queue building and dissipation.
5. Impact on travellers, e.g. delays, driver stress and increased risk of accidents.
6. Impact on communities, e.g. access to community facilities.
7. Impact on businesses, e.g. delays to deliveries/employees; and
8. Impact on the environment.

The Availability PI procedure presented here takes these factors into account, and as such may appear complex. However, it is expected that the procedure will be programmed into Bridge Management Systems, allowing the algorithms to run in the background on readily available information, thereby placing minimal additional burden on bridge managers. The Availability PI is not suitable for hand calculation.

2.2 Availability PI Scale

The Availability PI scale is from 0 to 100, where zero represents a very poor level of availability and 100 is full availability. Individual structures, route types and the structure stock are all scored on the 0 to 100 scale. The Availability PI scale is described in more detail in Section 7.3.

2.3 Availability PI Score

An Availability PI score is evaluated for each time a structure interacts with a section of the highway network, therefore some structures will have more than one Availability PI score. Section 2.3.1 describes the number of Availability PIs evaluated for some common highway structure arrangements.

If a structure interaction does not cause a network restriction then it has a score of 100 for that interaction. When a structure interaction does restrict a network then the

Availability PI score should be penalised accordingly, i.e. the interaction has a score of less than 100.

The Availability PI is a snapshot of the restrictions imposed on the network by structures over the last year (12 month period). Where a restriction was not in place for the full 12 month period the Availability PI procedure allows the actual duration of the restriction (in months) to be taken into account.

2.3.1 Number of Availability PI Scores Evaluated per Structure

The Availability PI measures the impact of structure restrictions on an authority's network caused by structures under the authority's stewardship (see Section 2.4 for dealing with structures that interact with an authority's network but are owned by another authority). A structure receives an Availability PI score for each time it interacts with a part of the authority's network. In the following examples the structures and the networks are assumed to be under the stewardship of the same authority.

1. A bridge that carries one route over another route (see Figure 1a) – an Availability PI score is evaluated for both interactions, i.e. one Availability PI for the route carried and one for the route crossed.

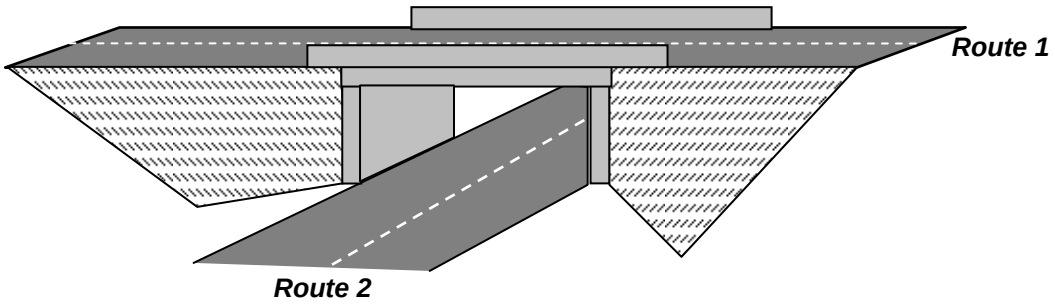
2. A retaining wall *adjacent to* one route and *supporting* a different route (see Figure 1b) - an Availability PI score is evaluated for both interactions, i.e. an Availability PI for the route adjacent to the wall and an Availability PI for the route supported by the wall. However, if the adjacent and supported roads are actually two carriageways of the same route then only one Availability PI score is calculated, i.e. only one Availability PI score is calculated for each interaction with a route not each interaction with a carriageway

3. Two parallel bridges (see Figure 1c):

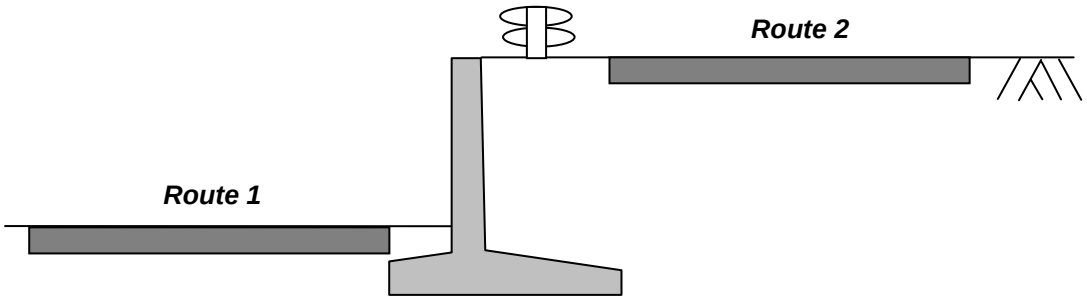
    a. If the two bridges support two parallel carriageways of the same route then one Availability PI score covers both structures, however this does not include structures on the entrance and exit routes to a site that are sufficient far enough apart to be treated as separate routes.

    b. If the bridges serve two different routes then an Availability PI score should be evaluated for each.

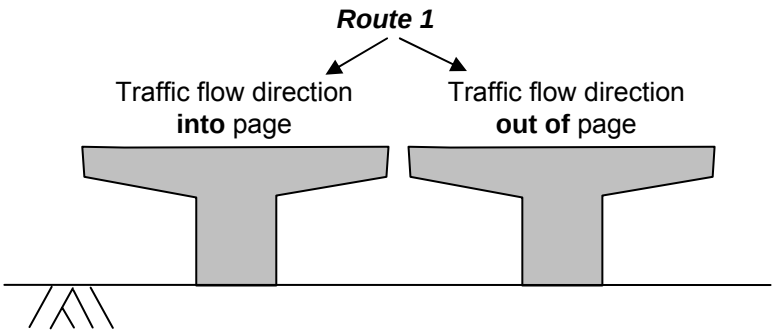
The evaluation of the network Availability PI therefore requires all structure interactions on an authority's network, related to structures under their stewardship, to be identified and an Availability PI score evaluated for each. This should not prove onerous because the majority of structures will receive an automatic Availability PI score of 100 because there was no restriction in place during the last 12 months.



a) Bridge passes over one route and carries the other –
two Availability PI scores are evaluated



b) Retaining wall serves two routes –
two Availability PI scores are evaluated



c) Two carriageways of one route supported by separate
structures – one Availability PI score is evaluated

Figure 1 Highway Structures and their Network Interactions

2.3.2 When to Penalise the Availability PI Score

A highway structure is penalised under the Availability PI procedure, i.e. has a score of less than 100, when the Level of Service provided by the structure is below that of the adjacent/served highway. This should include any restriction in the last 12 month period that had duration of greater than one month, but excluding maintenance work because the purpose of maintenance work is to repair the structure and therefore should not penalise the Availability PI. However, if a structure has an interim restriction in place while awaiting work, for example strengthening, then its Availability PI should be penalised for the duration of the waiting period

The majority of structures/interactions on a network will have an Availability PI score of 100, i.e. no network restrictions were caused by the structure over the last 12 months. Therefore, an authority may find the most suitable starting point is to assign a score of 100 to all structure interactions and only collect data to penalise the Availability PI score when a restriction arises.

Important: Environmental weight restrictions are not used to penalise the Availability Performance Indicator.

2.4 Other Highway Structure Owners

The Availability PI is a measure of the impact of structure restrictions on an authority's network caused by structures under their stewardship. The Availability PI excludes restrictions on the authority's network that are caused by structures under the stewardship of another authority. However, this does not preclude an authority from using this procedure to demonstrate the impact of restrictions, which are outside their direct control, on their network.

Important: In reporting the Availability PI an authority should, first and foremost, report the value for structures under their stewardship. This may be supplemented by further Availability PI scores that illustrate the additional impact of structures owned by other authorities.

2.5 Steps in the Availability PI Procedure

The Availability PI procedure is shown in Figure 2 and summarised in the steps below.

Step 1 – Select Structure

Identify if the structure type is appropriate for inclusion in the Availability PI, see Section 3.1. Identify the number of times the structure interacts with your network, an Availability PI score is evaluated for each interaction.

Step 2 – Is there a restriction?

Detailed data is not required for this step, only knowledge of whether a structure has restricted the network in the last 12 months or not. Structures that did not restrict the network have an Availability PI score of 100 for each interaction and no further calculation is required. Structures with one or more restrictions are passed to Step 3.

Step 3 – Restriction Data Review

Data for restrictions are reviewed and additional data collated where necessary, see Table 2 in Section 3.2. The procedure described in Section 5 is used for restrictions on vehicular routes and the procedure in Section 6 is used for restrictions on non-vehicular routes associated with the highway.

Step 4 – Availability PI for Vehicular Routes

The Availability PI formula and look-up tables are presented in Section 5. The procedure deals with weight, height and width restrictions. The look-up tables allow scores to be selected for:

- Route type and traffic volume.
- Restriction type (weight, height or width).
- Duration of the restriction (particularly relevant for restrictions not in place for the full 12 month calculation period).
- Increased length of journey for diverted traffic; and
- Environmental and Socio-economic impact (on restricted route and diversion route).

Step 5 – Availability PI for Non-Vehicular Routes

The Availability PI formula and look-up tables are presented in Section 6. The look-up tables allow scores to be selected for:

- Volume of users.
- Duration of the restriction (particularly relevant for restrictions not in place for the full 12 month calculation period)
- Increased length of journey for diverted users and any perceived increase in the risk of crime and/or accident; and
- Local importance of the structure/route.

Step 6 – Route Type Availability PI Score

The Availability PI score for each route type (Motorway, Primary A, Other Principal Roads, Classified B & C, Unclassified U and Non-Vehicular) is evaluated separately using Equation 8 (Section 7.1).

Step 7 – Stock Availability PI Score

The Stock Availability PI score is evaluated by combining the route type scores from Step 6 using Equation 9 (Section 7.2).

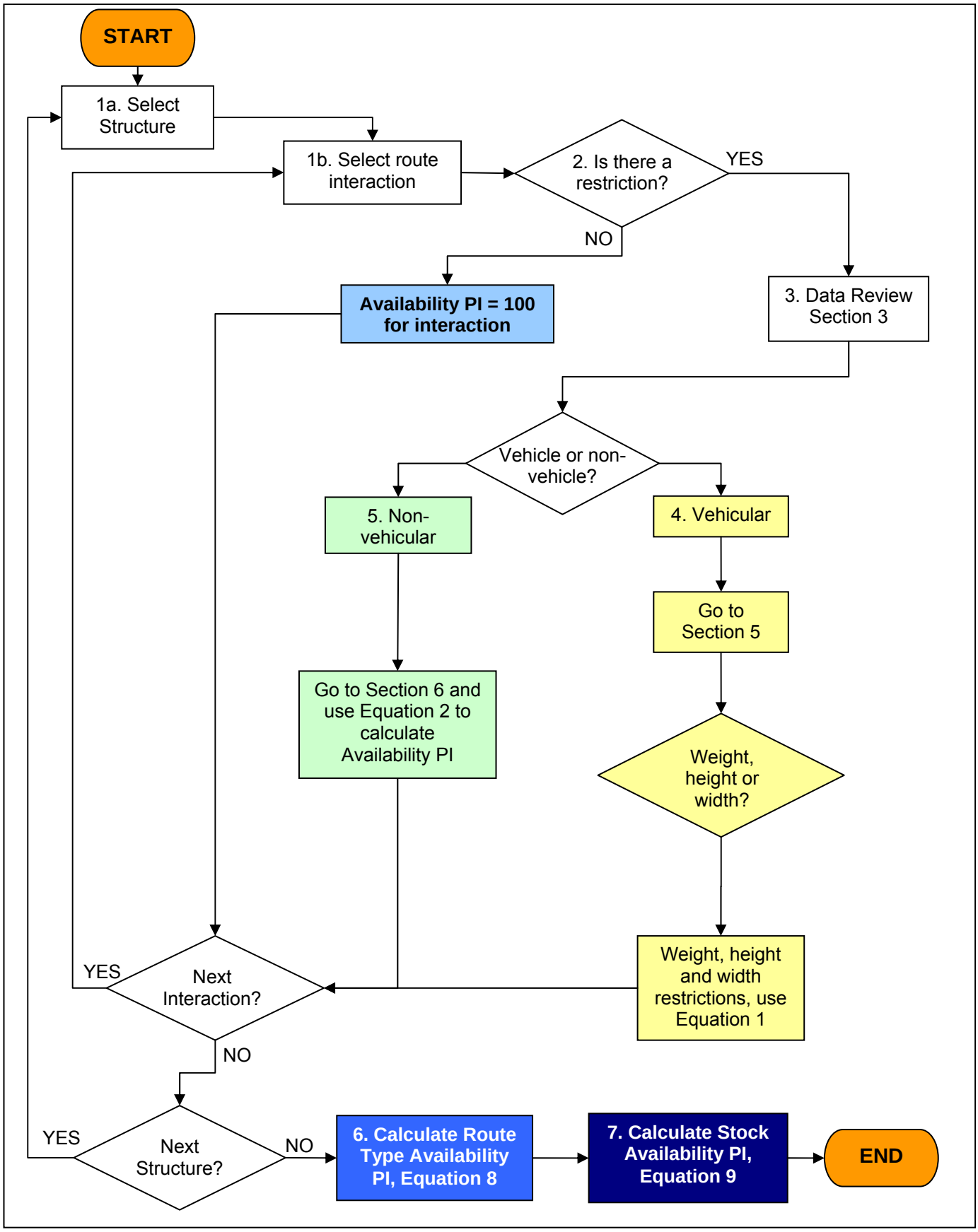


Figure 2 Overview of Availability PI Procedure

3. Data Requirements

3.1 Relevant Structure Types

The relevance of the Availability PI to a structure depends on how the structure interacts with highway traffic (vehicular and pedestrian). Table 1 shows the highway structure types considered under the Performance Measurement Framework and how they typically interact with the highway traffic. Definitions of the structure types are provided in the Code of Practice, BD62 and BD63 (Refs. 1, 2 and 3).

The right hand column of Table 1 shows the restrictions that may be relevant to each structure type.

Table 1 Highway Structure Availability Requirements

Structure Type	Typical interaction with highway traffic (vehicular and pedestrian)	Possible Restriction Types
Bridge and culverts	Allow highway traffic to pass over and/or under	Weight, height and width
Small culverts (if treated separately from bridges)	Allow highway traffic to pass over	Weight and width
Retaining Wall	Allow highway traffic above or below the wall to use the route	Weight* and width
Road Tunnel	Allow highway traffic to pass through and over (tunnel slab)	Weight, height and width
Sign/Signal Gantry	Allow highway traffic to pass under (only gantries that span the route are included, road side cantilever gantries are omitted)	Height and width
High Mast	N/A	N/A
Other structure types	N/A	N/A

* weight restrictions for a retaining wall may be based on a visual inspection when structural load assessment data is not available.

The interactions described in Table 1 are used to identify the total number of interactions on an authority's network. The total number of interactions is required when evaluating the final stock Availability PI. See Section 2.3 for the number of Availability PIs evaluated per structure.

Important: The Availability PI should be based on interactions between vehicular routes and highway structures, where vehicular routes are Motorways, Primary A, Other Principal Roads, Classified B & C and Unclassified routes. However, if an authority wishes to extend the Availability PI to include interactions with non-vehicular routes, including Public Right of Way (PROW) routes (public footpaths, cycle tracks, bridleways and byways), then they can do so.

3.2 Essential and Desirable Data

The data required to evaluate the Availability PI is shown in Table 2.

Table 2 Availability PI Data

No.	Data	Classification
1	Structure owner details (identify the structure owner, i.e. Authority or other, specifying the other owner where possible)	Essential
2	Number of times the structure interacts with the network and details of each interaction	Essential
The following is required for each interaction that has a restriction		
3	Restriction details, e.g. weight limit, height limit and width limit (e.g. road width, number of lanes open/closed)	Essential, where relevant to the restriction type
4	Classification of restricted route, e.g. Motorway, Primary A, other Principal Roads, Classified B & C, Unclassified U, Non-vehicular	
5	Duration of the restriction (in months) if it was not in place for the whole 12 month period. This is best achieved by recording the start and end dates of restrictions.	
6	Road classification of the preferred diversion route*	
7	Increased length of journey for diverted traffic (an estimation e.g. Short, Medium or Long is sufficient)	
8	Environmental and socio-economic impacts (selected from the appropriate tables in this document)	

* the classification of the preferred diversion route should be assessed as follows:

a. If one route type makes up greater than 70% of the preferred diversion length then this classification should be used; otherwise

b. An engineering judgement should be made as to which single route type is equivalent to the mix of route types present on the preferred diversion route.

Important: If a structure interaction has not created an associated network restriction over the previous 12 month period then it has an Availability PI score of 100. Data items 3 to 7 in Table 2 are only required when there is a restriction. An authority may find the most suitable starting point for the Availability PI is to assign a score of 100 to all structure interactions and only collect data items 3 to 7 when a restriction arises.

4. Levels of Service and Restrictions

4.1 Required Level of Service

The Levels of Service for highway structures are defined according to existing design standards and the route type. The weight and height and width requirements for each route type are shown in Table 3.

Table 3 Design Values for Vehicle Weight, Height and Width

Route Type	Weight (BD37 Ref. 4)	Height (minimum)	Width
Motorway	HA + 45HB	5.03m (or 6.18m for High Load Route) In accordance with TD27, Ref. 5	In accordance with vehicle dimensions, adjacent highway and/or TA46, Ref. 6
Primary A			
Other Principal	HA + 37.5HB		
Classified B	HA + 30HB		
Classified C			
Unclassified U			

The values shown in Table 3 represent the default Levels of Service used by the Availability PI procedure. These, in particular some of the loading levels, are not statutory requirements for all highway structures. Section 4.3 explains how performance target setting can take account of situations where an authority's policy does not align with these requirements.

4.2 Lower Bound Levels of Service

It is important to recognise that, while the Levels of Service shown in Table 3 are similar for all route types, the lower bound Levels of Service may not be. For example, a restriction that may be tolerated for a period of time on an unclassified road may receive no tolerance on a motorway. The Availability PI scores should reflect this difference in tolerance. Therefore, the tolerable lower bound Level of Service is taken into account when evaluating the Availability PI.

The lower bound Level of Service is defined as:

> *The average Level of Service at, and below which, the route type is deemed to be critically/severely restricted, by the structure owner/manager and/or public/users, when compared against the required Level of Service.*

The lower bound Levels of Service were determined through discussions with the Steering Group and validated using questionnaires that were completed by a sample of bridge managers. Vehicle weight restrictions are used to define the lower bound Levels of Service and are shown in Table 4.

Table 4 Lower Bound Levels of Service

Route Type	Lower Bound Level of Service*
Motorway	26 Tonne GVW
Primary A	26 Tonne GVW
Other Principal Roads	18 Tonne GVW
Classified B and C	7.5 Tonne GVW
Unclassified U	3 Tonne GVW

*Note: the lower bound Levels of Service must not be taken to indicate suitable levels of restriction for these route types. For example, it is unacceptable to have a 3 tonne restriction on an unclassified route if this is the only access point and it prevents emergency vehicles from entering. The lower bound limits are indicative and only used as a basis for comparing the economics and impact of restrictions on different route types.

Example: based on the above lower bound Levels of Service a motorway would receive a very low, possibly 0 score, when a 26 tonne, or worse, weight restriction is in place, while an unclassified route with a 26 tonne restriction is likely to have a relatively high score.

4.3 Acceptable Restrictions

Some highway structure restrictions (apart from environmental restrictions) may be classified as “acceptable” due to policy decisions or local considerations, e.g. certain height and width restrictions. These restrictions are to be included when calculating the Availability PI for the network, however, in reporting the score the bridge manager should indicate the influence of these “acceptable” restrictions relative to “unacceptable” restrictions.

For example, consider a network that has an Availability score of 85 out of 100. However, the “acceptable” restrictions alone give the network a score of 92 out of 100. In this case the score of 92 reflects that the network would not achieve an Availability PI score of 100 because there are a number of “acceptable” restrictions on the network. This would be reported as:

- Availability PI score reported as 85 out of 100.
- Target Availability PI score reported as 92 out of 100.

The acceptability of a restriction must be assessed on a structure by structure basis. It is the bridge engineer’s knowledge of local factors and opinions that will enable a restriction to be classified as “acceptable”. In addition to standard restriction data (e.g. restriction type, restriction start date etc.), records should indicate why a restriction was classified as “acceptable”.

5. Availability PI Score for Vehicular Routes

This section presents the equations and look-up tables used to evaluate the Availability PI for each time a structure restriction interacts with a vehicular route.

Remember: If a structure/network interaction has created no restriction for the previous 12 months then it automatically has a score of 100 and no calculation, or associated data collection, is required.

5.1 Availability PI Formula

The Availability PI is evaluated as a function of the:

1. Traffic volume on the restricted route.
2. Restriction type and the type of traffic it effects.
3. The difference between the classification of the restricted route and the classification of the preferred diversion route.
4. The increased length of journey for road users.
5. Environmental and socio-economic impacts of the restriction; and
6. Duration of the restriction.

Availability PI for each network interaction:

Vehicle Weight, Height and Width Restrictions

$$PI = 100 \times \left\{ \frac{C_{LB} - \left[\frac{T}{12} \left(\left[R \times DR \times OR \times IJL \right] + \left[\frac{C_{LB} \times (En + SE)}{2 \times (En_{\max} + SE_{\max})} \right] \right) \right]}{C_{LB}} \right\}$$

but not < 0 **Equation 1**

where:

C_{LB} = a constant, specific to the route type served, Section 5.2

T = number of months the restriction was in place for over the previous 12 months, Section 5.3

R = Restriction type score, Section 5.4
- based on the cost of the restriction per vehicle per km

DR = Diversion Route score, Section 0
- based on the difference between route types

OR = Original Route traffic volume score, Section 5.6
- based on the volume of traffic on the restricted route

IJL = Increased Journey Length score, Section 5.7
- based on the increased distance travelled by diverted traffic

En = Environmental score, Section 5.8

En_{max} = maximum value the Environmental score can take, Section 5.8

SE = Socio-Economic score, Section 5.9

SE_{max} = maximum value the Socio-Economic score can take, Section 5.9.

5.2 Lower Bound Constant, C_{LB}

The Lower Bound Constant, C_{LB}, adjusts the Availability PI so it suitably reflects the impact of a restriction on that route type. C_{LB} is calculated using Equation 2 and characteristic data for the route type shown in Table 5.

Lower Bound Constant

$$C_{LB} = (R_{LB} \times DR_{LB} \times OR_{LB} \times ILJ_{LB})$$

Equation 2

Where, the characteristic data for each route type are:

R_{LB} = lower bound weight restriction score
(based on the Levels of Service defined in Table 4, Section 4.2)

OR_{LB} = assumed Original Route type score for the restricted route

DR_{LB} = assumed classification score for the preferred diversion route

IJL_{LB} = assumed Increased Journey Length for diverted traffic

Table 5 Lower Bound Constant, C_{LB}, and Associated Variables

Route Type	R_{LB}	DR_{LB}	OR_{LB}	IJL_{LB}	C_{LB}
Motorway	0.83	1.03	9.0	4	**30.8**
Primary A	0.57	1.06	5.0	4	**12.1**
Other Principal Roads	0.82	1.05	3.0	4	**10.3**
Classified B and C	1.50	1.13	1.0	4	**6.8**
Unclassified U	0.75	1.00	0.3	4	**0.9**
Non-vehicular route	-	-	-	-	**6.8**

C_{LB} enables more meaningful Availability PI scores to be evaluated for individual interactions because they are assessed in terms of the route type they serve rather than their importance to the overall network. However, when the stock Availability PI is calculated the scores are re-adjusted by C_{LB} to ensure the economic consequences of each restriction is treated fairly in the stock evaluation.

5.3 Duration of Restriction, *T*

The Availability PI measures the availability of the network over that last year (12 months). The Availability PI formula (Equation 1) includes a factor to account for the proportion of the year a restriction was in place, i.e. the number of months it was in place. It is likely that:

- For long-term restrictions T = 12 months, i.e. the restriction was in place for the whole 12 month period; and
- For short-term restrictions or restrictions that were removed/installed during the year, T < 12 months, i.e. the restriction was not in place for the whole 12 month period. It is recommended that only restrictions of duration greater than one month are included in the Availability PI.

5.4 Restriction Scores, *R*

The restriction score, *R*, depends on the type of restriction in place, e.g. weight, height or width. The following sections provide look-up tables from which the restriction score, *R*, for each type of restriction is selected.

The Restriction score, *R*, has a 0 to 10 dimensionless scale that is based on:

1. The type of restriction and the hence the type of vehicle diverted.
2. The proportion of the traffic flow affected by the restriction (changes with route classification).
3. Typical vehicle operating costs and highway user time costs.

When a structure creates more than one restriction per interaction at the same time, e.g. a weight and height restriction on a structure apply to one route, then the more severe restriction should be used to calculate the Availability PI. If the restrictions are concurrent over the last 12 month period then a cumulative score should be evaluated for the interaction.

5.4.1 Weight Restriction Score, R_{WT}

The weight restriction score, R_{WT}, is selected from Table 6. The proportion of vehicles restricted by different load ratings is based on the vehicle types described in *Part A: Framework for Performance Measurement*. Examples of the scores selected from Table 6 are:

- A 26 Tonne restriction for a Primary A route has a score of R_{WT} = 0.57.
- A 3 Tonne restriction on an Unclassified route has a score of R_{WT} = 0.75.

When a route is not required to serve HB (or STGO) vehicles then rows 1 and 2 in Table 6 should be set to zero values.

Table 6 Weight Restriction Scores, R_{WT}

		Classification of Restricted Route				
ID	**Weight Restriction**	**Motorway**	**Primary A**	**Other Principal**	**Classified B & C**	**Unclassified U**
1	SV150	0.005	0.005	0.00	0.00	0.00
2	HA 40 tonne (also restricts 25 Units of HB and SV100)	0.02	0.01	0.00	0.00	0.00
3	HA 33 tonne	0.24	0.16	0.14	0.06	0.03
4	HA 26 tonne	0.83	0.57	0.50	0.22	0.12
5	HA 18 tonne	1.30	0.93	0.82	0.39	0.22
6	HA 13 tonne	1.51	1.13	1.07	0.69	0.36
7	HA 10 tonne	1.72	1.33	1.31	0.98	0.49
8	HA 7.5 tonne	2.01	1.62	1.71	1.50	0.70
9	HA 3 tonne	2.13	1.74	1.81	1.57	0.75
10	Closed to vehicular traffic	10.0	10.0	10.0	10.0	10.0

5.4.2 Height Restriction Score, R_H

The proportion of vehicles restricted by different height restrictions are based on:

- The vehicle types, described in *Part A*; and
- Typical dimensions of road traffic vehicles (Ref. 7).

The height restriction score, R_H, is selected from Table 7.

Table 7 Height Restriction Scores, R_H

	Classification of Restricted Route				
Clearance Height	**Motorway**	**Primary A**	**Other Principal**	**Classified B & C**	**Unclassified U**
> 5.03m	0.00	0.00	0.00	0.00	0.00
4.5 to 5.03m	0.20	0.10	0.10	0.00	0.00
4.25 to 4.5m	0.40	0.30	0.30	0.20	0.10
4.0 to 4.25m	0.80	0.60	0.60	0.40	0.20
3.75 to 4.0m	1.00	0.75	0.72	0.47	0.25
3.5 to 3.75m	1.20	0.90	0.85	0.60	0.30
3.25 to 3.5m	1.50	1.15	1.17	0.95	0.45
3.0* to 3.25m	1.70	1.40	1.50	1.35	0.60

*It is assumed that height restrictions below 3m will not be present on the highway.

5.4.3 Width Restriction Score, R_{WD}

Width restrictions are classified as:

1. **Vehicle Width Restrictions** – the structure can accommodate the traffic volume on the route but the actual width of the structure prevents some vehicle types from using the route, i.e. width is less than 2.5m ➔ go to 1 below.

2. **Lane Restrictions** – the width of the carriageway at the structure is less than the route it accommodates, e.g. when four lanes decrease to two, or two lanes decrease to one due to a narrow structure (Note: but not due to maintenance works as these are excluded from the Availability PI). This approach implicitly includes *Vehicle Width Restrictions* when they occur alongside a *Lane Restriction* ➔ go to 2 below.

1. Vehicle Width Restriction

The Width Restriction Score, R_{WD}, caused by a vehicle width restriction is:

R_{WD} = 0 if the lane width is > 2.5m

R_{WD} = 2.5 if the lane width is > 2.0m and ≤ 2.5m

R_{WD} = 9.0 if the lane width is ≤ 2.0m

Equation 3

An R_{WD} score of 9.0 means that only bicycles, motorcycles and small cars can gain easy access.

2. Lane Restriction

It is assumed that lane restrictions (i.e. where the structure is narrower than the adjacent route) start to cause traffic delays (e.g. queue building) when the traffic volume on the route exceeds the Congestion Reference Flow (*CRF*), see Ref. 6. When the *CRF* is reached, this indicates that congestion is occurring during the Peak Hour Flow. A rigorous evaluation of the congestion and queue building during Peak Hour Flow is beyond the scope of the Availability PI, therefore the following simplified approach is used (which is based on the *CRF* and Peak Hour Flow described in Ref. 6). The Width Restriction Score, R_{WD}, is:

$$R_{WD} = \left[\frac{(x - CRF_S)}{x} \times y \right] \times 10$$

Given that if $CRF_S \geq OR$ then $R_{WD} = 0$

if $CRF_S < OR$

then if $CRF_R < OR$ then $x = CRF_R$

if $CRF_R \geq OR$ then $x = OR$

but not < 0 **Equation 4**

Where:

OR = Original Route score (see Section 5.6)

CRF_S = Congestion Reference Flow score of the structure (Table 8)

CRF_R = Congestion Reference Flow score of the adjacent route (Table 8)

x = takes account of whether or not the route is already congested

y = relates to the proportion of the traffic delayed (see Table 9)

10 = 0 to 10 scale that restriction scores are evaluated on

If the *CRF* score is greater than or equal to *OR* this indicates the narrow structure has not created any traffic delays and hence R_{WD} is equal to zero (see Equation 4).

Table 8 CRF score for different lane types

Lane Type	*Estimated vehicle flow capacity*	*CRF score*
Dual Lane	32,500 ×*NL*	3.25 ×*NL*
Wide Single	32,500	3.25
Single 7.3	22,500	2.25
Narrow Lane (but at least one lane in each direction (*LW* > 2.5m but < 3.65m)	$22{,}500 \times \frac{LW}{3.65} \times NL$	$2.25 \times \frac{LW}{3.65} \times NL$
Total road width > 2.5m and < 5m	5000	0.5

Where:

NL = the number of lanes in each direction at the structure
or (total number of lanes)/2 if there is an odd number of lanes

LW = Lane Width

Table 9 Proportion of Traffic Delayed (y)

$\frac{x}{CRF_S}$	y
≤ 1.0	0
> 1.0 and ≤ 1.25	0.05
> 1.25 and ≤ 1.5	0.15
> 1.5 and ≤ 1.75	0.30
> 1.75 and ≤ 2.0	0.60
> 2.0	1.0

5.5 Diversion Route Score, *DR*

The Diversion Route Score, *DR*, accounts for the economic consequences of diverting traffic to a different route classification. The criteria considered in developing the relationship were:

1. Frequency of traffic accidents on different route classifications.
2. Average vehicle speed on different route classifications.
3. Vehicle operating and user costs for different route types.

The economic consequences of a route type change were evaluated as:

Economic consequences per vehicle per km =
cost per vehicle per km on diversion route
- cost per vehicle per km on original route

The factors shown in Table 10 are applied to the Restriction score, *R*, in Equation 1 as a direct multiplication factor. If the diversion route has a higher classification than the original route then the reduced consequences are also reflected.

Table 10 Diversion Route Score, *DR*

		Original Route Type				
		Motorway	**Primary A**	**Other Principal**	**Classified B & C**	**Unclassified U**
Diversion Route Type	**Motorway**	1.00	0.99	0.98	0.93	0.80
	Primary A	1.01	1.00	0.99	0.94	0.81
	Other Principal	1.03	1.01	1.00	0.95	0.83
	Classified B & C	1.08	1.06	1.05	1.00	0.88
	Unclassified U	1.20	1.19	1.18	1.13	1.00

If there are road works on the preferred diversion route there is a higher likelihood of road accidents and a slower average speed. When road works are present on the diversion route, *DR* is amended as follows (Ref. 8):

$$DR_{RW} = DR \times 1.5$$

Equation 5

where DR_{RW} = score for Diversion Route with Road Works

If the road works are only on the diversion route for part of the diversion period then the *DR* used in Equation 1 should be a weighted average of *DR* and DR_{RW}, where the weighting used is the number of months applicable to each.

5.6 Original Route Type Score, *OR*

The Original Route Type score, *OR*, is based on the traffic volume (AADT) the route accommodates when there is no restriction. *OR* is evaluated as:

$$OR = \frac{AADT}{10{,}000}$$

Equation 6

AADT is the Average Annual Daily Traffic flow which is the average 24 hour two-way flow on the route. The *OR* factor is applied to the product of *R* and *DR* in Equation 1 to take account of the total volume of traffic on the route. The Original Route Type score, *OR*, is selected from Table 11.

Table 11 Original Route Type Score, *OR*

Original Route Type	Traffic Flow		*OR*
	Description	AADT	
Motorway	Heavy	> 90,000	9.0
	Moderate	30,000 to 90,000	6.0
	Light	< 30,000	3.0
Primary A	Heavy	> 50,000	5.0
	Moderate	20,000 to 50,000	3.5
	Light	< 20,000	2.0
Other Principal Roads	Heavy	> 30,000	3.0
	Moderate	10,000 to 30,000	2.0
	Light	< 10,000	1.0
Classified B & C	Heavy	> 10,000	1.0
	Moderate	3000 to 10000	0.65
	Light	< 3000	0.30
Unclassified U	Heavy	> 3000	0.30
	Moderate	1000 to 3000	0.20
	Light	< 1000	0.10

5.7 Increased Journey Length Score, *IJL*

Restrictions normally cause some road users to make longer journeys. The length of the increased journey created by a restriction is assumed to be relative to the route type restricted, i.e. higher route classifications are primarily used for longer journeys while lower route classifications are primarily used for shorter local journeys,

therefore the nature of the assumed diversion should reflect this. The increased journey length is therefore defined as:

Motorway, Primary A and Other Principal Routes (also see Figure 3)

Increased Journey Length = (Length of diversion route, *DR*, from junction A to B)

– (Length of original route, *OR*, from junction A to B)

Classified B & C and Unclassified U Routes (also see Figure 4)

Increased Journey Length =

Distance from one side of the restricted structure to the other via a diversion

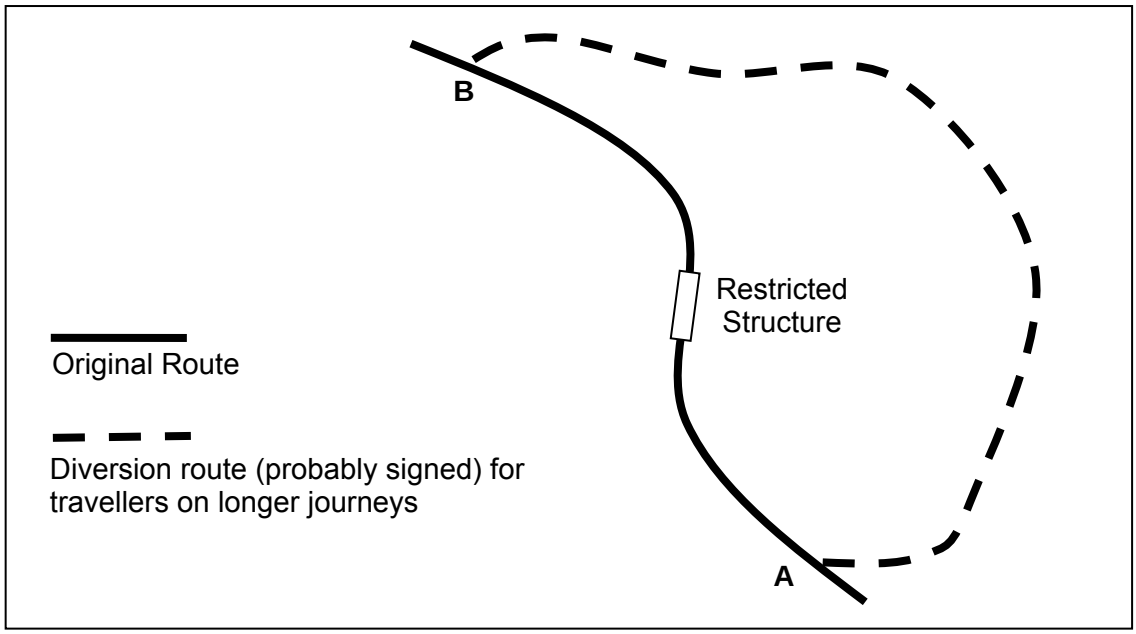


Figure 3 IJL for Motorway, Primary A and Other Principal Routes

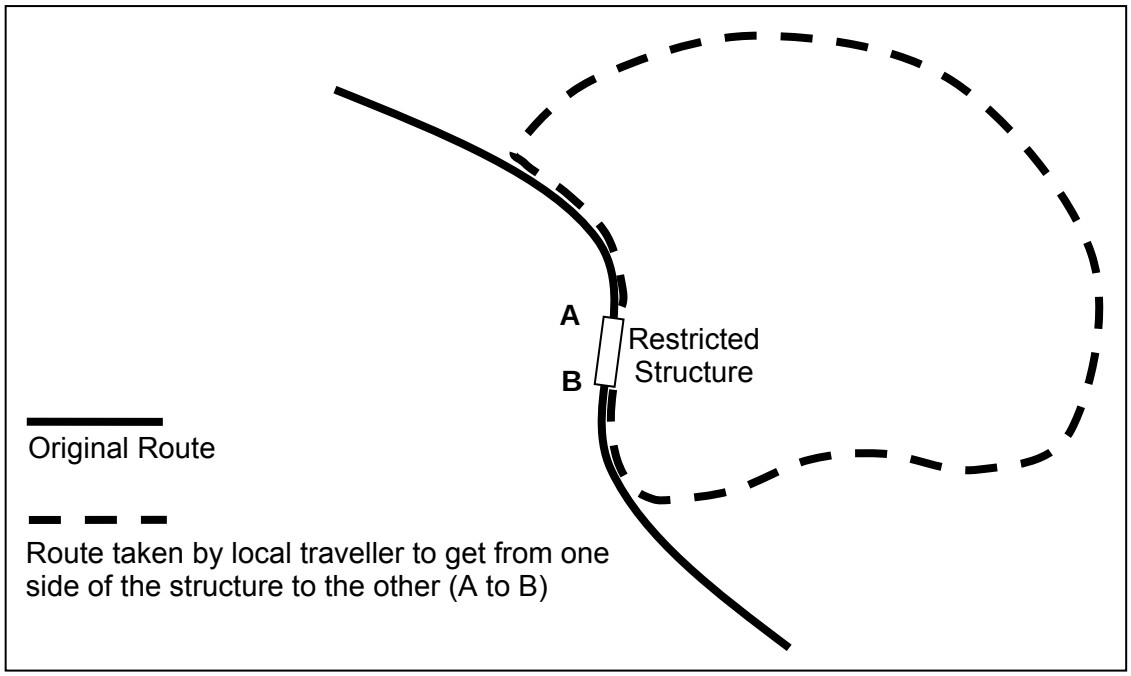


Figure 4 IJL for Classified B & C and Unclassified U Routes

IJL is applied to the product of *R*, *DR* and *OR* in Equation 1 to account for the extra distance actually travelled. The *IJL* score is selected from Table 12 and should be based on the preferred diversion route.

The *IJL* score is not based on a one-to-one mapping of the actual increased diversion length. Instead, the real journey lengths were translated to an *IJL* score that reflects engineering opinion. The engineering opinion was provided via a questionnaire survey which indicated that the absolute length of the diversion should not be used in the Availability PI calculation.

Table 12 Increased Journey Length Score, *IJL*

Preferred Diversion Route	Increased Journey Length, km	*IJL*
Negligible	Zero/minimal	0
Very Short	< 2km	1
Short	2 to 5km	2
Medium	5 to 10km	3
Long	10 to 20km	4
Very Long	> 20km	5
No alternative	-	10

5.8 Environmental Score, *En*

The environmental score is based on:

1. The environmental sensitivity of the diversion route, Table 13; and
2. The magnitude of the impact on the diversion route, Table 14.

The environmental sensitivity, Table 13, takes into account the type of area the diversion route passes through and the other users on this route, i.e. non vehicular traffic.

Table 13 Environmental Sensitivity

		Dominant use of area surrounding diversion route		
		Industrial or unused	**Rural or urban commercial**	**Residential or Environmental Class 2, 3 or 4 from App. B**
Number of non vehicular users, e.g. pedestrian, cyclist and equestrian	**Low**	Low	Low	High
	Medium	Low	Medium	High
	High	Medium	High	High

The magnitude of the environmental impact, Table 14, is based on the difference between the original and diversion route classifications. The greater the difference between the classifications the greater the environmental impact, that is:

- A small volume of traffic diverted from a higher route classification is likely to represent a significant traffic volume increase for a lower route classification.
- On average driver stress levels will increase as route class decreases, e.g. poorer road signs & lighting, reduced sight distances, poorer road surface quality, narrower lanes etc.

Table 14 Magnitude of Environmental Impact

		Original Route Classification				
		Motorway	**Primary A**	**Other Principal**	**Classified B & C**	**Unclassified U**
Diversion Route Classification	**Motorway**	Medium	Low	Low	Low	Low
	Primary A	Medium	Medium	Low	Low	Low
	Other Principal	High	Medium	Medium	Low	Low
	Classified B & C	High	High	Medium	Medium	Low
	Unclassified U	High	High	High	Medium	Medium

The ratings from Table 13 and Table 14 are used to select the Environmental Score, *En*, from Table 15.

Table 15 Environmental Score

		Environmental Impact		
		Low	**Medium**	**High**
Environmental Sensitivity	**Low**	0	5	10
	Medium	5	10	15
	High	10	15	20

Important: The environmental score should be taken as 20 if there is no alternative diversion route because it is assumed that the queuing traffic will have a detrimental impact on the environment. The environmental score is zero if there is no restriction.

5.9 Socio-Economic Score, *SE*

The Socio-Economic impact is evaluated as a function of:

- The impact on the area/community served by the restricted route, Table 16; and
- The impact on the area/community served by the preferred diversion route, Table 17.

Table 16 Impact on Restricted Route

Rating	Description
Low	No/negligible impact on business and communities; or No restrictions on emergency vehicles
Medium	Some loss of business; or Some loss of access to community facilities; or Access for emergency vehicle restricted to < 7.5 tonne
High	Significant loss of business; or Loss of access to important community facilities e.g. hospital, schools; or Loss of access to many community facilities; or No access for emergency vehicles; or No diversion route available

Table 17 Impact on Diversion Route

Rating	Description
Low	No/negligible impact on diversion routes
Medium	Some impact on diversion routes e.g. noticeable increase in traffic volume
High	Alternate routes nearing saturation level or gridlocked; or Traffic/HGVs diverted past schools, nurseries, sensitive areas etc.; or No diversion route available

The ratings from Table 16 and Table 17 are used to select the Socio-Economic score, *SE*, from Table 18.

Table 18 Socio-Economic Score, *SE*

		Impact on Restricted Route		
		Low	**Medium**	**High**
Impact on Diversion Route	**Low**	0	10	20
	Medium	10	20	30
	High	20	30	40

Important: The socio-economic score is zero if there is no restriction.

6. Availability PI Score for Non-Vehicular Routes

If an authority wishes to extend the Availability PI for interactions with non-vehicular routes, including Public Right of Way (PROW) routes (public footpaths, cycle tracks, bridleways and byways), then they can do so using the equations and look up tables presented below.

Remember: If a structure/network interaction has created no restriction for the previous 12 months then it automatically has a score of 100 and no calculation, or associated data collection, is required.

6.1 Non-Vehicular Availability PI Formula

The economic costs to non-vehicular traffic are difficult to quantify and therefore the procedure is more subjective than that presented in Section 5 for vehicular routes. The Availability PI for non-vehicular routes is based on:

1. The restriction.
2. The quantity of non-vehicular users on the restricted route.
3. The characteristics of the preferred diversion route.
4. Local importance of the restricted route.
5. Duration of restriction.

The Availability PI is evaluated as show in Equation 7:

Availability PI for each Network Interaction

$$PI = 100 - \frac{T}{12}\left(R_{NV} \times \left\{\left(OR_{NV} \times Div\right) + L_{imp}\right\}\right)$$

but not < 0 **Equation 7**

where R_{NV} = restriction score for the non-vehicular route, Section 6.2

OR_{NV} = volume of users on the restricted route, Section 6.3

Div = diversion characteristics, Section 6.4

L_{imp} = local importance of the restricted route, Section 6.4

T = duration of restriction in months, see Section 5.3

6.2 Restriction Score, R_{NV}

Restrictions on non-vehicular routes are classified into two categories:

1. The route is not restricted or not fully closed by the structure restriction.
2. The route is fully closed by the structure restriction.

The restriction score is selected from Table 19.

Table 19 Restriction Score for Non-Vehicular Routes

	Restricted and fully closed	No restriction or not fully closed by restriction
R_{NV}	1.0	0.0

6.3 Volume of Users, OR_{NV}

This score accounts for the volume of non-vehicular traffic that uses the route. The score is selected from Table 20.

Table 20 Score for Volume of Users, OR_{NV}

	Volume	OR_{NV}
Low	< 100 users per day	1.0
Medium	100 to 1000 users per day	5.0
High	> 1000 users per day	10.0

6.4 Diversion Score, *Div*

This score accounts for the diversion characteristics and takes into account the increased length of journey the diverted users need to make, the increased risk of crime to the user and the increased risk of accident to the user, see Table 21.

Table 21 Score for Diversion Characteristics, *Div*

	Increased Journey Length		
	< 100m	**100 to 500m**	**> 500m**
Crime and accident risk is less than or similar to restricted route	1.0	2.0	3.0
Increased risk of crime and/or accident compared to restricted route	3.0	4.0	5.0

6.5 Local Importance Score, L_{imp}

This score accounts for the importance of the structure to the local community and is selected from Table 22. The local importance of a non-vehicular route is a subjective issue, but the criteria considered should include:

- Access to important community facilities, e.g. hospitals, schools, council offices etc.
- Access to residential areas.
- Number of alternative routes.
- Is the structure, or route, a locally important feature, e.g. tourist attraction?

Table 22 Local Importance of Route, L_{imp}

Importance	L_{imp}
Low	0
Medium	20
High	50

7. Structure Stock Availability PI

The Availability PI score for each Route Type within the stock *must* be evaluated prior to the Structure Stock Availability PI, see Figure 2 in Section 2.5. The Route Type Availability PIs are evaluated separately because the scales differ due to the lower bound constant, C_{LB}, as described in Section 5.2. The Route Type Availability PIs are combining to produce the Structure Stock Availability PI.

Important: The Availability PI should be based on interactions between vehicular routes and highway structures, where vehicular routes are Motorways, Primary A, Other Principal Roads, Classified B & C and Unclassified routes. However, if an authority wishes to extend the Availability PI to include interactions with non-vehicular routes, including Public Right of Way (PROW) routes (public footpaths, cycle tracks, bridleways and byways), then they can do so.

7.1 Availability PI by Route Type

The Availability PI score for each route type is evaluated using Equation 8.

Route Type Availability PI score

$$\text{Route Type PI Score } (PI_R) = 100 - \frac{\sum\left[(100 - API)\times\left(F_R - API\left[\frac{F_R}{100}\right]\right)\right]}{N_R}$$

but not < 0 **Equation 8**

Important

$$\left[(100 - API)\times\left(F_R - API\left[\frac{F_R}{100}\right]\right)\right] = 0$$

when API = 100

Therefore, the numerator is simply a summation for those structures/interactions that have had a restriction over the previous 12 months.

where:

API = Individual Availability PI score for an interaction on this route type, this is the output from Equation 1 in Section 5.1

N_R = the number of times structures on this route type interact with the network

F_R = route type factor, see below

The objective of the route type factor, F_R, is to produce scores for each route type that are:

- More sensitive to change; and

- More reflective of the percentage of restrictions that are likely to cause severe/critical disruption for the route type on a network wide scale.

The proposed Route Type Factors, F_R, and the percentage of lower bound restrictions they are based on, are shown in Table 23.

Table 23 Route Type factors, F_R

Route Type	% of lower bound restrictions deemed to make the route type severely restricted	F_R
Motorway	5%	20
Primary A	10%	10
Other Principal	10%	10
Classified B & C	15%	6.67
Unclassified U	20%	5
Non-vehicle routes	15%	6.67

The format of Equation 8 is such that as the severity of an individual restriction increases its influence on the group, or overall stock, Availability PI score increases disproportionately.

7.2 Availability PI Score for Stock

The Availability PI score for the structure stock is evaluated using Equation 9.

$$\text{Stock Availability PI Score} = \frac{\sum\left(PI_i \times N_i \times C_{LB-i}\right)}{\sum\left(N_i \times C_{LB-i}\right)}$$

Equation 9

Where:

PI_i = Availability PI score for route type i, from Equation 8

N_i = the number of structure/network interactions on route type i

$C_{LB\text{-}i}$ = Lower Bound constant for route type i, from Table 5

The weighting, C_{LB}, is used in Equation 9 to remove the economic imbalance it imposed in Equation 1. C_{LB} was originally used to give a more meaningful score, on the 0 to 100 scale, for each route type relative to their respective lower bound restrictions and route economics, i.e. number of vehicles, user costs etc. In the stock evaluation the economics should be comparable across all route types therefore C_{LB} is used again to counter its initial influence.

7.3 Interpretation of Availability PI Score

Availability PI interpretations are provided in Table 24 for individual structures and Table 25 for structures on a route type and the structure stock. All the Availability PI scores are on the 0 to 100 scale and take into account the required Levels of Service, shown in Table 3 in Section 4.1, and the lower bound restrictions, shown in Table 4 in Section 4.2 and Table 5 in Section 5.2. Therefore, a score of zero does not mean that the network is completely unavailable; instead it means that the structure stock has fallen below the lower bound availability levels defined.

Note: The Availability PI scores for individual structures should be with caution as they could be easily misinterpreted by those not familiar with the procedure. It is recommended that only the structure stock Availability PI score is used for reporting performance.

Table 24 Individual Structure Availability PI Interpretations

Score	Interpretation of Score
90 ≤ x ≤ 100	**Very Good Availability** – structure is causing negligible/no loss of availability on the route
80 ≤ x < 90	**Good Availability** - structure is causing a minor loss of availability on the route
65 ≤ x < 80	**Fair Availability** - structure is causing a moderate loss of availability on the route
40 ≤ x < 65	**Poor Availability** - structure is causing a considerable loss of availability on the route
0 ≤ x < 40	**Very Poor Availability** - structure is causing a major/severe loss of availability on the route

Table 25 Route and Stock Availability PI Interpretations

Score	Interpretation of Score
90 ≤ x ≤ 100	**Very Good Availability** - Negligible loss of availability on the route type or whole network
80 ≤ x < 90	**Good Availability** - Minor loss of availability on the route type or whole network
65 ≤ x < 80	**Fair Availability** - Moderate loss of availability on the route type or whole network
40 ≤ x < 65	**Poor Availability** - Considerable loss of availability on the route type or whole network
0 ≤ x < 40	**Very Poor Availability** – Major/severe loss of availability on the route type or whole network

8. References

1. Management of Highway Structures: A Code of Practice, UK Bridges Group, September 2005, TSO.

2. BD62 As Built, Operational and Maintenance Records for Highway Structures (DMRB 3.2.1).

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5. TD 27: Cross-sections and Headrooms (DMRB 6.1.2).

6. TA46: Traffic Flow Ranges for use in the assessment of new rural roads (DMRB 5.1.3).

7. New Metric Handbook, P. Tutt and D. Adler.

8. DMRB, Volume 14, Section 1: The QUADRO Manual, Part 5: The traffic input to QUADRO.

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APPENDIX A
Environmental Classifications

Environmental Classifications

The list of *Designated Sites* is taken from the DMRB (Ref. 9). More detailed descriptions of each site type are provided in Ref. 9, along with guidance on assessing and classifying a non-designated site that may be of potential nature conservation interest.

Category	Site Importance	Classifications (Designated Sites)
Class 1	Non-Designated Sites (Default Value)	Site not classified as one of the following (if it is believed the site may be of potential nature conservation interest then refer to Ref. 9 Annex V for guidance).
Class 2	Sites of Regional and Local Importance	• Local Nature Reserves (LNRs) • Regional Parks • Non-Statutory Sites of Importance for Nature Conservation • Non-Statutory Nature Reserves • Forest Nature Reserves
Class 3	Sites of National Importance	• National Nature Reserves (NNRs) • Marine Nature Reserves (MNRs) • Sites of Special Scientific Interest (SSSIs) • Areas of Special Scientific Interest • Areas of Special Protection for Birds • Ancient Woodlands • Natural Heritage Areas
Class 4	Sites of International Importance	• World Heritage Sites • Biosphere Reserves • Biogenetic Reserves • Ramsar Sites (Wetlands of International Importance) • Special Protection Areas (SPAs) • Special Areas of Conservation (SACs) • The Berne Convention • The Bonn Convention