

## 1. INTRODUCTION

Transit New Zealand has initiated a review of the earthquake resistance of bridges for which it is responsible, in order to identify structures that may not perform satisfactorily during earthquakes. Such structures could represent an excessive risk of injury to the public, or of loss of serviceability and consequent impediment to travel during and after emergencies.

Review of the main bridge stock is being undertaken in stages, similar to a sieving process with increasing degrees of fineness, so as to minimise the number of structures to which detailed analysis is applied.

This document sets out the required screening procedure to be used for the initial stage, which identifies and ranks those bridges that are considered by the screening consultant to justify subsequent detailed assessment of their earthquake resistance.

To illustrate the context of this initial stage of work as part of the overall process of retrofitting the highest priority bridges, the further stages envisaged beyond the twelve stage screening procedure that is summarised in Figure 1 are as follows:

- merging of regional lists into a national priority list;
- development of annual plans that identify on a regional basis the structures that will be assessed in detail;
- completion of the assessment and retrofit design of the priority structures for retrofitting;
- letting contracts for completing the retrofitting works, all as part of the National Roading Programme, and
- annual review of the remaining bridges on the priority lists.

*The primary output from this initial screening procedure is a list of bridges, ranked in order of priority, that are considered by the screening consultant to justify detailed seismic assessment and, subsequently for some, assessment of seismic retrofitting. Supporting information forms the secondary output.*

## 2. OVERVIEW

Figure 1 illustrates the screening procedure, which comprises:

- *Selection of the bridges to be screened;*
- *Assembly and recording of the bridge data;*
- *Preliminary screening;*
- Derivation of the *Provisional Seismic Attributes Grade* values;
- *Site inspection* when necessary;
- *Specialist review;*
- *Finalising the Seismic Attributes Grade* values;
- *Risk assessment;*
- Derivation of the *Economic Ranking Indicator;*
- *Ranking of bridges for further analysis;*
- *Reporting.*

The procedure requires inputs with increasing degrees of bridge and seismic specialisation as the steps are completed.

The *Total Exclusion* (Stage 1) identifies those structures, such as culverts and most bridges that are programmed for replacement within five years, for which the risk of seismic damage is considered to be so low that assembly of drawings and further assessment are not necessary.

The *Assembly and Recording of Bridge Data* (Stages 2 and 4) form the basis for the assessments and should normally be undertaken by personnel most familiar with the bridges, to minimise the likelihood of inaccurate data being assembled. Data are assembled in two stages, to avoid gathering information that will not be required for those bridges that are excluded in Stage 3 of the procedure.

The *Preliminary Screening* (Stage 3) identifies those bridges for partial exclusion from the screening procedure, in that they clearly do not warrant further ranking because their size or form gives them inherent resistance to significant seismic damage. The bridges are initially identified as conforming to a list of required physical properties, and are subsequently confirmed by specialist review in Stage 7. Drawings and data for these bridges are assembled before their exclusion from further assessment.

The *Seismic Attributes Grade* (SAG) (Stages 5 and 8) is an arithmetically derived indicator value based on a combination of weighted "scores" that are assigned to each bridge being graded, according to its attributes. Ranking by this indicator alone is not sufficient, but the SAG has been found to be useful in helping with the judgement-based final stage of the ranking procedure.

The *Specialist Review of the Bridges* (Stage 7) comprises a critical consideration of the bridges by specialists who are conversant with the seismic behaviour of bridges. The purpose is to confirm that there is justification for the exclusion of the bridges that were excluded in Stage 3, and to familiarise the specialists with the structures for which a risk assessment is to be undertaken in Stage 9.

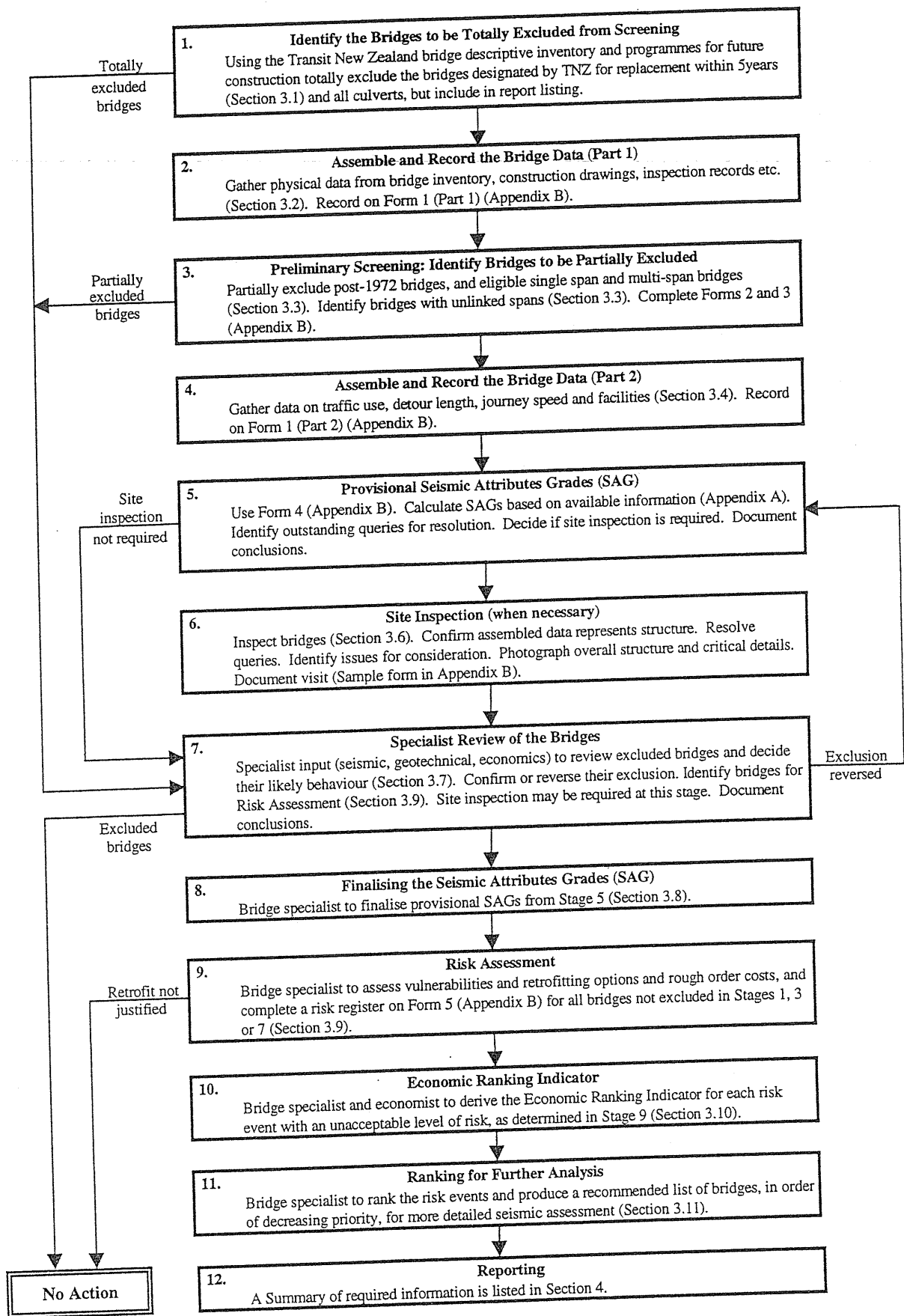
The *Risk Assessment* (Stage 9) comprises the identification and description of seismic "risk events" (possible failures or damage to various specific parts of the structure), assessment of their likelihood and consequences of occurrence, and determination of options and approximate costs of mitigation by retrofitting. This information is used to decide those bridges, or parts of bridges, that are most likely to return the greatest benefit from retrofitting, and hence to assist in deciding an order of priority of bridges that justify subsequent further detailed analysis.

The *Economic Ranking Indicator* (Stage 10) is derived by calculation using the most significant economic consequences that would be associated with the risk events identified in Stage 9. The indicator is based on key factors such as traffic volume, traffic disruption and other extra costs, and the estimated cost of retrofitting. It should be noted that the numerical value of the economic ranking indicator does not represent the actual benefit/cost ratio, which would be derived from a more detailed analysis, and is only for the purpose of assisting with the ranking of the bridges that are being assessed.

The *Ranking for Further Analysis* (Stage 11) uses information gained from the SAG, the Risk Assessment, the Economic Ranking Indicator and from other indicators listed in 3.11.3.2 to decide a final list of bridges, in order of decreasing priority, that are judged to justify subsequent detailed assessment of their earthquake resistance. This list is the primary output from the screening procedure.

Figure 1

Bridge Seismic Screening Procedure



**Note:** Stages of work will normally be undertaken by the following personnel:  
 Stages 1 to 5 Engineering personnel familiar with the structures  
 Stage 6 Experienced bridge inspector or competent bridge designer  
 Stage 7 to 12 Bridge engineers, geotechnical engineers and economists experienced in the seismic aspects of bridges.