INFRASTRUCTURE AND TRANSPORTATION

LEVEL 2

BIM INSPECTION MANUAL

BIM
Bridge Inspection and Maintenance

**Bridge Inspection
&
Maintenance System**

Version 1.1

Preface to Version 1.1

Technical Standards Branch

BRIDGE INSPECTION AND MAINTENANCE SYSTEM

LEVEL 2 INSPECTION MANUAL

(Release 1.1)

Revisions prepared by:
Reg Quinton, P.Eng.,
Reg Quinton Consulting

and

the Technical Standards Branch Review Committee, consisting of:

Lloyd Atkin, P.Eng.	Bridge Preservation Specialist
Garry Roberts	Senior Bridge Technologist
Clarence Wong, P.Eng.	Bridge Materials Engineer
Ryan Kohlenberg, E.I.T.	Materials Engineering Intern

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Preface to Version 1.0

Technical Standards Branch

BRIDGE INSPECTION AND MAINTENANCE SYSTEM

LEVEL 2 INSPECTION MANUAL

(Release 1.0)

Prepared by:
Don Hamilton, P.Eng.,
CH2M HILL Canada Ltd.

and

the Technical Standards Branch Review Committee, consisting of:

Tom Loo, P.Eng.	Bridge Preservation Specialist
Ed Kowal, C.E.T.	Bridge Maintenance Technologist
Abdul Waheed, P. Eng.	Bridge Fabrication Standards Specialist
Jennifer Smid, P. Eng.	Bridge Engineer
Paul Carrier, C.E.T.	Bridge Technologist
Holly Will, C.E.T.	Bridge Support Technologist
Gabrielle Moser, E.I.T.	Bridge Intern Engineer

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1.0 CHAPTER 1 – INTRODUCTION

1.1 INTRODUCTION

The Alberta Transportation bridge inspection program is an essential part of a comprehensive inventory, inspection, maintenance, and data management system called the Bridge Inspection and Maintenance (BIM) System. The inspection component, introduced in 1987, allows for regular scheduled inspections at all bridge and culvert sites.

These inspections provide information to the system that allow inspection management, maintenance programming, budget development, strategic planning, and life cycle planning so that the safety of the traveling public and the investment in bridge structures is optimized.

Occasionally, the regular Level 1 inspections highlight problems that require more detailed inspections in order to determine the proper course of action to address a problem. The Level 2 inspections are the tools that provide the detailed inspection and test information to the system. This helps to maximize the life and serviceability of bridge structures by identifying problems and initiating effective maintenance, rehabilitation, or monitoring schemes.

1.2 LEVEL OF INSPECTION

Level 1 inspections conducted on a routine basis are adequate for monitoring the condition of most major bridges, standard bridges, and culverts. Some sites or components will require an inspection by a bridge or culvert inspector with specialized knowledge, tools and equipment during their service life. This specialized inspection is a Level 2 inspection.

1.2.1 LEVEL 1 INSPECTIONS

Level 1 inspections are general visual inspections conducted using standard tools and equipment. This level of inspection requires completion of the BIM Level 1 inspection forms by certified bridge inspectors and must be performed at time intervals not exceeding those specified by Department policy. Level 1 inspections rate the worst part of each element and do not take the overall element condition into account.

1.2.2 LEVEL 2 INSPECTIONS

Level 2 inspections are in-depth, quantitative inspections conducted using specialized tools, techniques, and equipment. This level of inspection requires completion of the appropriate BIM Level 2 forms by a bridge inspector with specialized knowledge and experience. This level of inspection gathers detailed information on the condition of a particular bridge component.

1.2.2.1 Types of Level 2 Inspections

There are numerous types of Level 2 inspections. Each type of inspection focuses on a particular part or aspect of a greater bridge component.

Common Level 2 inspections described in this manual include:

- Concrete Deck Inspection
- Copper Sulfate Electrode (CSE) Testing
- Chloride Testing
- Ultrasonic Truss Inspections
- Culvert Barrel Measurements
- Vertical Clearance Measurements

Other types of Level 2 inspections that have been identified for regular use but are not described in this manual include:

- Paint Inspection
- Concrete Girder Inspection
- Scour Monitor
- Timber Coring
- Special Structure Monitor

There are additional specialized inspections that may be performed. However, these inspections are not completed routinely enough to warrant a formal Level 2 inspection module. These inspections will usually be conducted using program or site specific terms of reference and reports. Examples include:

- Underwater Inspection
- Linear Polarization Measurement
- Bond Testing
- Steel Culvert Corrosion Testing
- Pin and Hanger Connection Inspections
- Steel Girder Cover Plate Inspections

Other types of inspections such as collision damage assessments are not considered to be Level 2 inspections since they do not gather consistently similar data.

1.3 ITEMS COMMON TO LEVEL 2 FORMS

Several numbering systems, fields, and terms are common to most Level 2 forms, thus allowing for consistent, repeatable results between different Level 2 inspections. Persons familiar with a single Level 2 form will also be able to understand the general content of another Level 2 form. Several fields common to Level 2 forms are described in the following sections.

1.3.1 BRIDGE STATIONING AND ELEMENT NUMBERING

Bridge stationing and element numbering refers to how bridge structures and their elements are numbered and referenced relative to compass directions and the road. The same numbering convention applies to all bridge structures and their elements except for truss bridge elements (described in Chapter 5). A standard numbering system allows different inspectors to consistently identify and refer to the same individual elements of a bridge or culvert during an inspection.

1.3.1.1 Longitudinal Direction

Bridge stationing increases from south to north and from west to east along the general direction of the road. This is generally also the direction of increasing chainage.

Elements such as spans and supports are numbered starting at the south or west end of the structure. Supports are identified by two digits: one digit represents the function of the element and the other digit represents the assigned number of the element. Therefore, abutment 1 would be A1 and abutment 2 would be A2. Similarly, piers would be numbered P1, P2, and so forth. Hinges would be identified as H1, H2 and so on. There is an example on the numbering of bridge elements shown in Figure 1.1.

1.3.1.2 Transverse Direction

For the transverse direction, element numbering will increase from south to north or from west to east. This will apply to elements such as girders or stringers.

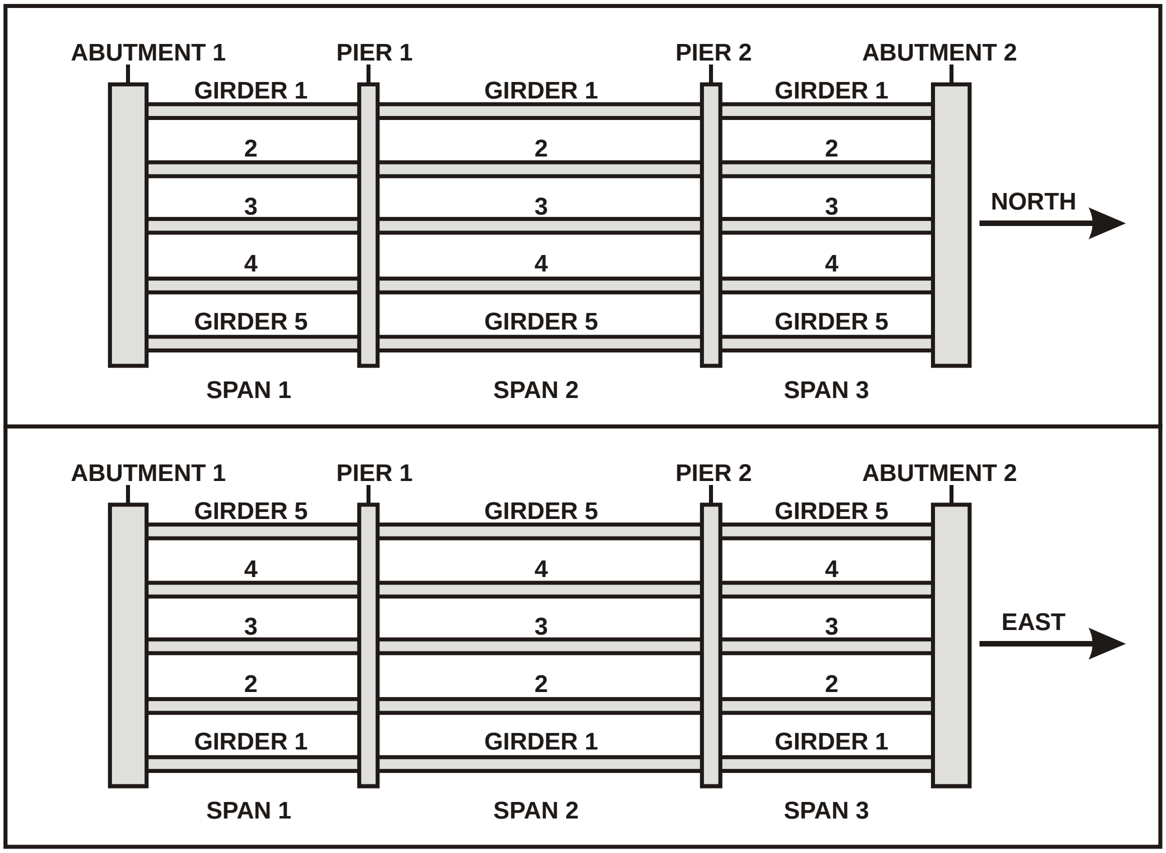

Figure 1.1 – Element Numbering Examples

1.3.1.3 Adding or Removing Elements

When elements are added or removed from the structure, the elements will be renumbered accordingly. For example, a culvert or bridge span may be added to an existing structure or the structure may be widened.

1.3.1.4 Intersections

For structures at intersections, the stationing and element numbering will be referenced with respect to the road on which the structure is located, as described in the Bridge Information System (BIS) Codes and Explanation Manual. In general, structures on numbered highways will be properly identified in the BIS inventory as being 'on' a given road. If it does not clearly define the road (i.e. intersecting local roads), then the structure will be considered to be on the east-west road.

1.3.2 INVENTORY DATA

The following inventory data shown in Figure 1.2 is stored in the Department's BIS Inventory. These fields will automatically be populated by the BIM system.

```
Bridge File Number : ..... ...          Structure Usage   : ..
Legal Land Location: ...-..-...-..-.    Year Built        : ../..
Latitude/Longitude : ........./.........Clear Roadway/Skew: ....m/...Deg
Road Auth./Region  : .../R.
Bridge or Town Name: .............      Prev. Insp. Date  : ____/__/__ (YMD)
Stream Name        : .............      Insp. Req'd Date  : ____/__/__ (YMD)
Highway #:Cntrl Sec: ....:...           (based on ___________________)
Road Classification: ........-...
AADT/Year          : .-....../..        Current Insp. Date: ____/__/__ (YMD)
Detour Length      : ...km              Inspector's Code  : ____
```

Figure 1.2 – Common Level 2 Inventory Fields

1.3.2.1 Bridge File Number

Every bridge and culvert in the Alberta Transportation inventory is identified by a unique five-digit bridge file number. Multiple structures sharing the same bridge file number will also have an additional visual identifier of up to three letters. The first letter indicates the direction of the traffic (N, S, E or W). The second and possibly third letter indicate the structure usage, such as a sign structure or a collector.

1.3.2.2 Legal Land Location

The Legal Land Location is defined by the following designations:

a) Quarter Section designation (3 letter code from Figure 1.3, i.e. 'WNE')
b) Section Number (01 to 36),
c) Township Number (001 to 126),
d) Range Number (01 to 30), and
e) Meridian east of the site (4 to 6).

An example of a Legal Land Location is 'WNE25-028-03-5'. This is the sum of the above designations, and is also illustrated in Figure 1.3 below.

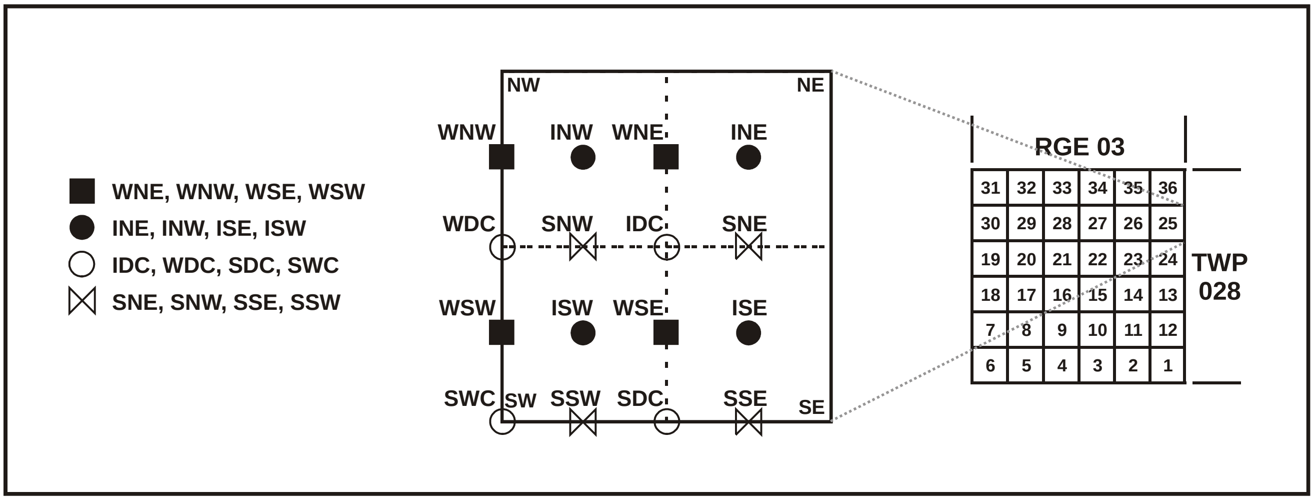

Figure 1.3 – Legal Land Location

1.3.2.3 Latitude/Longitude

These fields are for the Longitude and Latitude of the site. This information is not currently stored in the BIS and is shown only for future use. These fields should be left blank unless otherwise directed.

1.3.2.4 Road Authority and Region (Road Auth./Region)

The Road Authority field is an alphanumeric entry consisting of a single letter followed by a two-digit number. This field describes the road authority that has geographical jurisdiction of the site. The road authority may be the Department or a Municipal Authority. The first digit of this road authority indicates the type of Municipal Authority, while the last two digits identify the number of the municipality. Only the last two numbers are used for municipalities with three digit numbers.

Alberta Transportation has divided the province of Alberta into four geographic regions. Each region has been assigned single numeric value to represent it. The number that represents the region that the bridge or culvert is located in is entered in the Region field. The numbers assigned to the four geographic regions are:

1 = Southern Region
3 = Central Region
5 = North Central Region
6 = Peace Region

1.3.2.5 Bridge Or Town Name

This is a text field that describes the bridge name or the nearest town name. The naming convention in order of precedence is: structures with an established name, the nearest well known town or lesser known town shown on the Alberta road map, and finally, the nearest post office. This field may be a maximum of 12 characters in length.

1.3.2.6 Stream Name

This is a field for the name of the river, stream, highway, railway, or other facility that the structure crosses. Unnamed streams are left blank or called ‘Watercourse’. This field may be a maximum of 12 characters in length.

1.3.2.7 Highway Number And Control Section (Highway #:Cntrl Sec)

The Highway Number is a code of up to four characters in length that refers to the highway that the structure is located on. The following are examples of Highway Number codes:

Primary Highways	-	M01A
Secondary Highways	-	S520
Local Roads	-	L
Approach Roads	-	A046
Provincial Park Roads	-	P109
Forestry Roads	-	F
Indian Reserve Roads	-	R
Railroad (over)	-	CPR, CNR, etc.
None of the above	-	X

The control section of a numbered highway is a two-digit number that identifies a specific section of that highway. For example, in the code ‘M02:04’, the primary highway is ‘02’, while ‘04’ refers to the control section of that section of the highway. If two control sections meet at the middle of the structure, then the structure will be coded with the higher control section number of the two.

1.3.2.8 Road Classification

All public rural roads in Alberta have a Road Classification that describes the highway standard of the facility that the bridge is a part of. This classification is described in a typical format such as ‘RLU 209G-090’, where:

- The first letter 'R', is an abbreviation for Rural.
- The second letter is either a ‘L’ for Local, ‘C’ for Collector, ‘A’ for Arterial, or ‘F’ for Freeway.
- The third letter is either an ‘U’ for Undivided or a ‘D’ for Divided.
- The first numerical digit indicates the number of lanes.
- The second and third numerical digits (also fourth for RAD, RAU and RFD), indicate the sum of the lane and shoulder width in metres.
- The last three digits indicate the design speed in kilometres per hour.

Refer to Section 4.23 of the Level 1 BIM Inspection Manual for a complete list of road standards.

1.3.2.9 Average Annual Daily Traffic (AADT/Year)

The Average Annual Daily Traffic (AADT) is brought forward from the Alberta Traffic Information System or from the BIS Inventory. This information is described in a typical format such as 'A001250/98', where:

- The first letter is either an 'A' for Actual AADT or 'E' for Estimated AADT.
- This is followed by the traffic count, which may be up to 6 digits.
- Next, there is a '/' followed by a two-digit number that indicates the year the traffic count was completed or estimated.

1.3.2.10 Detour Length

The Detour Length is recorded to the nearest kilometre and is the minimum extra distance to be traveled if the bridge on the intended route is removed or closed. The detour bridge is the nearest bridge on the same stream that has about the same load capacity as the removed or closed bridge. The detour bridge can also be a bridge that is capable of being temporarily strengthened on short notice.

The Detour Length applies to the general overall flow of vehicles and is determined from the intersections on the detour route and the original route. The recorded value does not apply to the individual that resides next to the bridge and is required to backtrack.

There are exceptions for this detour length field in certain situations. These exceptions are as follows:

Detour Length = 0 for bridges on roads with four or more lanes.
Detour Length = 1 for bridges on divided highways.
Detour Length = 999 for bridges that are on a dead end route.

1.3.2.11 Structure Usage

The following two character codes are used to describe the Structure Usage:

RV - River or Stream crossing
FB - Pedestrian River or Stream crossing
FY - Ferry
GS - Grade Separation
IC - Irrigation Canal
PS - Pedestrian Grade Separation
RO - Railway Overpass (road over railway)
RU - Railway Underpass (road under railway)
SP - Stockpass or Cattlepass
XX - None of the Above

1.3.2.12 Year Built

This field is a four-digit number. The first two digits indicate the earliest year of fabrication or construction. These two digits are followed by a `/`, and then the last two digits specify the year the last construction or rehabilitation took place. For example '65/87' represents a bridge that was constructed in 1965 and underwent a major rehabilitation in 1987. If a bridge is completely reconstructed, then both the year constructed and the year rehabilitated are changed, such as '99/99'.

1.3.2.13 Clear Roadway and Skew

For bridges, the Clear Roadway is the distance between the inner faces of the curbs, measured perpendicular to the centre line of the structure. For culverts, it is the width of the road over the culvert between the edge of the shoulders. The clear roadway is to be recorded to the nearest 0.1 m. Use the minimum width for tapered roadways. For structures with medians, the total clear width of all the lanes is used.

The Skew Angle is the complement of the acute angle between two centrelines both parallel and perpendicular to the curb. A 0º skew denotes a bridge with rectangular, right angle ends in plan view. A positive skew angle is a 'RHF' or right-hand-forward skew and a negative skew angle is a 'LHF' or left-hand-forward skew as shown in Figure 1.4.

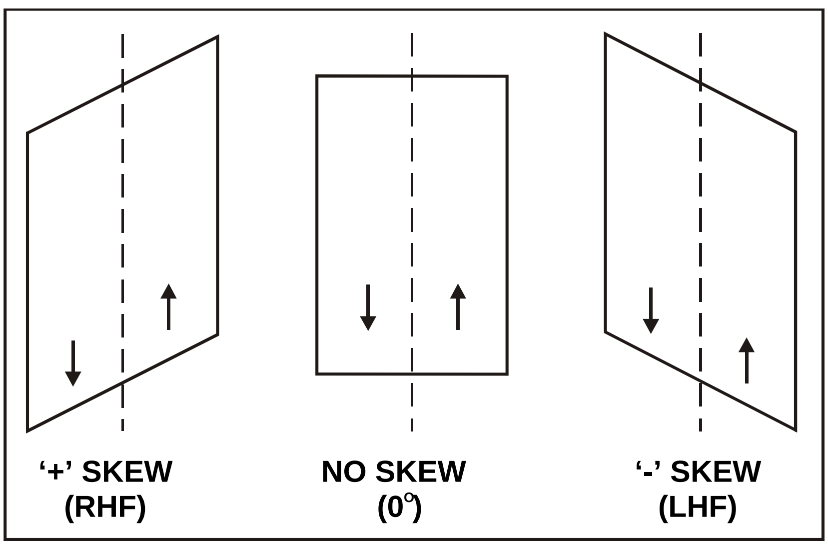

Figure 1.4 – Skew Angles, Plan View

1.3.3 SCHEDULING INFORMATION FIELDS

The Scheduling Information area is found on the lower right half of the header information on the first page of every Level 2 form. It contains the following information and is shown in Figure 1.5.

Bridge File Number :	Structure Usage : ..
Legal Land Location: ...-..-...-..-.	Year Built : ../..
Latitude/Longitude : ..../........	Clear Roadway/Skew: ....m/...Deg
Road Auth./Region : .../R.	
Bridge or Town Name:	**Prev. Insp. Date : ____/__/__ (YMD)**
Stream Name :	**Insp. Req'd Date : ____/__/__ (YMD)**
Highway #:Cntrl Sec: ....:...	**(based on ___________________)**
Road Classification: ....-...	
AADT/Year : .-....../..	**Current Insp. Date: ____/__/__ (YMD)**
Detour Length : ...km	**Inspector's Code : ____**

Figure 1.5 – Common Level 2 Scheduling Information Fields

1.3.3.1 Previous Inspection Date

On a blank inspection form, this field contains the date of the last inspection. When viewing or printing an inspection that has already been completed, this field will contain the date of the last inspection. The format is yyyy/mm/dd.

1.3.3.2 Inspection Required Date (Insp. Req'd Date:_____Based On)

The 'Inspection Required Date' is the date by which the next inspection should be completed. The method of calculating this next inspection date is explained in the Inspector and Reviewer sections (Sections 1.5.4 and 1.5.5).

On a blank, unused form, this date is calculated by the Department after the input of the last inspection. When printing a completed report, this is the date calculated by the Department after the input of the next to last inspection. The 'Based On' field is a brief description of how the Inspection Required Date was arrived at. For example, the date may be based on annual monitoring or on a predetermined default inspection cycle.

1.3.3.3 Current Inspection Date

On a blank inspection form for a new inspection, this is the date the inspection is carried out. The format is yyyy/mm/dd. The inspector completes this field.

1.3.3.4 Inspector's Code

This is a unique code of up to 3 letters given to each inspector by the Department. The inspector is to enter their assigned code in this field. If the inspector has not been assigned a code, the field should be left blank. Ensure the full name of the inspector is recorded on the last page of the Level 2 form, as outlined in Section 1.5.4.2.

1.4 ADDITIONAL INVENTORY INFORMATION

In addition to the inventory data in the header of the form, several Level 2 forms provide supplementary information about the structure. The additional inventory information is located immediately below the header information on page one of most Level 2 forms. This information is taken from BIS or from the most recently completed Level 1 inspection.

Additional culvert information appears on culvert-related Level 2 forms, such as the Steel Culvert Barrel Measurement forms. Refer to Section 6.2 for a complete description of these fields.

The fields that appear on most bridge-related Level 2 forms, including the Level 2 Concrete Deck Inspection, CSE Testing, Chloride Testing, and Vertical Clearance Measurement forms are shown in Figure 1.6 and described in the sections below.

```
STRUCTURE INFORMATION:

No. of spans: ..    Span Types: .../...  Substructure Types: .../...
Span Lengths: .....-.....-.....-.....-.....m    Total Length: .....m
```

Figure 1.6 – Additional Structure Information for Bridges

1.4.1 NUMBER OF SPANS (NO. OF SPANS)

This is a two-digit numeric value (i.e. 01 to 99) that describes the number of spans at a bridge site. Spans are numbered from west to east or from south to north, in the direction of increasing chainage.

1.4.2 SPAN TYPES

This field identifies up to two different span types for a given bridge. The first field is used to identify the primary span type. This is considered to be the most important span type of the bridge, typically the main or middle spans. If there is a secondary span type at the bridge, this span type is recorded in the second field. The secondary span type is typically those of the approach spans.

Refer to the BIS Codes and Explanations Manual for a complete list of span types.

1.4.3 SUBSTRUCTURE TYPES

The 'Substructure Types' field is a three letter code that is brought out of BIS. There are fields for two different substructure elements (i.e. two different 3-letter fields). The first 3-letter field is for the abutments while the second 3-letter field is for the pier.

The first letter of each of these 3-letter fields represents the type of Foundation, the second letter corresponds to the type of Pier Shaft, Column, or Abutment Backwall, and the third letter is the type of Pier Cap or Abutment Seat.

Detailed descriptions of substructure codes are in the BIS Codes and Explanations Manual.

1.4.4 SPAN LENGTHS

The length of each span is taken from BIS and recorded in these blank fields. The span length is nominal, and noted in metres, to the nearest 0.1 m. The order of the spans is south to north, or west to east (increasing chainage). A maximum of five spans may be listed in this field, starting with span number 1. Span length measurements are further detailed in Section 4.19 of the Level 1 BIM Inspection Manual.

1.4.5 TOTAL LENGTH

This is the total length of the bridge to the nearest 0.1 m. The total span length is taken from BIS and is the sum of all of the span lengths. If there are more than five spans at the site, then this field represents the total of all of the spans, not just the 5 spans shown in the 'Span Length' fields.

1.4.6 COMMENT FIELDS

Each section of the Level 2 form has four lines provided for additional comments. Use the comment lines to help describe the situation at the bridge. Note trends, typical conditions, and isolated conditions.

One of the goals of the Level 2 deck inspection is to create a clear picture of an existing problem or concern at a bridge site for the Department, so a decision or course of action can be undertaken. Inspectors must continually ask themselves if their inspection report is accomplishing this goal of accurately portraying a bridge site.

1.5 THE LAST PAGE OF THE LEVEL 2 FORMS

All of the Level 2 inspection forms have similar fields on the last page. Some of the fields on the last page are provided for information only, others will be completed by the inspector or the Department.

1.5.1 LEVEL 1 INSPECTION (INFORMATION ONLY)

The Level 1 Inspection information section shown in Figure 1.7 is for the inspector's information only. It includes the date of the last Level 1 inspection that has been entered into the BIM system and the calculated Structural Condition Rating, Sufficiency Rating, Estimated Remaining Life of the Structure, and any Special Comments, all from the last Level 1 inspection. The next scheduled Level 1 inspection (yyyy/mm/dd) and the Level 1 inspection cycle in months are also shown.

```
LEVEL 1 INSPECTION (INFORMATION ONLY)     Level 1 date: ____/__/__

Structural Condition Rating: __%    Sufficiency Rating: __%
Estimated Remaining Life of Structure: __ years

Special Comments for Next Inspection:



Next Scheduled Level 1 inspection: ____/__/__        Current Cycle: __months
```

Figure 1.7 – Last Page of Level 2 Forms; Level 1 Inspection Information

1.5.2 ITEMS REQUIRING IMMEDIATE ATTENTION

This critical text field, as shown in Figure 1.8, is for the inspector to describe items that may require immediate attention and cannot wait for the next Level 1 or Level 2 inspection. If any item is a hazard to the safety of the public, the inspector must take appropriate action, such as closing the structure or contacting the Bridge Manager. These critical items may or may not be related to the component that is being tested or inspected. Leave this area blank if no immediate action is required.

```
ITEMS REQUIRING IMMEDIATE ATTENTION:
```

Figure 1.8 – Last Page of Level 2 Forms; Items Requiring Immediate Attention

1.5.3 LEVEL 2 INSPECTION SPECIAL REQUIREMENTS

Record in this section shown in Figure 1.9, any special requirements for tools, equipment, traffic control, or access required to carry out the Level 2 inspection.

Normally, the person responsible for initiating the Level 2 inspection, typically the previous Level 1 inspector or Department personnel, will identify the special requirements so that these are in place at the time of the Level 2 inspection.

```
LEVEL 2 INSPECTION SPECIAL REQUIREMENTS:

Y =>  Snooper: __   Lift: __   Traffic control: __    Boat: __   Ladder: __
Other: ____________________________________________________________________
```

Figure 1.9 – Last Page of Level 2 Forms; Special Inspection Requirements

1.5.4 INSPECTOR

This section, as shown in Figure 1.10, is to be completed by the inspector.

```
INSPECTOR:

Recommended Cycle __ months OR Next Insp. Date ____/__/__ (blank for default)
Recommended Additional Cycles: _ (blank for default, 0 for discontinue)
Inspector’s Code: ___ | Inspector’s Name: __________________________ | Class: _
Assistant’s Code: ___ | Assistant’s Name: __________________________ | Class: _
Assistant’s Code: ___ | Assistant’s Name: __________________________ | Class: _
Comments: ____________________________________________________________________
          ____________________________________________________________________
```

Figure 1.10 – Last Page of Level 2 Forms; Inspector Information

1.5.4.1 Recommendations for Adjustments to the Inspection Schedule

The inspector may recommend adjustments to the default inspection cycle and to the number of additional inspection cycles required. Alternately, the inspector may recommend the next inspection date. However, the inspector cannot make recommendations regarding both the inspection cycle and the next inspection date. These fields should be left blank to continue with the current defaults shown in the Reviewer section. To recommend discontinuing the inspections, the inspector enters ‘0’ in the Recommended Additional Cycles field. These inspection date recommendations provide information to the Department’s Reviewer and will not necessarily be used to make adjustments to the scheduled inspections.

1.5.4.2 Inspector Information and Inspector’s Team Information

After each inspection, the inspector and any assistants must print their Department assigned three-letter Inspector’s Code, their names and their inspector class on the Level 2 form. Some members of the inspection team may not have a Department assigned three-letter Inspector’s Code. In this case, it is sufficient to write the individual’s name and their inspector class. There are fields provided for the principal inspector who is responsible for the inspection, and up to two assistants.

The standard format for names in this section is the first name in full, followed by the middle initial with a period, and then the last name, such as ‘ROBERT H. SMITH’. Names should be written in all capital letters.

1.5.4.3 Miscellaneous Comments

The inspector shall record any miscellaneous comments in the lines provided that are pertinent to the current inspection, but do not belong in any another area of the Level 2 form.

1.5.5 REVIEWER

This is the last section of the Level 2 form and is shown in Figure 1.11. It is very similar to the Inspector's section that is directly above it, as described in Section 1.5.4. This section is completed by the Department's Reviewer and it describes revisions made to the inspection cycle and the Reviewer's name.

```
REVIEWER:   Review Date: ____/__/__

Approved Cycle __ months OR Next Insp. Date ____/__/__ (blank for default)
Approved Additional Cycle: _ (blank for default, 0 for discontinue)\

Reviewer's Code: ___ | Reviewer's Name:_____________________________ | Class: _

Comments: ___________________________________________________________________
          ___________________________________________________________________

Default No. of Inspections: _ | Number completed to date: __
Default Cycle: __ months      | Next Inspection Required Date ____/__/__
```

Figure 1.11 – Last Page of Level 2 Forms; Reviewer Information

1.5.5.1 Review Date

In this field, the Reviewer from the Department records the date the inspection was reviewed. The format is 'yyyy/mm/dd'.

1.5.5.2 Approved Adjustments to the Bridge Inspection Schedule

The inspector can recommend changes be made to the inspection cycle, however only Department personnel can approve this recommendation. The Reviewer records the approved adjustments to the inspection cycle, next inspection date, or number of additional inspections to be performed. They can either recommend a shorter inspection cycle or define the next inspection date, but not both.

The Reviewer will leave these fields blank to continue with the current defaults for the inspection cycle. To approve discontinuing the inspections, the Reviewer enters a '0' in the Approved Additional Cycle field.

1.5.5.3 Reviewer Information

The Reviewer records their Department assigned three-letter Inspector's Code, their name, and their inspector class as applicable. The name should be recorded in the standard format described in Section 1.5.4.2.

1.5.5.4 Miscellaneous Comments

The Reviewer records any comments pertinent to the inspection or the review.

1.5.5.5 Default Number of Inspections

This is the total number of inspections of that particular type to be completed on the structure. This value may have been adjusted by a previous reviewer who had approved an adjustment to the number of additional cycles. This field may be blank if the inspection is on an ongoing cycle.

1.5.5.6 Default Cycle

This is the current cycle, in months, at which the inspections are to be performed. The cycle can be set for a particular site or for a given inspection type. This field will rarely be blank. An example where it may be blank is when an inspection of a bridge element is performed on a one time only basis using the Special Structure Monitor inspection.

1.5.5.7 Number Completed To Date

This is the number of inspections that have been completed to date, not including the current inspection.

1.5.5.8 Next Inspection Required Date

This field is the date that the next inspection should be completed by. This date is calculated using the current inspection date and the default cycle, or as modified by the Reviewer's approved adjustment. Where the reviewer has approved a next inspection date, this date will govern. The 'Next Inspection Required Date' is in the format of 'yyyy/mm/dd'.

2.0 CHAPTER 2 – CONCRETE DECK INSPECTION (CDK2)

2.1 INTRODUCTION

The Level 2 Concrete Deck Inspection is primarily a quantitative condition inspection. It is a visual inspection that groups areas of like condition and quantifies signs of deterioration such as cracking, staining and debonding. The inspection is focused on the concrete components of the deck, but includes other elements that influence the condition and service life of the concrete components, such as a wearing surface or concrete overlay. The inspection also focuses on components that would be included in rehabilitation work done to the deck, such as concrete edge elements or deck joints.

Level 2 deck inspections are usually performed by specialized inspectors without the use of special tools, with the exception of a chain for chain dragging. The inspection is usually performed from the deck, ground level, or from permanent access-ways such as catwalks. No special access is generally required.

The components of the deck that are inspected are the following:

- Wearing Surface
- Concrete Overlay
- Concrete Deck
- Concrete Edge Elements
- Deck Joints

Additional reference information on these bridge components can be found in the Level 1 BIM Inspection Manual.

Level 2 concrete deck inspections are currently performed on approximately 120 bridge sites per year throughout Alberta on a 4 to 5 year inspection cycle. Additional Level 2 deck inspections are also carried out on an 'as required' basis on other bridge sites. These may be completed as part of a bridge assessment or because of a need identified in a previous Level 1 inspection.

2.1.1 PURPOSE OF LEVEL 2 CONCRETE DECK INSPECTIONS

The purpose of the inspection is to rate and measure the deterioration according to established guidelines in order to provide a condition assessment of the deck components. This assessment gives the Department a detailed picture of the deck condition to help determine appropriate deck maintenance and rehabilitation strategies.

2.2 LEVEL 2 ELEMENT RATINGS

Level 2 concrete deck inspection ratings are fundamentally different than those of the Level 1 inspection ratings. Level 2 inspections collect quantified condition data that provide information on how much of each deck element is in a particular condition state. This condition, and change in condition, can then be tracked over time. Level 1 inspections only reflect the worst condition state of a particular element to flag the Department to follow up with a more detailed inspection.

2.2.1 PERCENT INSPECTED (%/I) AND RATING BREAKDOWN

The inspector identifies the visible amount of each major component to be inspected. If the entire component is visible, the inspector records that 100% of the component was inspected in the %/I field. If only half of the component is visible, the inspector records that 50% of the component is inspected.

The inspector then rates the area of the component that is visible. The ratings are based on the 9 point rating scale used in the Level 1 inspections as shown in Table 2.1. For additional information on this rating scale, refer to Section 1 of the Level 1 BIM Inspection Manual. This rating scale reflects the condition and functionality, as well as the priority or urgency for maintenance actions. This urgency for maintenance depends heavily on the importance of the element to the safe function of the structure.

Rating		Commentary	Maintenance Priority
9	Very Good	New condition.	No repairs in foreseeable future.
8		Almost new condition.	No repairs in foreseeable future.
7	Good	Could be upgraded to new condition with very little effort.	No repairs necessary at this time.
6		Generally good condition. Functioning as designed with no signs of distress of deterioration.	No repairs necessary at this time.
5	Adequate	Acceptable condition. Minor flaws, but functioning as intended.	No repairs necessary. Consider preventative measures.
4		Below minimum acceptable condition.	Low priority.
3	Poor	Presence of distress or deterioration. Not functioning as intended.	Medium priority.
2		May require continued observation until work is completed.	High priority.
1	Immediate Action	Danger of collapse and/or danger to users.	Immediate action required. Bridge closure.

Table 2.1 – Condition Rating System

In Level 2 inspections, several ratings are grouped together into categories. Ratings from 9-7 are grouped together since these are very good condition ratings, and then ratings 6 and 5 are also grouped as adequate ratings. Ratings of 4 and 3 each have their own category since these ratings are the most critical and will influence the maintenance priority of the element. Ratings of 2 and 1 are grouped together as well since these ratings are relatively uncommon and the maintenance or repair approach for these ratings is basically the same – fix the element now.

If the visible area of the component has one uniform condition throughout, then one general rating will suffice. When the visible area of the component has numerous areas of varying conditions, then each different area receives its own rating. The inspector identifies how much of the visible area is represented by each particular rating. For example, 60% of the area may be rated 6/5, 35% of the area may be rated 4, and 5% of the visible area may be rated 3. The total of the ratings should always add up to 100%, as in this example 60% + 35% + 5% = 100% of the visible area.

When determining the respective percentage amounts of the inspected area in each rating category, the inspector should use areas that are multiples of 5%. The only exception to this rule is when there is a very small or isolated area that is in poor condition and the rest of the element is in adequate, good or very good condition. In this case, rate the area of the element that is in very poor condition as if it is 1% of the area, even though the actual affected area may be much less that 1%.

For additional clarification, consider the example of a wearing surface rating as shown in Figure 2.1. In this example, the wearing surface is a polymer overlay over the entire deck, with a seal coat placed overtop of the polymer. However, the seal coat was not applied from curb to curb but only in the travel lanes and not on the shoulders. The entire seal coat wearing surface is visible, so it is 100% inspected as shown in the %/I column. On the shoulders, the polymer overlay is still visible, therefore 10% of the polymer overlay can be inspected and '10' is recorded in the %/I column. Of that 10% visible area of the polymer, 90% is rated 6/5, and the remaining 10% is rated 4. Meanwhile, the entire surface of the seal coat is visible and 95% is rated 9-7 and 5% is rated 4.

ITEM		CONDITION NOW					
		%/I	9-7	6/5	4	3	2/1
Polymer rating:	% area	10		90	10		
ACP rating:	% area	X					
Seal Coat rating:	% area	100	95		5		

Figure 2.1 – Example of Concrete Deck Inspection Ratings for a Wearing Surface

2.2.2 CONDITION LAST / CONDITION NOW

Each major element that is inspected in the Level 2 deck inspection has columns for both the current condition and the ratings from the previous Level 2 inspection. These are respectively, the Condition Now and the Condition Last columns. The inspector is only required to complete the Condition Now fields and not the Condition Last fields. The Condition Last fields will be brought forward from the previous Level 2 deck inspection if it exists. These previous values are provided only for comparison to the current ratings.

2.2.3 COMMENT FIELDS

Each section of the Level 2 Concrete Deck Inspection form has four lines provided for additional comments. These comment lines should be used to help describe the situation at the bridge. Clarifying comments are required for ratings of 4 or less. These can be general comments for large areas of like ratings but they should be more location specific for smaller or isolated areas of deterioration.

One of the goals of the Level 2 deck inspection is to create a clear picture of an existing problem or concern at a bridge site for the Department such that a decision or course of action can be undertaken. Inspectors must continually ask themselves if their inspection report is accomplishing this goal of accurately portraying a bridge site.

2.2.4 FOLLOW-UP ACTION

The inspector is required to follow up on any inspected elements that are in such poor condition that a structural or safety hazard to the travelling public exists. These items must be photographed and reported to an appropriate Department representative, such as the Bridge Manager. The inspector should also complete the Items Requiring Immediate Attention field on the last page of the Level 2 forms, as described in Section 1.5.2.

Similar to Level 1 inspections, the inspector should photograph and comment on all deteriorated areas that are rated 3 or less. These may also be reported to the Bridge Manager as critical items. A rating of 2 or less for a critical element must be reported to the Bridge Manager immediately. Ratings of 4 require a comment and may also be photographed at the inspector's discretion.

The Level 2 inspection reports should also include additional photographs that illustrate the representative condition of the deck underside, wearing surface or rideability, curbs, parapets, medians, bridgerail, deck joints, superstructure, bearings, and substructure. Photos of any special or unique problems should also be included. The photos should be notated to indicate the location relative to the bridge and whether the subject is a typical phenomena throughout the site or an isolated single occurrence. The goal is to effectively communicate the current condition of the bridge to the Department.

2.2.5 CRACK WIDTHS

A crack is defined as a break without complete separation of the parts. It can be described as the following:

- **Structural** - Flexural, shear, anchorage
- **Shrinkage** - Caused by rapid drying of concrete
- **Settlement** - Caused by settling of formwork or foundation
- **Map** - Closely spaced cracks in all directions
- **Corrosion of steel reinforcement** - Usually due to lack of cover

Cracks in concrete deck elements are measure and recorded during a Level 2 inspection. The cracks are further categorized by crack width definitions as follows:

H -	Hairline	Less than 0.1 mm
N -	Narrow	0.1 mm to less than 0.3 mm
M -	Medium	0.3 mm to less than 1.0 mm
W -	Wide	Equal to or greater than 1.0 mm

2.2.6 SCALING

Scaling is the deterioration of the concrete surface due to a continuous loss of surface mortar and aggregate. Under certain conditions the hardened sand and cement paste that forms the smooth surface layer of the concrete breaks down over time, and falls away in scaly patches. This scaling can be caused by inadequate air entrainment, repeated freeze-thaw cycles in the presence of salts, or poor workmanship. Scaling can also be found under an asphalt wearing surface without a waterproofed membrane.

Typically, the depth of the scaling patches is shallow, but the coarse aggregate of the interior generally becomes exposed. The extent of scaling, for the purpose of Level 2 inspections, is described below:

L -	Light	Loss of surface mortar only up to 5 mm depth. Some surface exposure of coarse aggregate.
M -	Moderate	Loss of surface mortar to a depth of 10 mm. Some exposure of coarse aggregate.
H -	Heavy	Loss of surface mortar to a depth of 25 mm. Coarse aggregate clearly exposed and projecting from the surface.
S -	Severe	Loss of surface mortar to a depth greater than 25 mm. Loss of coarse aggregate.

2.2.7 SPALLING

Spalling is the breaking or bursting of concrete that occurs due to expansion forces that develop when steel reinforcing bars begin to corrode. Spalling also occurs to a lesser extent when poor quality aggregate swells. Divot-like deteriorated areas in the concrete surface are referred to as ‘spalls’.

2.2.8 STAINING

Inspectors have to distinguish between water staining and corrosion staining as these represent two different stages of deterioration. Water staining is an earlier stage and is generally white or gray coloured. Corrosion stains originate from the reinforcing steel or prestressing strands and are generally red or rust coloured.

In this Level 2 inspection, the staining severity guides are described below:

L -	Light	Efflorescence or exudation at cracks. Light grey damp appearance.
M -	Moderate	Dark grey damp appearance.
H -	Heavy	Efflorescence or exudation in stained areas. Light rust stains.
S -	Severe	Heavy rust stains.

2.2.8.1 Stained Cracks

Cracks in concrete can be stained as described in Section 2.2.8. Rust stains are the most serious stains that can be observed coming from cracks. Commonly, cracks in the underside of concrete components will have areas of white carbonate salt stains called efflorescence. These stains result from the evaporation of a calcium hydroxide solution that flows out of the concrete.

2.3 THE CDK2 FORM - STRUCTURE INVENTORY INFORMATION

The inventory information found at the top of the Level 2 Concrete Deck Inspection form (CDK2) contains the same inventory data found on the typical Level 1 and other Level 2 bridge and culvert inspection forms. Descriptions of these fields are found in Section 1.3.2 of the Level 2 Inspection Manual or Section 4 of the Level 1 BIM Inspection Manual.

Ensure the date of the Level 2 inspection is recorded in the header information on the first page. This date will be echoed onto the last page of the CDK2 form.

2.3.1 ADDITIONAL STRUCTURE INVENTORY INFORMATION

In addition to the inventory data in the header of the form, the CDK2 form provides additional information about the bridge structure. This section is located immediately below the header information on page one of the CDK2 form and is shown in Figure 2.2. Refer to Section 1.4 for a complete description of the Structure Information fields.

```
STRUCTURE INFORMATION:

No. of spans: ..    Span Types: .../...  Substructure Types: .../...
Span Lengths: ....-....-....-....-.....m    Total Length: .....m
```

Figure 2.2 – CDK2, Additional Structure Information

2.4 WEARING SURFACES

The wearing surface of the deck is typically defined as the surface that is in direct contact with the wheels of a vehicle. In the Level 2 Concrete Deck Inspection, the wearing surface definition is refined further to include layers that are added on top of the concrete deck or concrete overlays. This includes polymer overlays, asphalt or seal coats. Note that polymer overlays may also be referred to as epoxy overlays, asphalt may be referred to as ACP, and seal coats may be called a chip coat or a chip seal.

The wearing surface typically extends across the entire bridge deck surface. It is considered to be a sacrificial layer that protects the structural deck or overlay against wear, road salt, and environmental effects. It also provides a smooth riding surface and skid resistance. The wearing surface is not considered a structural component, as it does not contribute to the load-carrying capacity of the bridge.

2.4.1 WEARING SURFACE INVENTORY INFORMATION

At the top of the Wearing Surface section as shown in Figure 2.3, there is a subsection that contains specific inventory information on the polymer, ACP, or seal coat wearing surfaces.

The inspector is required to complete the 'yes' or 'no' (Y/N) fields at the top of the section to indicate which wearing surfaces are present on the bridge. A 'Y' is recorded for all types that are present while an 'N' is recorded for all others. Note that the wearing surface does not necessarily have to be the top surface or be visible to be recorded.

```
WEARING SURFACE:     Polymer (Y/N): _    ACP (Y/N): _     Seal Coat (Y/N): _
```

	Type	Year 1	Year 2	Avg. Total Thickness	Area
Polymer	...	....	....	..mm	.....sq m
ACP	...	....	....	...mm	.....sq m
Seal Coat	...	....	....	..mm	.....sq m

Figure 2.3 – CDK2, Wearing Surface Inventory Information

The remaining detailed inventory information in this section should be brought forward automatically from the Department's inventory system or from a previous inspection. If the fields are blank, the inspector should attempt to fill in what they can, but only with known values. It is not required that the inspector determine all of the inventory items unless specifically directed by the Department.

The fields in the wearing surface inventory are further explained below:

- **Type** - This field is for the specific type of wearing surface within the generic type. For example, polymer modified asphalt is a sub type of ACP.
- **Year 1** - This is the year that the wearing surface was placed.
- **Year 2** - This field is for the year that a second placement of the wearing surface occurred. This can occur with ACP and seal coat wearing surfaces. Polymer overlays will not use this field as only one placement year is allowed.
- **Average Total Thickness** - This is the total wearing surface thickness, in millimetres. The wearing surface thickness can vary greatly, but generally they are in the order of 5-10 mm for polymer, 50-150 mm for ACP, and 15 mm for seal coat. If the ACP depth varies greatly, the average thickness is provided.
- **Area** - This is the surface area of the wearing surface, in square metres.

2.4.2 WEARING SURFACE INSPECTION

The Wearing Surface Inspection part of the form is shown in Figure 2.4. This section requires entry of rating information on the polymer, ACP, or seal coat wearing surfaces.

ITEM		CONDITION LAST						CONDITION NOW					
		%/I	9-7	6/5	4	3	2/1	%/I	9-7	6/5	4	3	2/1
Polymer rating:	% area												
ACP rating:	% area												
Seal Coat rating:	% area												
Measured damage:		***	***	***	***	***	***	***	***	***	***	***	***
tot. debond/lost area (sq m)		P______		A______		S_______		P______		A______		S_______	

Figure 2.4 – CDK2, Wearing Surface Inspection

2.4.2.1 Rating Wearing Surfaces

Inspect the visible wearing surfaces and record the percentage of the total area inspected to the nearest 5% in the %/I field.

The top wearing surface is always 100% inspected unless it is covered by thick dirt and gravel. If there is a significant amount of area missing from the top wearing surface, such as 10%, the percent of the wearing surface inspected would still be 100% and not 90%. This is because 100% of the overall wearing surface area is visible and can be inspected, despite 10% of it being in very poor condition because it is missing.

If there are multiple layers of wearing surfaces, such as a seal coat applied on top of a polymer overlay or ACP, rate the top wearing surface and all lower wearing surfaces that are visible as shown previously in the example in Section 2.2.1. If the lower wearing surface is not visible at all, record an 'N' in the %/I field. Record an 'X' in the field if the wearing surface is not present at this site. Use comments whenever necessary to clarify why the wearing surface was not 100% inspected.

Rating guides for polymer, seal coat, and ACP wearing surfaces are shown in Tables 2.2, 2.3, and 2.4. These tables are guidelines only, as the actual wearing surface rating is based on the inspector's judgement. Group areas of like condition together and record the percent of the total area visible that falls into each rating category. Ensure that these areas add up to 100%. Consider the urgency of required maintenance or repairs in determining the rating.

As an example to illustrate how to rate wearing surfaces with large amounts of lost or debonded area, consider a site that has 10% missing polymer. Group the areas of the wearing surface into groups of like condition. According to Table 2.2, a polymer wearing surface with 10% area that is missing is rated 4. The remaining 90% of the area, assuming it is of uniform condition throughout, would be rated according to its condition, such as a rating of 6 or 7.

Rating	Polymer Debond/ Lost Area	Seal Coat Lost Area	Polymer Cracking	Slipperiness
7		≤1%		
6	≤1%	≤3%	≤$^1/_{30}$ m/m^2	
5	≤3%	≤10%	≤$^1/_{10}$ m/m^2	Light
4	≤10%	≤30%	≤$^1/_3$ m/m^2	Moderate
3	≤30%	>30%	≤$^1/_1$ m/m^2	Heavy
2	>30%		>$^1/_1$ m/m^2	Severe

Table 2.2 – Polymer & Seal Coat Wearing Surface Rating Guide

Rating	Severity	Flushing	Rutting and Surface Distortions	Skid Resistance (Skid Number)	Longitudinal, Transverse, Random Cracks	Lost Area (%) Potholes & Patches	Debond (%)
6					≤$^1/_{30}$ m/m^2		≤1
5	Light	Variable colouring, localised veining	>10 mm	40-50	≤$^1/_{10}$ m/m^2	≤1	≤3
4	Moderate	Distinct colour with free asphalt	10-25 mm	30-40	≤$^1/_3$ m/m^2	≤3	≤10
3	Heavy	Wet look & tire noise. Traffic leaves tire impressions	25-50 mm	20-30	≤$^1/_1$ m/m^2	≤10	≤30
2	Severe	Excess free asphalt with wet look. Feet leave impressions	>50 mm	< 20	>$^1/_1$ m/m^2	>10	>30

Table 2.3 – ACP Wearing Surface Rating Guide (1 of 2)

Rating	Severity	Ravelling	Cracking
5	Light	Noticeable loss of material.	1+ cracks < 10 mm width. Alligator pattern establishing, numerous interconnecting cracks. 1 or 2 edge cracks within 600 mm of edge.
4	Moderate	Shallow disintegration of surface with open textured appearance	1+ cracks 10-20 mm width. Alligator pattern established with corners of polygons fracturing. Multiple edge cracks within 900 mm of edge.
3	Heavy	Shallow disintegration of surface, small potholes. Open texture loose surface materials	1+ cracks 20-30 mm width. Alligator pattern established with spalling of polygon blocks. Multiple edge cracks within 1200 mm of edge with alligator cracking along edges.
2	Severe	Deep surface disintegration many potholes Very open texture with loose surface materials.	1+ cracks >30 mm width. Alligator cracking with polygon blocks lifting, creating potholes. Multiple edge cracks over 1200 mm of edge with alligator cracking along edges.

Table 2.4 – ACP Wearing Surface Rating Guide (2 of 2)

The inspector should also note the following other wearing surface rating guidelines from the Level 1 BIM Inspection Manual:

- If a wearing surface is relatively smooth without defects or cracks, it is rated 9-7.
- If an area of the wearing surface is in relatively good condition but has some cracking, it is rated 6/5.
- If traffic speed has to be reduced due to cracks, potholes, or other defects, it should be rated 4 or less.
- Seal coat ratings of 3 are rare, and should not be rated less than a 3. It is never critical that a seal coat be replaced immediately.
- If a thick wearing surface does not extend all the way to the curbs and the condition may be hazardous, it is rated 4 or less. The problem should be described in the comment field.
- If an excessive thickness of asphalt is found on the bridge deck, the wearing surface in not automatically rated down. The wearing surface is rated according to its condition and functionality. Make a comment describing the thickness and possibly recommend reducing the wearing surface thickness. If there are structural concerns, request an evaluation of the load carrying capacity of the bridge with the additional asphalt dead load.
- If certain areas of the wearing surface for a particular bridge seem to be in worse condition than others such as along a cold joint, in the gutters, or in a specific lane this should be identified in the comment lines.
- Note any longitudinal cracks that have reflected through the wearing surface in the comments.

2.4.2.2 Measured Damage

The inspector is to complete the measured damage field for all visible areas of the wearing surface. The measured damage field is further described below:

- **Total Debond/Lost Area (m^2)** - Record the Total Debonded or Lost Area for each wearing surface. Debonded areas require chain dragging or hammer sounding to identify while lost area measurements are determined visually. Patched areas are included as lost area for ACP and seal coat. Patched areas on polymer overlays are treated the same as areas that are not patched. Complete loss of seal coat aggregate counts towards the lost area.

Record the amount of de-bonded or lost area for all wearing surfaces that are present at the site, even if the amount is zero. If the particular wearing surface is not present at the bridge site, put a '**-**' in the Total Debond/Lost Area field.

2.4.2.3 Comments

The inspector may use the comment area to distinguish how much of the recorded value is debonding and how much is lost area. They can also identify the location of localized debonding or lost areas.

2.5 CONCRETE OVERLAYS

A concrete overlay is a layer of concrete placed on the existing concrete deck, subsequent to or at the time of construction. The concrete overlay may have traffic directly on top of it or it may have an additional wearing surface placed on top of it, such as a seal coat or polymer overlay.

The purpose of the concrete overlay is to protect the underlying concrete deck from the ingress of chloride ions. This concrete overlay also adds protective cover to the rebar and has a relatively low permeability. Overlays may also contain steel fibre reinforcement to help control cracking.

2.5.1 CONCRETE OVERLAY INVENTORY INFORMATION

At the top of the Concrete Overlay section, there is a subsection that contains specific inventory information on the concrete overlay as shown in Figure 2.5. Each span type is inspected separately and the inspection results for each span type are located on a separate page. Therefore, if there are two span types at the bridge site, there will be two different pages for the concrete overlay inspection, with one for each span type. These pages of the CDK2 form will be numbered pages 2A and 2B.

For each span type, the inspector is required to complete the 'yes' or 'no' (Y/N) field at the top of the section that states whether or not a concrete overlay is present on the bridge. A 'Y' in this field means that a concrete overlay is present, even if there is another wearing surface on top of it. A 'N' is recorded when there is no overlay.

```
CONCRETE OVERLAY:        Overlay (Y/N): _

Deck Group: ..    Span Type: ...    Span Numbers: ...........     Area: .....sq m
Overlay Type: ...       Year Placed: ....    Avg. Thick.: ...mm
Long. Rebar -> Type: ..   Size: ...   Cover: ...mm   Spacing: ....mm
Trans. Rebar -> Type: ..   Size: ...   Cover: ...mm   Spacing: ....mm
Avg. 28 Day Strength: ....Mpa
```

Figure 2.5 – CDK2, Concrete Overlay Inventory Information

The remaining detailed inventory information in this section should be brought forward automatically from the Department's inventory system or from a previous inspection. However, if the fields are blank, the inspector is required to complete the Deck Group, Span Type, Span Numbers, Area and Overlay Type fields for each different span type. These fields are described below:

- **Deck Group** - A group number, starting with 1, is assigned to each span type. The main span should be Deck Group 1 and secondary span types should be 2 or greater.

- **Span Type** - The Span Type code according to the BIS Inventory. Examples of concrete spans types are in the BIS Codes and Explanations Manual.
- **Span Numbers** - All of the spans are numbered, beginning with number 1. They are numbered from south to north or from west to east. List all the span numbers that are included in the specific Deck Group in this field, separated by a comma. For example, if the site had 5 spans, and the middle 3 were in Deck Group 1 (the main spans), the Span Numbers field would be '2, 3, 4'.
- **Area (m^2)** - The deck area of all of the spans in the Deck Group, in square metres.
- **Overlay Type** - The type of concrete overlay, according to the BIS codes listed below. If more than one overlay type exists in the deck group, record both codes separated by a slash. If there are multiple overlay types, describe the areas with the different overlay types in the comment lines.

  C - Concrete
  F - Fibre Reinforced Concrete
  H - High Density Concrete
  I - Silica Fume Concrete
  J - Silica Fume Concrete with Steel Fibre Reinforcement
  L - Latex Modified Concrete
  Y - Pyrament Concrete
  Z - Pyrament Concrete with Steel Fibre Reinforcement
  X - Other

  The year the overlay was placed may provide information as to the kind of overlay that may be present at a site. High density concrete overlays were placed on both new construction and on rehab projects from 1977 to 1985. Pyrament concrete was placed on a limited number of structures in the early 1990's and was found to be susceptible to early onset cracking. Since 1990, most concrete overlays are silica fume concrete, with or without steel fibre reinforcement.

The inspector can attempt to fill in the remaining fields of this section, but only with verified values. It is not required that the inspector determine all of the inventory items unless specifically directed by the Department. These remaining fields are listed below:

- **Year Placed** - The year the concrete overlay was placed.
- **Average Thickness (mm)** - The actual average thickness of the concrete overlay, above the deck, in millimetres. Several overlays are specified to a nominal 50 mm depth. However, the actual thickness tends to be 65-75 mm due to the removal of the top 15-25 mm of the concrete deck prior to placement of the overlay. The thickness can be variable along the length or width of the bridge due to adjustments made for camber, sag and crown.
- **Longitudinal and Transverse Rebar** - These fields describe the reinforcing steel that is in the reinforced concrete overlay. If the overlay does not have steel

reinforcement in it, then leave these fields blank. Do not include information on the rebar found in the deck, as it is recorded in the Deck section as described in Section 2.6.1. Identify the following for the steel reinforcement in the overlay:

- **Type** - The type of reinforcing in the edge element, if applicable. Examples include plain steel, epoxy coated, stainless steel, galvanized and steel fibre.
- **Size** - The size designation of the reinforcement, if applicable.
- **Cover** - The actual average clear cover over the reinforcement, if applicable.
- **Spacing** - The nominal bar spacing of the reinforcement, if applicable.

▪ **Average 28 Day Strength** - The average 28 day compressive strength of the concrete overlay, in MPa. The tested value is preferred.

2.5.2 CONCRETE OVERLAY INSPECTION

The Concrete Overlay Inspection section of the form is shown in Figure 2.6.

ITEM	CONDITION LAST						CONDITION NOW					
	%/I	9-7	6/5	4	3	2/1	%/I	9-7	6/5	4	3	2/1
Overlay rating: % area												
Measured damage:	***	***	***	***	***	***	***	***	***	***	***	***
total crack length (m)	M/W ________						M/W ________					
tot. scaled area (sq m)	L ________ M/H/S ________						L ________ M/H/S ________					
delam/spall/patch area (sq m)	d________ s________ p________						D________ s________ p________					

Figure 2.6 – CDK2, Concrete Overlay Inspection

2.5.2.1 Rating Concrete Overlays

Inspect the visible area of the concrete overlay in the Deck Group and record the percentage of the total area inspected to the nearest 5% in the %/I field.

The top of the concrete overlay will be 100% inspected unless it is covered by thick dirt and gravel or unless there is another wearing surface applied on top of the overlay. If there is no overlay present at all, record an ‘X’ in the %/I field. If the overlay is covered completely by another wearing surface, record a ‘N’. Use comments when necessary to clarify why the overlay was not inspected. For example, an appropriate comment might be “Overlay not inspected because it is protected by a polymer overlay”.

A rating guide for concrete overlays is included as Table 2.5. This table provides rating guidelines for concrete overlays, however the final rating breakdown is based on the inspector’s own judgement. Group areas of like condition together first, then record the percent of the total area that falls into each rating category. Consider the urgency of the required maintenance or repairs when determining the rating.

Rating	Scaling	Crack Frequency	Delaminated Areas	Spalled & Patched Areas
7		H/N $\leq ^1/_{30}$ m/m^2		
6		H/N $\leq ^1/_{10}$ m/m^2 M/W $\leq ^1/_{30}$ m/m^2	≤1%	
5	Light	H/N $\leq ^1/_3$ m/m^2 M/W $\leq ^1/_{10}$ m/m^2	≤3%	
4	Moderate	H/N $\leq ^1/_1$ m/m^2 M/W $\leq ^1/_3$ m/m^2	≤10%	≤1%
3	Heavy	H/N $> ^1/_1$ m/m^2 M/W $\leq ^1/_1$ m/m^2	≤30%	≤3%
2	Severe	M/W $> ^1/_1$ m/m^2	>30%	>3%

Table 2.5 – Concrete Overlay Rating Guide

Use the comment fields to help describe the condition at the site. Identify locations of similar condition, especially for areas of the overlay that are in poor condition. Also describe notable trends or generalities. For example, make a comment if most of the cracks are transverse and near the piers, if the cracks are random or in a certain lane, or if the majority of the delaminated areas are in the gutter or along the cold joint. Note any longitudinal or grout key cracks. Measure their distance out from the inside curb face and record which spans they are located on.

2.5.2.2 Measured Damage – Concrete Overlay

The inspector is to complete the measured damage fields for all visible areas of the concrete overlay. A '0' should be recorded if no damage is observed in a particular field. These measured damage fields are described below:

- **Total Crack Length (m)** - When measuring the crack length, only consider Medium (M) and Wide (W) cracks. Give the total crack length to the nearest metre for the entire Deck Group or Span Type. On large overlays with frequent cracks, a representative area can be measured such as ½ or ¼ of the area, and then extrapolated for the entire overlay. The inspector can only extrapolate for visible areas of the overlay that are in uniform condition throughout.
- **Total Scaled Area (m²)** - Record the scaled area of the concrete overlay to the nearest square metre. Light scaling (L) is measured separately from Moderate, Heavy or Severe scaling, which are all grouped together (M/H/S).
- **Delaminated Area (m²)** - Chain drag or hammer-sound the overlay and measure the total area of the overlay that is delaminated. Record it to the nearest square metre.
- **Spalled Area (m²)** - Measure the total area of spalls in the overlay and record them to the nearest square metre.

- **Patched Area (m²)** - Measure and record the area of all visible patches in the concrete overlay to the nearest square metre.

If there is no concrete overlay at the site, record a '**-**' in each of the measured damage fields.

2.6 CONCRETE DECKS

The concrete deck referred to in this section is the structural deck. The primary function of the deck is to carry traffic and transfer live loads from the vehicles to the bridge's main structural members below.

The deck top is the surface to which the concrete overlay or wearing surface is bonded. The deck may also serve as the wearing surface in the absence of a concrete overlay or other wearing surface. If the deck top is also acting as the wearing surface, it will be in direct contact with the traffic, so it must also provide a smooth skid resistant surface for vehicles. Typically, the top surface of concrete box girders is also the deck top.

The deck underside is the bottom side of the deck above the girders. In the case of precast concrete channel girders, the deck underside is considered to be the area between the girder legs. The underside needs to be inspected and monitored as serious deck problems can be observed from the underside such as cracking and heavy staining.

The inspector may not be able to inspect the deck underside of some box girders or voided slab spans because the visible bottom surface of the girder is not the underside of the deck. However, in some cases the inspector may still be able to rate the exposed deck underside between girder units.

2.6.1 CONCRETE DECK INVENTORY INFORMATION

At the top of the Concrete Deck Inventory Information section, there is a subsection containing specific inventory information on the deck as shown in Figure 2.7. Each span type is presented on separate pages. Therefore, if the bridge has two span types, each span type will have its own deck inspection page. All sites inspected with the CDK2 Level 2 form will have a concrete deck.

```
DECK:

Deck Group: ..    Span Type: ...    Span Numbers: ...........     Area: .....sq m
Deck Type: ...    Year Const: ....   Year Widened: ....    Min. Thickness: ...mm
Long. Rebar -> Type: ..   Size: ...   Cover: ...mm   Spacing: ....mm
Trans. Rebar -> Type: ..   Size: ...   Cover: ...mm   Spacing: ....mm
Avg. 28 Day Strength: ....Mpa
```

Figure 2.7 – CDK2, Concrete Deck Inventory Information

The detailed inventory information in this Concrete Deck Inventory Information section should be brought forward automatically from the Department's inventory system or from a previous inspection. If there is a concrete overlay at the site, the values for the Deck Group, Span Type, Span Numbers, and Area are the same as the Concrete Overlay Inventory Information described in Section 2.5.1. However, if the fields are blank, the inspector is required to complete the Deck Group, Span Type, Span Numbers, Area and Deck Type fields for each different span type. These fields are further described below:

- **Deck Group** - A group number, starting with 1, is assigned to each span type. The main span should be Deck Group 1 and secondary span types should be 2 or greater.
- **Span Type** - The Span Type code according to the BIS Inventory. Examples of spans types are in the BIS Codes and Explanations Manual.
- **Span Numbers** - All of the spans are numbered, beginning with number 1. They are numbered from south to north or from west to east. List all the span numbers that are included in the specific Deck Group in this field, separated by a comma. For example, if the site had 5 spans, and the middle 3 were in Deck Group 1 (the main spans), the Span Numbers field would be '2, 3, 4'.
- **Area (m²)** - The deck area of all of the spans in the Deck Group, in square metres.
- **Deck Type** - The type of deck. Since this is a concrete deck inspection, all of the decks will be made of concrete. Record a 'C' in this field for 'reinforced concrete'.

The inspector can attempt to fill in the remaining fields of this section, but only with verified values. It is not required that the inspector determine all of the inventory items unless specifically directed by the Department. These remaining fields are listed below:

- **Year Constructed** - Identify the construction year of the deck.
- **Year Widened** - If the deck has been widened, identify the year. If the deck has not been widened, this field will be blank.
- **Minimum Thickness (mm)** - This field is the actual thickness of the concrete deck. For variable thickness decks, this will be the minimum thickness. If the thickness has been reduced (i.e. milling the surface to place an overlay), the deck thickness is to be reduced to the new value.
- **Longitudinal and Transverse Rebar** - These fields describe the top mat of reinforcing steel that is in the concrete deck. If the site has a reinforced concrete overlay on top of the deck, do not include information on the rebar found in the concrete overlay. It is recorded in the Concrete Overlay section described in Section 2.5.1. Identify the following for the steel reinforcement in the deck:
  - **Type** - The type of reinforcing in the deck. Examples include plain steel, epoxy coated, stainless steel, galvanized, and steel fibre.
  - **Size** - The size designation of the reinforcement, if applicable.
  - **Cover** - The actual average clear cover over the reinforcement in the deck. Do not include any additional wearing surfaces or overlays.
  - **Spacing** - The nominal bar spacing of the reinforcement, if applicable.
- **Average 28 Day Strength** - The average 28 day compressive strength of the concrete deck, in MPa. The tested value is preferred.

2.6.2 CONCRETE DECK INSPECTION ITEMS

The Concrete Deck Inspection area of the form is shown in Figure 2.8. This section requires entry of rating information on the concrete deck.

DECK:

ITEM	CONDITION LAST						CONDITION NOW					
	%/I	9-7	6/5	4	3	2/1	%/I	9-7	6/5	4	3	2/1
Top rating: % area												
Measured damage:	***	***	***	***	***	***	***	***	***	***	***	***
total crack length (m)	M/W __________						M/W __________					
tot. scaled area (sq m)	L _________ M/H/S _______						L _________ M/H/S _______					
delam/spall/patch area (sq m)	d_______ s_______ p_______						d_______ s_______ p_______					
Underside rating: % area												
Measured damage:	***	***	***	***	***	***	***	***	***	***	***	***
total stained area (sq m)	M _______ H/S _______						M _______ H/S _______					
tot. crk. Len. (m)/% stained	M/W _________ % stn ____						M/W _________ % stn ____					

Figure 2.8 – CDK2, Concrete Deck Inspection

2.6.2.1 Deck Top Ratings

Inspect the visible area of the concrete deck in the Deck Group and record the percentage of the total area inspected to the nearest 5% in the %/I field.

If the deck top is completely exposed, it will be 100% inspected. If parts of the deck are covered with a wearing surface or debris, the percent inspected will be reduced accordingly. If the deck top is not visible at all because it is completely covered by an overlay or other wearing surface, then the inspector should record a 'N' in the %/I field. Comments should be used for clarification when the deck was partially inspected or not inspected at all.

A rating guide for concrete deck tops is included in Table 2.6. This table is only a guideline, as the actual concrete deck top rating breakdown is based on the inspector's judgement. Group areas of like condition together and record the percent of the visible areas of the concrete deck top that fall into each rating category. Consider the urgency of required maintenance or repairs in each area to determine the rating.

Rating	Scaling	Crack Frequency	Delaminated Areas	Spalled & Patched Areas	Underside Staining
7		H/N $\leq {}^{1}/_{30}$ m/m^2			
6		H/N $\leq {}^{1}/_{10}$ m/m^2 M/W $\leq {}^{1}/_{30}$ m/m^2			
5	Light	H/N $\leq {}^{1}/_{3}$ m/m^2 M/W $\leq {}^{1}/_{10}$ m/m^2	≤1%		Light
4	Moderate	H/N $\leq {}^{1}/_{1}$ m/m^2 M/W $\leq {}^{1}/_{3}$ m/m^2	≤3%	≤1%	Moderate
3	Heavy	H/N $> {}^{1}/_{1}$ m/m^2 M/W $\leq {}^{1}/_{1}$ m/m^2	≤10%	≤3%	Heavy
2	Severe	M/W $> {}^{1}/_{1}$ m/m^2	>10%	>3%	Severe

Table 2.6 – Concrete Deck Rating Guide

Other relevant aspects to consider when rating a deck top are listed below:

- The concrete paving lip that is visible on decks with an ACP wearing surface is part of the deck top and should therefore be included in the inspection of the deck top. Use the comments to note this situation.
- The top of concrete box girders and concrete channel girders is considered to be the deck top.
- Only measure and record the length of Medium (M) and Wide (W) cracks. Note in the comments if there are widespread or notable narrow cracks.
- Use the comment fields to help describe the condition at the site. Identify locations of similar condition, especially for areas of the deck in poor condition. Also describe notable trends or generalities. For example, make comments if most of the cracks are transverse and near the piers, if the cracks are random or in a certain lane, or if the majority of the delaminated areas are in the gutter or along the cold joint. Note any longitudinal or grout key cracks. Measure their distance out from the inside curb face and record which spans they are found on.

2.6.2.2 Measured Damage – Deck Top

The inspector is to complete the measured damage fields for all visible areas of the concrete deck. A ‘0’ should be recorded if the deck top area was inspected, but no damage was observed for a particular field. These measured damage fields are further described below:

- **Total Crack Length (m)** - When measuring the crack length, only consider Medium (M) and Wide (W) cracks. Give the total crack length to the nearest metre for the entire Deck Group or Span Type. On large decks with frequent cracks, a representative area can be measured such as ½ of the area, and then extrapolated for the entire deck. The inspector can only extrapolate for visible areas of the deck that are in uniform condition throughout.

- **Total Scaled Area (m²)** - Record the scaled area of the deck to the nearest square metre. Light scaling (L) is measured separately from Moderate, Heavy or Severe scaling, which are all grouped together (M/H/S).
- **Delaminated Area (m²)** - Chain drag or hammer-sound the deck and measure the total delaminated area. Record it to the nearest square metre.
- **Spalled Area (m²)** - Measure the total area of spalls in the overlay and record them to the nearest square metre.
- **Patched Area (m²)** - Measure and record the area of all visible patches in the concrete overlay to the nearest square metre.

If the deck is not visible at all, such as if there is a wearing surface on top of it, record a '**-**' in each of the measured damage fields.

2.6.2.3 Deck Underside Ratings

Inspect the visible area of the concrete deck underside in the Deck Group and record the percentage of the total area inspected to the nearest 5% in the `%/I` field.

If the deck underside is completely exposed and accessible, it will be 100% inspected. If parts of the deck are over water and cannot be inspected, reduce the percent inspected accordingly.

When a cast-in-place deck is inspected, the deck underside is visible in all locations except directly above the girder flanges, such as for WG or PO girders. However, this will not affect the percent inspected, as the deck underside is still considered to be 100% visible. Precast channel girders, such as FC girders, are also inspected in this way. The underside of channel girders is considered to be the deck underside and the legs do not affect the percent inspected, as they are not part of the deck underside,.

The deck underside is not generally visible when concrete box girders or voided slabs are present. The deck underside is considered to be the underside of the top surface of the box girder, not the underside of the bottom surface of the girder. In this situation, the inspector is to record a 'N' in the `%/I` field. If some area of the deck underside is visible between the girders then this area can be inspected. Use comments to clarify why the deck underside was not inspected. Also comment on the condition of the girders. Note cracked areas, stains between girders and other notable features.

Steel box girders also impair the visibility of the deck underside. Reduce the percent inspected by the percent of deck area that the steel box girders cover. The inspector can only rate the reduced area of the deck underside between the steel box girders.

A rating guide for concrete deck undersides is included in Table 2.6. This rating guide is only a recommendation of how to rate deck undersides as the final rating breakdown is based on the inspector's own judgement. Group areas of like condition together first, then record the percent of the total area that falls into each rating category. Consider the urgency of required maintenance or repairs in each area to determine the rating. Stained areas may be indicators of the deck underside condition.

Other relevant aspects to consider when rating a deck underside are listed below:

- Note any shear or lateral stressing that is present at the site in the comment field.
- Only measure and record the length of Medium (M) and Wide (W) cracks in the deck underside. Note in the comments if there are widespread or notable narrow cracks. Also comment on whether typical cracks are longitudinal, transverse, or random for all widths.
- Describe location and degree of staining in the comment lines, especially for Moderate (M), Heavy (H), or Severe (S) stains.
- Rate and note bearing condition in the Deck Joints section, as described in Section 2.8.
- Girders and the legs of precast channel girders are not rated as part of the deck inspection. Their condition does not influence the deck underside rating. However, the inspector should make brief general comments on any notable deterioration. Note defects such as cracking, staining between box girders, and shoe plate anchorage problems. Also note problems with steel or concrete diaphragms.
- Use the comment fields to help describe the condition at the site. Identify locations of similar condition, especially for areas of the deck underside in poor condition. Also describe notable trends or generalities. For example, make comments if most of the cracks are transverse and near the piers or if the cracks are random or in a certain area of the deck underside.

2.6.2.4 Measured Damage – Deck Underside

The inspector is to complete the measured damage fields for all visible areas of the deck underside. The girder legs should not be included in the measurements. Record a '0' if the underside was inspected, but no damage was observed for a particular field. These measured damage fields are further described below:

- **Total Stained Area (m^2)** - Record the total stained area of the deck underside to the nearest square metre. It is not required to record the amount of light scaling. Moderate scaling (M) is measured separately from Heavy or Severe scaling, which are grouped together (H/S). Do not include stains from cracks in this field. Stained cracks are identified separately.

- **Total Crack Length (m) / Percent Stained -** When measuring the crack length, only consider Medium (M) and Wide (W) cracks. Give the total crack length to the nearest metre for the entire Deck Group or Span Type. On large decks with frequent cracks, a representative area can be measured such as ½ of the area, and then extrapolated for the entire deck, but only if the entire deck underside is accessible. The inspector can only extrapolate for visible areas of the deck underside that are in uniform condition throughout.

  Record the percent of cracks that are stained in the '% stained' field. Efflorescence is considered staining. Comment in the comment lines if the stains are not efflorescence, such as if they are wet, dark grey, or rust coloured.

  Chamfer cracks in precast channel girders are not considered to be cracks in the deck underside.

If the deck underside is not visible at all, as in the case of concrete box girders for example, record a '**-**' in each of the measured damage fields.

2.7 EDGE ELEMENTS

Edge elements are raised surfaces located at the edges of the roadway. These are used to guide or redirect traffic, minimize damage to other bridge components, and redirect vehicles back onto the road in the event of a collision. Only precast and cast-in-place concrete edge elements are considered in this Level 2 inspection.

Exterior bridge elements like curbs, parapets, medians and sidewalks are generally designed without being part of the load carrying system.

An edge element consists of the vertical or sloped face along the edge of the roadway, the fascia, and the raised horizontal surface. The inspection includes the top and vertical surfaces as well as the fascia. These components are exposed to the same types of physical and chemical attacks as the deck, but the conditions can be more severe.

2.7.1 CURB, PARAPET, MEDIAN, AND SIDEWALK INVENTORY INFORMATION

At the top of the Edge Element section, there is subsection that contains specific inventory information on the concrete curbs, parapets, medians and sidewalks as shown in Figure 2.9.

The inspector is required to complete the 'yes' or 'no' (Y/N) fields at the top of the section to indicate which edge elements are present on the bridge. A 'Y' is recorded for all types that are present while a 'N' is recorded for all others.

Note that if there is a sidewalk along one side of the bridge, there is no curb along that same side. However, there may still be a curb along the other side of the deck.

```
EDGE ELEMENTS:            Curbs (Y/N)   : _     Parapets  (Y/N) : _
                          Medians  (Y/N): _     Sidewalks  (Y/N): _
```

		Tot.			Avg.	Reinforcement			
	Type	Len.	Ht.	Width	Str.	Type	Size	Cover	Spacing
Curbs	...	....m	...mm	....mm	...MPa	..	...	...mm	....mm
Parapets	...	....m	...mm	....mm	...MPa	..	...	...mm	....mm
Medians	...	....m	...mm	....mm	...MPa	..	...	...mm	....mm
Sidewalks	...	....m	...mm	....mm	...MPa	..	...	...mm	....mm

Figure 2.9 – CDK2, Curb, Parapet, Median, and Sidewalk Inventory Information

The remaining detailed inventory information in this section should be brought forward automatically from the Department's inventory system or from a previous inspection. If the fields are blank, the inspector should attempt to fill in what they can. It is not required that the inspector determine all of the inventory items unless specifically directed by the Department.

For each edge element, the following inventory information should be provided:

- **Type** - The code for the specific type of edge element within the generic type. For example, reinforced concrete is shown as 'C'. All edge elements inspected in this Level 2 form will be reinforced concrete.
- **Total length** - The total length of the edge element on the bridge to the nearest 0.1 m. For most edge elements, this would typically be the bridge length multiplied by 2.
- **Height** - The height of the edge element in millimetres.
- **Width** - The width of the edge element in millimetres.
- **Average Strength** - The average 28 day compressive strength of the concrete, in Mpa. The tested value is preferred. This field is only used for concrete edge elements.
- **Reinforcement**:
    - **Type** - The type of reinforcing in the edge element, if applicable. Examples include plain steel, epoxy coated, stainless steel, galvanized, and steel fibre.
    - **Size** - The size designation of the reinforcement, if applicable.
    - **Cover** - The actual average clear cover over the reinforcement, if applicable.
    - **Spacing** - The nominal bar spacing of the reinforcement, if applicable.

2.7.2 CURB AND PARAPET INSPECTION ITEMS

Curbs and parapets are both edge elements found along the exterior edges of bridges and are therefore rated using the same fields. The inspection fields are shown in Figure 2.10.

It is uncommon for parapets and curbs to be at the same site, but it is nevertheless possible. When it does happen, they are not rated any differently from a site that has two curbs or two parapets. If the ratings between the curb and parapet are significantly different, the comments are used to describe which has the worse rating. The following subsections will describe the rating fields in terms of curbs, although the same guidelines apply to parapets.

ITEM	CONDITION LAST						CONDITION NOW					
	%/I	9-7	6/5	4	3	2/1	%/I	9-7	6/5	4	3	2/1
Curbs/Parapets rtg: % len.												
Measured damage:	***	***	***	***	***	***	***	***	***	***	***	***
total crack length (m)	M/W __________						M/W __________					
tot. scaled len. (m)	L ________ M/H/S ________						L ________ M/H/S ________					
delam/spall/patch len. (m)	d________ s________ p________						d________ s________ p________					

Figure 2.10 – CDK2, Curb and Parapet Inspection

2.7.2.1 Curb/Parapet Ratings by Length (Curb/Parapets rtg, % len.)

Inspect the curbs and record the percent of the total length of the curb that is inspected, to the nearest 5%, in the %/I field.

The entire curb length will be inspected as long as the curb is not covered with gravel and debris. If the curb does have significant debris piled on it and in the gutter, note the percentage of the curb that is not covered and make a comment that describes why the remaining curb area was not inspected.

It is not necessary to observe the total length of the curb underside for 100% of the curb to be inspected. However, if the curb and gutter are completely covered in thick debris but the underside and fascia are visible, the curb can still be 50% inspected.

Rate the visible curb along its length and record the percent of the total curb length that falls into each rating category. The rating of the curb is based on the inspector's judgement. Consider the urgency of required maintenance or repairs in the curb to help determine the rating. Also consider the measured damage on the curb such as the total crack length, scaling and spalling.

If there are no curbs or parapets present at the site, put a 'X' in the %/I field.

Other relevant aspects to consider when rating curbs or parapets are listed below:

- Curb lengths that require no maintenance are rated a 5 or higher.
- Curb areas with holes and exposed voids must be rated a 4 or less. It is possible to down rate the length of the immediate curb section in this case, since water may get into the void for the section. It is also possible to down rate the entire curb length if the exposed voids are significant and the voids in the curb are continuous for the length of the structure.
- Curb lengths that are scaled to a depth of 5 mm with exposed aggregate from light scaling are rated a 6/5. Rate a 4 or less if in combination with another type of deterioration.
- When rating, consider curb damage such as snowplow damage, failing patches, and accident damage.

- The curb rating may be reduced if the curb height is insufficient. If the curb height is insufficient, measure and record the height and make a note in the comment lines.
- Make a comment if a sealer is observed on the curbs.
- Curb cover plates are rated in the Deck Joint section, described in Section 2.8.
- If the curbs have both good and deteriorated areas, note the location of the deteriorated areas, such as the side of bridge and span number, in the comment lines.
- The bridgerail condition does not affect the curb rating. Comment on the bridgerail and bridgerail post condition in the comment lines. Note items such as the general paint condition, number of missing nuts, or number of deteriorated concrete posts.
- Parapets are rated in the same way curbs are.

2.7.2.2 Measured Damage – Curbs and Parapets

The inspector is to complete all of the measured damage fields that are located directly below the curb and parapet rating fields. Record a '0' if no damage is observed in a particular field. Parapets are assessed with the same criteria as curbs. These measured damage fields are described below:

- **Total Crack Length (m)** - When measuring the crack length, only consider the crack length that is on the curb top and inside face or the inside face of the parapet. Only Medium (M) and Wide (W) cracks are measured. Record the total crack length to the nearest metre.
- **Total Scaled Length (m)** - Record the length of the curbs that are scaled to the nearest metre. The length of the curbs that show Light scaling (L) are measured separately from the length of the curbs that have Moderate, Heavy or Severe scaling, which are all grouped together (M/H/S).
- **Delaminated Length (m)** - Measure the total length of the curbs that are delaminated and record this value to the nearest metre. Several delaminated areas can be observed visually, such as vertical cracks parallel to the curbs near the inside curb face. Chain drag or hammer-sound other areas where delamination is suspected but cannot be observed visually. Patched areas may also be delaminated. Do not include parging delamination or deterioration in this rating.
- **Spalled Length (m)** - Measure the total length of spalls along the curbs and record to the nearest metre.
- **Patched Length (m)** - Measure the total length of all patches along the curbs and record this value to the nearest metre. Parging is not considered to be patching. If parging is deteriorating, note this in the comments.

If there are no curbs or parapets at the site, record a '-' in each of the measured damage fields.

2.7.3 MEDIAN AND SIDEWALK INSPECTION ITEMS

Medians and sidewalks are both rated in the same fields since they are very similar components. Medians delineate traffic flow while sidewalks are for pedestrian usage. The inspection fields are shown in Figure 2.11.

ITEM	CONDITION LAST						CONDITION NOW					
	%/I	9-7	6/5	4	3	2/1	%/I	9-7	6/5	4	3	2/1
Medians/Sidewalks rtg: % area												
Measured damage:	***	***	***	***	***	***	***	***	***	***	***	***
total crack length (m)	M/W ________						M/W ________					
tot. scaled area (sq m)	L ________ M/H/S ________						L ________ M/H/S ________					
delam/spall/patch area (sq m)	d________ s________ p________						d________ s________ p________					

Figure 2.11 – CDK2, Median and Sidewalk Inspection Items

2.7.3.1 Median/Sidewalk Ratings by Percent Area (Medians/ Sidewalks rtg, % area)

Inspect the medians and/or the sidewalk and record the percent of the total area that was inspected to the nearest 5% in the %/I field.

Typically, the entire median or sidewalk will be inspected as long as it is not covered with gravel and debris. If the median or sidewalk does have significant debris piled on it and in the gutter, note the percentage of the total area that is not covered and add a comment that describes why the remaining area was not inspected. Note that if the sidewalk is covered with debris or is obstructed in some way it may be a safety hazard to the public.

If the structure has both a median and a sidewalk, the ratings will be for the combination of these components. If they have different conditions, use the comments section to define which rating applies to which component.

Rate the visible area and record the percent of the total visible area that falls into each rating category. Consider the urgency of required maintenance or repairs to help determine the rating. Also consider the measured damage such as the total crack length, scaling and spalling. The ratings are ultimately based on the inspector's judgement.

If there are no medians or sidewalks present at the site, put a 'X' in the %/I field.

Other relevant aspects to consider when rating medians or sidewalks are listed below:

- Median and sidewalk areas that require no maintenance are rated a 5 or higher.

- Median and sidewalk areas with holes and exposed voids must be rated a 4 or less. It is possible to down rate the length of the immediate median or sidewalk section in this case, since water may get into the void for the section. It is also possible to down rate the entire median or sidewalk length if the exposed voids are significant and the voids are continuous for the length of the structure.
- Median and sidewalk areas that are scaled to a depth of 5 mm with exposed aggregate from light scaling are rated a 6/5. Rate a 4 or less if in combination with another type of deterioration.
- When rating, consider other median and sidewalk damage such as snowplow damage, failing patches and accident damage.
- The median and sidewalk ratings may be reduced if their height is insufficient. If the median or sidewalk height is insufficient, measure and record the height and make a note in the comment lines.
- Make a comment if a sealer is observed on the median or sidewalk.
- If the median or sidewalk has both good and deteriorated areas, note the location of the deteriorated areas such as the general area and span number in the comment lines.
- The bridgerail and pedestrian rail conditions do not affect the median or sidewalk rating. Comment on the bridgerail and bridgerail post condition in the comment lines. Note items such as the general paint condition, number of missing nuts, or number of deteriorated posts.

2.7.3.2 Measured Damage - Medians and Sidewalks

The inspector is to complete all of the measured damage fields that are located directly below the median and sidewalk rating fields. Record a ‘0’ if no damage is observed in a particular field. Medians and sidewalks are assessed with the same criteria. These measured damage fields are further described below:

- **Total Crack Length (m)** - Measure the cracks that are on top of the median or sidewalk. Only Medium (M) and Wide (W) cracks are measured. Record the total crack length to the nearest metre.
- **Total Scaled Area (m^2)** - Record the scaled area of the median and/or sidewalk to the nearest square metre. The area that shows Light scaling (L) is measured separately from the area that has Moderate, Heavy or Severe scaling, which are all grouped together (M/H/S).
- **Delaminated Area (m^2)** - Measure the total delaminated area to the nearest square metre. Patched areas may also be delaminated.
- **Spalled Area (m^2)** - Measure the total spalled area and record to the nearest square metre.
- **Patched Area (m^2)** - Measure the total area of all patches and record to the nearest square metre.

If there are no medians or parapets at the site, record a '**-**' in each of the measured damage fields.

2.8 DECK JOINT INSPECTIONS

Deck joints are a structural discontinuity in the deck that permit relative rotation due to vehicular load or translation due to thermal expansion of the superstructure.

On major and standard bridges, deck joints may be watertight, open joints with plumbing, or open joints without plumbing. Open joints that were not designed to be watertight or damaged joints that were designed to be watertight, allow the water and salt to leak onto the superstructure and substructure elements below. This leakage can damage the girder ends, bearings, prestressed cables, abutments and piers, and can significantly reduce the service life of the structure. The Deck Joint inspection fields are shown in Figure 2.12.

DECK JOINTS:

ITEM					CONDITION LAST						CONDITION NOW					
					%/I	Leakage		Damage Rating		L1 Jnt Rtg	%/I	Leakage		Damage Rating		L1 Jnt Rtg
Grp No.	Type	No. Jts	Exp/ Fix	Location		% Jts	% Len	Sup	Sub			% Jts	% Len	Sup	Sub	
1	...	..	...	....												
2	...	..	...	....												
3	...	..	...	....												

Figure 2.12 – CDK2, Deck Joint Inspection

2.8.1 DECK JOINT INVENTORY INFORMATION

The deck joint inventory fields are described below. These fields will have to be completed on site unless the information can be brought forward from a previous Level 2 deck inspection.

- **Deck Joint Group Number (Grp No.)** - The group number fields are already completed on the CDK2 form. The different deck joint groups are numbered starting with number 1. Try to number the deck joint groups consistently with previous Level 2 deck inspections whenever possible.
- **Deck Joint Type** - This field defines the type of deck joint in the deck joint group. Record the code for the deck joint type as defined in the BIS Codes and Explanation Manual.

  If a joint is completely covered by a wearing surface such as ACP and the inspector is unable to determine the joint type from the Deck Joint Maintenance Report or previous Level 1 or Level 2 inspections, record a 'N' in the Joint Type field and make a comment.
- **Number of Deck Joints (No. Jts)** - Record the number of joints that are in the particular deck joint group. Deck joints of different types are in different groups. Also, fixed and expansion joints are also in separate groups.

- **Expansion Joint or Fixed Joint (Exp/Fix)** - Indicate if the deck joints in the particular group are expansion joints or fixed joints. To determine if the joint is an expansion joint or fixed joint, examine the bearings at the bridge site, reference the bridge drawings or locate the information in the BIM Inventory Information. Record 'EXP' in this field if the joints in the group are expansion joints, or 'FIX' if the joints in the group are fixed.
- **Location of Joints (Location) -** List the locations of all the deck joints in that group. Use the two-digit element numbering system described in Section 1.3.1, separating each location by a comma. For example if the deck joint locations of a particular group are located at the west abutment, the west pier and the east abutment, the inspector would record 'A1, P1, A2' in the Location field.

2.8.2 DECK JOINT INSPECTION ITEMS

The following subsections describe the deck joint inspection fields that are to be completed by the inspector during the Level 2 inspection.

2.8.2.1 Percent of Deck Joints Inspected (%/I)

Record the percentage of joints that were inspected from the current deck joint group. The top of the joint and anchorage condition must be visible from the top of the deck in order to count as a joint that is inspected.

The percent of deck joints inspected in each group is the number of joints inspected divided by the total number of joints in that group, multiplied by 100.

If all joints in the group are not visible, for example if they are covered by an ACP wearing surface record a '0' in this field. Note that the Level 1 joint rating would be a 'N' for this joint group.

Partial joints can also be inspected. For example, if there is a single joint in a group, and the joint is covered by a wearing surface such as ACP, except for 5% of the length in the gutter, the percent inspected would be 5%. Use comments to clarify partial inspection amounts.

Joints that are filled with debris should be cleaned and rated if possible. If they cannot be cleaned, describe this in the comment field.

2.8.2.2 Percent of Joints That Leak (Leakage - % Jts)

The underside of the watertight joints must also be inspected for leakage. If the joint is designed to be watertight, it should be flooded with water to help determine if it is still watertight. This field may still be completed even if the top of the deck joint is not visible.

The percent of joints that leak is the number of leaking joints in the group divided by the total number of deck joints in the group, and multiplied by 100. Even the smallest leak or tear in a joint that is designed to be watertight is considered to be a leaking deck joint.

A gland type joint with a tiny tear in the gland is considered to be a leaking joint even if no leakage is observed. For deck joints with drainage troughs, the trough should be rated in this field. If the trough leaks it is considered a leaking joint.

This field is 100% for joints that are not designed to be watertight, such as buffer angles or sliding plates.

2.8.2.3 Percent of Joint Length That Leaks (Leakage - % Len)

This field records as a percentage the total length of all the joints in the group that are leaking. For example, if there are three deck joints in the group, and 30% of one of the joints is leaking, the percent of the total joint length that is leaking for this deck joint group is 10%.

If a gland type deck joint is visibly torn, yet no water is observed leaking through the joint when it is flooded, the joint is still considered to be leaking. However, the inspector is to note in the comment lines that the joint did not leak through the tear when flooded with water

This field is generally completed using a multiple of 5%, with the exception of a very small tear. A small tear in a watertight joint or drainage trough is entered in the field as 1% of the total length to flag it in the Level 2 inspection, even if the actual length of the tear is much less than 1%. Record the location of the tear in the comment lines.

When the deck joint has a drainage trough, the trough should be rated in this field. If the trough leaks it is recorded as a leaking joint.

This field will always be 100% for joints such as buffer angles or sliding plates that are not designed to be watertight.

2.8.2.4 Superstructure and Substructure Damage Rating (Sup, Sub)

Rate the damage caused to the superstructure and the substructure by the deck joints or leakage through the deck joints.

If other damage that was not related to deck joint function past or present is observed, note the damage in the comment lines but do not down-rate the superstructure or substructure damage rating. Watch for stains to help determine the source of any damage. If still unsure if the damage is related to the joints or not, then rate it as if it was related to the joint.

Superstructure Damage
This is damage to superstructure elements that are related to the deck joint. The superstructure includes the girder ends and bearings. Pay special attention to girder ends that have strand in them as leakage can run along any exposed strand deep into the girder.

On longer structures, the inspector may not be able to observe one of the spans since it is too far from the shore. If the inspector cannot see the span under one deck joint, even if all the others are visible, a 'N' is recorded in this field. Comment on the spans that are visible.

The inspector will not be able to observe and rate the ends of box girders at the abutment or pier joints. Place a 'N' in this field if the structure has box girders. Note whatever condition and staining is visible in the comment lines.

Bearing condition is included in the superstructure damage rating. Do not down-rate the superstructure if the bearings are covered in debris unless it is known that they are damaged or not functioning. Only down-rate the superstructure if problems with the bearing were caused by a deficient deck joint. Regardless of whether the deck joint was the source of problems for the bearing, comment on the bearing condition such as if it is rusted or jammed. Also comment on the bearing condition if it is overextended for the current temperature and record the current temperature.

Substructure Damage
This is damage to substructure elements that are related to the deck joint. The substructure includes the backwall, abutment seat, and piers.

If an inspector cannot see the substructure elements under one of the deck joints, they must record a 'N' in this field. Comment only on the substructure elements under the deck joints that are visible.

Additional Rating Guidelines
Rating the damage to the superstructure and substructure elements is a matter of applying the Department rating guidelines. These guidelines also take into consideration the maintenance priority of the elements.

The inspector's judgement must be used to rate the elements. The rating described in this section however, is not a Level 1 inspection. A Level 1 inspection is used to highlight the worst condition state of an element. The rating described herein is a Level 2 inspection used to collect quantified data in order to provide information on how much of an element is in a particular condition state. The inspector is to rate the general condition and not the worst case. The inspector should note that if the damage was significant to the structural capacity or function of the element, a Level 1 rating should be used that reflects the worst damage to the element.

A rating of 5 or higher is for elements that are functioning as designed. For a rating of 5 an element may have minor structural flaws, but these flaws should not compromise the structural capacity of the member. A rating of 4 is a low maintenance priority, and these elements would generally be scheduled for repair in more than 3 years time. A rating of 3 is a medium priority for maintenance, as repairs would typically be scheduled from 6 months to 3 years away. A rating of 2 is a high priority for maintenance and repairs would likely be less than 6 months away. Finally, a rating of 1 requires immediate action.

It is common for the leaking deck joint that caused damage to the superstructure or substructure to have been repaired or replaced, but the damage to the underside still remains. Rate the superstructure or substructure based on the existing damage even if the cause of the damage has been repaired. The deck joint itself will not be down-rated since it has been repaired and is functional. Further, the percent of leaking joints will also show that no further leakage is occurring. Make a comment to help clarify the situation.

Use the comment lines in the Deck Underside section, described in Section 2.6.2.3, to note deficiencies or damage to the superstructure that are not related to the joint.

2.8.2.5 Level 1 Joint Rating (L1 Jnt Rtg)

Record the one-digit Level 1 rating for the deck joint group in this field. This rating should be the minimum or lowest Level 1 deck joint rating of the joints in the group.

Level 1 ratings rate the worst condition of the element. If the joints are functioning as designed, the rating will be 5 or higher. For example, joints that leak, but are not designed to be watertight, are rated a 5 or higher unless they have an additional problem. If one joint in the group is not functioning as designed, the Level 1 rating will be a 4 or less. Therefore, a single leaking joint in a group of watertight joints ensures that the Level 1 rating for the group of joints is 4 or less. Use a comment to describe which joint brought the rating down and why.

The Level 1 joint rating would be a ‘N’ for the joint group if one of the joints was not visible and therefore was not inspected.

Curb cover plates are to be rated under the deck joints and not the curb rating. Do not down-rate the joint if a curb cover plate is missing a single bolt. If several bolts are missing or the plate is not functioning, it can be down-rated to a 4 or 3. Ensure comments are made to describe the location of cover plates when bolts are missing or damaged.

For armoured gland plates note all missing bolts and rate a 4 or less. Record the missing location of the bolts and make a comment.

Do not down-rate a joint to a 4 if there is a single snowplow deflector missing, only rate a 4 or less if the plow could get caught in the joint due to several missing snowplow deflectors. In either case, note the number of missing plow deflectors in the comments field.

If the joint has a drainage trough, its performance should be included in the Level 1 rating. Flood the joint and observe if the trough functions as designed. If the trough leaks, rate a 4 or less and comment on the defect that is causing the leakage. Note any rust stains that are observed on galvanized troughs. Also note the leakage in the % Joints Leaking and % Joint Length Leakage fields.

Observe and note any damage in the wearing surface around the joint. Use judgement to determine if this damage affects the structural capacity of the joint.

Refer to Section 7.6 of the Level 1 BIM Inspection Manual for complete Level 1 rating guidelines.

2.9 OTHER CDK2 DATA – LAST PAGE

Refer to Section 1.5 for instructions on completing the last page of the CDK2 form. The last page shares a common format with the other Level 2 forms.

2.10 CONCRETE DECK INSPECTION SUPPLEMENT

The Level 2 Concrete Deck Inspection Supplement section can be used to assist the inspector when conducting deck inspections. This supplement acts as an organized 'scratch pad' whereby the inspector can record measurements and quantities of the various concrete deck inspection items. These items can then be totaled and summarized to aid the inspector in determining the final ratings for the CDK2 form. The fields on the Supplement section are the same fields as those used in the CDK2 form. The descriptions of the fields in the Supplement section have already been included in this chapter.

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CONCRETE DECK INSPECTION SUPPLEMENT

Date: ____/__/__ | Bridge File: ..... | Page: __ of __

Span Group: __ Type: __ Span No.: _______ Tot. Area: _______ m

Segment Location	Area sq m	Polymer			ACP			S/C			Summary			
		%/I	Rtg	Loss	%/I	Rtg	Loss	%/I	Rtg	Loss		Poly	ACP	S/C
											%/I			
											9-7			
											6/5			
											4			
											3			
											2/1			
											Loss			

Figure 2.13 – Sample Section of the CDK2 Supplement

The inspector is not required to complete the CDK2 Supplement, or submit it with the completed CDK2 inspection form. The Supplement is intended only as an additional tool for the inspector. It has been included in this manual with the CDK2 form.

Bridge File Number : ....
Legal Land Location: ...-..-...-..-.
Latitude/Longitude : ..../.........
Road Auth./Region : .../R.
Bridge or Town Name: ....
Stream Name : ....
Highway #:Cntrl Sec: ....:...
Road Classification: ....-...
AADT/Year : .-....../..
Detour Length : ...km

Structure Usage : ..
Year Built : ../..
Clear Roadway/Skew: ....m/...Deg

Prev. Insp. Date : ____/__/__ (YMD)
Insp. Req'd Date : ____/__/__ (YMD)
(based on ____________________)

Current Insp. Date: ____/__/__ (YMD)
Inspector's Code : ____

STRUCTURE INFORMATION:
No. of Spans: .. Span Types: .../... Substructure Types: .../...
Span Lengths: ....-.....-.....-.....-.....m Total Length: .....m

WEARING SURFACE: Polymer (Y/N): _ ACP (Y/N): _ Seal Coat (Y/N): _

	Type	Year 1	Year 2	Avg. Total Thickness	Area
Polymer	...	....	....	..mm	.....sq m
ACP	...	....	....	...mm	.....sq m
Seal Coat	...	....	....	..mm	.....sq m

ITEM	CONDITION LAST						CONDITION NOW					
	%/I	9-7	6/5	4	3	2/1	%/I	9-7	6/5	4	3	2/1
Polymer rating: % area												
ACP rating: % area												
Seal Coat rating: % area												
Measured damage:	***	***	***	***	***	***	***	***	***	***	***	***
tot. debond/lost area (sq m)	P______ A______ S_______						P______ A______ S_______					

Comments:

Debond/lost area includes patched area for ACP and seal coat but not for polymers

Crack Width Key: H - Hairline, N - Narrow, M - Medium, W - Wide
Scaling/Staining Severity Key: L - Light, M - Moderate, H - Heavy, S - Severe

CONCRETE OVERLAY: Overlay (Y/N): _

Deck Group: .. Span Type: ... Span Numbers: .... Area: .....sq m
Overlay Type: ... Year Placed: .... Avg. Thick.: ...mm
Long. Rebar -> Type: .. Size: ... Cover: ...mm Spacing: ....mm
Trans. Rebar -> Type: .. Size: ... Cover: ...mm Spacing: ....mm
Avg. 28 Day Strength: ....MPa

ITEM	CONDITION LAST						CONDITION NOW					
	%/I	9-7	6/5	4	3	2/1	%/I	9-7	6/5	4	3	2/1
Overlay rating: % area												
Measured damage:	***	***	***	***	***	***	***	***	***	***	***	***
total crack length (m)	M/W __________						M/W __________					
tot. scaled area (sq m)	L _________ M/H/S ________						L _________ M/H/S ________					
delam/spall/patch area (sq m)	d________ s________ p________						d________ s________ p________					

Comments:

DECK:

Deck Group: .. Span Type: ... Span Numbers: .... Area: .....sq m
Deck Type: ... Year Const: .... Year Widened: .... Min. Thickness: ...mm
Long. Rebar -> Type: .. Size: ... Cover: ...mm Spacing: ....mm
Trans. Rebar -> Type: .. Size: ... Cover: ...mm Spacing: ....mm
Avg. 28 Day Strength: ....MPa

ITEM	CONDITION LAST						CONDITION NOW					
	%/I	9-7	6/5	4	3	2/1	%/I	9-7	6/5	4	3	2/1
Top rating: % area												
Measured damage:	***	***	***	***	***	***	***	***	***	***	***	***
total crack length (m)	M/W __________						M/W __________					
tot. scaled area (sq m)	L _________ M/H/S ________						L _________ M/H/S ________					
delam/spall/patch area (sq m)	d________ s________ p________						d________ s________ p________					
Underside rating: % area												
Measured damage:	***	***	***	***	***	***	***	***	***	***	***	***
total stained area (sq m)	M _______ H/S _______						M _______ H/S _______					
tot. crk. len. (m)/% stained	M/W _________ % stn ____						M/W _________ % stn ____					

Comments:

Stained area does not include stains at medium or wide cracks. These stains are identified separately as the % of total crack length stained.

EDGE ELEMENTS:

Curbs (Y/N) : _ Parapets (Y/N) : _
Medians (Y/N): _ Sidewalks (Y/N): _

	Type	Tot. Len.	Ht.	Width	Avg. Str.	Reinforcement Type	Size	Cover	Spacing
Curbs	...	....m	...mm	....mm	...MPa	..	...	...mm	....mm
Parapets	...	....m	...mm	....mm	...MPa	..	...	...mm	....mm
Medians	...	....m	...mm	....mm	...MPa	..	...	...mm	....mm
Sidewalks	...	....m	...mm	....mm	...MPa	..	...	...mm	....mm

ITEM	CONDITION LAST						CONDITION NOW					
	%/I	9-7	6/5	4	3	2/1	%/I	9-7	6/5	4	3	2/1
Curbs/Parapets rtg: % len.												
Measured damage:	***	***	***	***	***	***	***	***	***	***	***	***
total crack length (m)	M/W ___________						M/W ___________					
tot. scaled len. (m)	L _________ M/H/S _________						L _________ M/H/S _________					
delam/spall/patch len. (m)	d_________ s_________ p_________						d_________ s_________ p_________					
Medians/Sidewalks rtg: % area												
Measured damage:	***	***	***	***	***	***	***	***	***	***	***	***
total crack length (m)	M/W ___________						M/W ___________					
tot. scaled area (sq m)	L _________ M/H/S _________						L _________ M/H/S _________					
delam/spall/patch area (sq m)	d_________ s_________ p_________						d_________ s_________ p_________					

Comments:

DECK JOINTS:

Grp No.	Type	No. Jts	Exp/ Fix	Location	CONDITION LAST %/I	Leakage % Jts	Leakage % Len	Damage Rating Sup	Damage Rating Sub	L1 Jnt Rtg	CONDITION NOW %/I	Leakage % Jts	Leakage % Len	Damage Rating Sup	Damage Rating Sub	L1 Jnt Rtg
1	...	..	...	....												
2	...	..	...	....												
3	...	..	...	....												

Comments:

LEVEL 1 INSPECTION (INFORMATION ONLY)   Level 1 date: ____/__/__

Structural Condition Rating: __% Sufficiency Rating: __% Estimated Remaining Life of Structure: __ years Special Comments for Next Inspection:
Next Scheduled Level 1 inspection: ____/__/__ Current Cycle: __months

ITEMS REQUIRING IMMEDIATE ATTENTION:

LEVEL 2 INSPECTION SPECIAL REQUIREMENTS:

Y => Snooper: __ Lift: __ Traffic control: __ Boat: __ Ladder: __ Other: ____

INSPECTOR:

Recommended Cycle __ months OR Next Insp. Date ____/__/__ (blank for default) Recommended Additional Cycles: _ (blank for default, 0 for discontinue)		
Inspector's Code: ___	Inspector's Name: __________________________	Class: _
Assistant's Code: ___ Assistant's Code: ___	Assistant's Name: __________________________ Assistant's Name: __________________________	Class: _ Class: _
Comments: ____ ____		

REVIEWER: Review Date: ____/__/__

Approved Cycle __ months OR Next Insp. Date ____/__/__ (blank for default) Approved Additional Cycle: _ (blank for default, 0 for discontinue)\		
Reviewer's Code: ___	Reviewer's Name:____________________________	Class: _
Comments: ____ ____		

Default No. of Inspections: _ Default Cycle: __ months	Number completed to date: __ Next Inspection Required Date ____/__/__

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CONCRETE DECK INSPECTION SUPPLEMENT

Bridge File: .....

Date: ____/__/__

Page: __ of __

Span Group: __ Type: __ Span No.: _______ Tot. Area: _______ m

Segment Location	Area sq m	Polymer			ACP			S/C			Summary			
		%/I	Rtg	Loss	%/I	Rtg	Loss	%/I	Rtg	Loss		Poly	ACP	S/C
											%/I			
											9-7			
											6/5			
											4			
											3			
											2/1			
											Loss			

Segment Location	Area sq m	Overlay/Deck Top								Summary			
		%/I	Rtg	Crk	Scl/L	Scl/O	Deb	Spl	Ptch				
										%/I		Crk	
										9-7		Sc/L	
										6/5		Sc/O	
										4		Deb	
										3		Spl	
										2/1		Ptch	

Segment Location	Area sq m	Deck Underside							Summary			
		%/I	Rtg	St/M	Stn/HS	Crk	% Stn					
								*****	%/I		St/M	
								*****	9-7		St/H	
								*****	6/5		Crk	
								*****	4		% St	
								*****	3			
								*****	2/1			

Segment Location	Len. m	Curb/Parapets								Summary			
		%/I	Rtg	Crk	Scl/L	Scl/O	Del	Spl	Ptch	%/I		Crk	
										9-7		Sc/L	
										6/5		Sc/O	
										4		Del	
										3		Spl	
										2/1		Ptch	

Segment Location	Area sq m	Medians/Sidewalks								Summary			
		%/I	Rtg	Crk	Scl/L	Scl/O	Del	Spl	Ptch	%/I		Crk	
										9-7		Sc/L	
										6/5		Sc/O	
										4		Del	
										3		Spl	
										2/1		Ptch	

Joint Group _						Joint Group _						Joint Group _					
Jt#	%/I	% LK	Sup	Sub	Rtg	Jt#	%/I	% LK	Sup	Sub	Rtg	Jt#	%/I	% LK	Sup	Sub	Rtg
Sum						Sum						Sum					

3.0 CHAPTER 3 – COPPER SULFATE ELECTRODE TESTING (CSE2)

3.1 INTRODUCTION AND BACKGROUND

The Level 2 Copper Sulfate Electrode (CSE) test is a repeatable, non-destructive field test that measures the electrical potential between the steel reinforcement of the bridge and a reference electrode. CSE testing is performed on concrete decks that have a top mat of electrically continuous reinforcing steel.

3.1.1 THE CORROSION PROCESS

Corrosion of reinforcing steel in concrete is an electrochemical process. In new concrete where the pH is greater than 12, the reinforcing steel is in a passive state. However, concrete is a permeable material and chloride ions from de-icing salts diffuse into the concrete. Rebar corrosion begins once the concentration of chloride ions at the rebar is sufficient, or when the carbonation front reaches the rebar.

Numerous chemical corrosion cells develop on the surfaces of the reinforcing steel. Each corrosion cell has an anode and a cathode. The anode appears pitted, where iron ions are dissolving from the rebar. The cathode is oppositely charged and has no apparent corrosion, but is an essential component of the corrosion cell.

Chemical oxidation reactions occur at the anodes, where iron and oxygen chemically react. Hydrogen gas is given off as a byproduct of the chemical reduction reactions at the cathode. The cathodes and anodes must be electrically connected in order to act as a battery and generate electrical potential. The corrosion cells may be microcells, small and isolated on individual rebars, or large macrocells, such as an entire deck, where the top reinforcing mat is the anode and the bottom mat is the cathode.

The process of corrosion generates electrical potentials and corrosion currents. When numerous small cells are present within a given area, the resulting potentials represent an overall electrical picture. Electrical potential reflects the probability that corrosion is occurring, while current reflects the rate of the chemical reaction that is corroding the steel.

3.1.2 CSE TESTING IN ALBERTA

Since 1977, Alberta Transportation has been using CSE testing to help evaluate the condition of concrete bridge decks. Several structures were tested repeatedly to determine the cause of any variations in electrical potential. During these early years, the test method was refined and evolved into an economical procedure with highly repeatable results.

In the late 1970's and early 1980's an annual testing program was developed. Bridge sites were tested every few years on a rotation basis. Test results were collected and compiled in mainframe computers. This allowed the Department to observe historical trends and create prediction models. The quick and cost-effective nature of the test allowed 100 to 150 bridge sites to be tested annually by a single crew.

Today, approximately 500 bridge sites are regularly tested across Alberta and a tremendous database of test results has been collected. Several agencies outside Alberta use CSE testing to evaluate bridge decks just prior to rehabilitation, however, Alberta Transportation remains one of the few agencies that use CSE testing as a predictive tool for preventative maintenance programs.

3.1.3 THE PURPOSE OF CSE TESTING

CSE testing, also referred to as half-cell testing and copper-copper sulfate electrode testing, is used to determine the potential of corrosion in reinforcing steel. A CSE test at an individual location cannot determine whether corrosion is occurring at that particular location. Rather, it is the cumulative results of a number of tests over the deck that provides an indication of the underlying condition of the reinforcement. A group of active half-cell readings indicates a high probability of the presence of active corrosion, but they do not indicate a corrosion rate.

Test results from one year to another are compared to assess the advancement of corrosion and predict the future deck condition. Prediction models based on the CSE data are used to help determine the ideal time to rehabilitate a deck, use preventative maintenance (prior to any visible damage), or help evaluate the condition of a deck that is not visible, such as a deck that is covered with ACP or another protection system.

CSE data is also used to evaluate the effectiveness of various rehabilitation methods and protection systems such as membranes and overlays. CSE testing is ideally suited to testing large surfaces such as bridge decks as it is non-destructive, quick, and cost-effective in evaluating the deck condition.

3.1.4 INTERPRETATION OF CSE TEST RESULTS

CSE tests measure the electrical potential of the steel reinforcement within the bridge deck. The half-cell, also known as a reference electrode, acts as a reference point from which electrical potential measurements are made. The more negative the potential, the higher the probability that the steel is experiencing corrosion.

Alberta Transportation has been performing CSE tests since 1977. By combining CSE testing experience with field experience in repairing bridge decks, Alberta Transportation has developed a data interpretation scale:

0.000 V to -0.300 V = Inactive (very low probability of active corrosion)
-0.301 V to -0.400 V = Transition (good probability that corrosion is initiating)
-0.401 V to -0.800 V = Active (very high probability of active corrosion)

Note that -0.800 V is theoretically the most negative test result possible.

ASTM-C876, "Standard Test Method for Half-Cell Potentials for Reinforcing Steel in Concrete", also describes CSE Testing and discusses the probability of corrosion relative to the CSE readings and defines inactive, uncertain, and active ranges in CSE test results. The ASTM ranges used are slightly different than those used by Alberta Transportation.

3.1.5 TESTING CYCLE

CSE testable concrete bridge decks in Alberta are generally tested on a four or five year rotation. Primary highway sites may be tested more often and isolated local road sites with low traffic volumes may be tested less often.

Sites may also be tested just prior to deck rehabilitation as well as shortly after rehabilitation. This testing can help establish baselines for predictive modeling and programming priorities.

3.2 ESSENTIAL TEST EQUIPMENT

The equipment used in CSE testing can vary depending on the size and number of the bridge decks being tested. Items such as drills, files, shovels, and extra water containers will aid the testing crew, but are not essential. Other equipment, including the copper-copper sulfate electrode half-cell, the voltmeter and the electrical lead wire are essential to CSE testing. This essential equipment is further described in the sections below.

Note that old test equipment, such as frayed electrical lead wires must be repaired regularly or replaced. Low voltmeter batteries can produce erroneous results. The batteries must be checked and charged regularly. It is recommended that spare batteries and chargers be available on site whenever possible.

3.2.1 THE COPPER-COPPER SULFATE ELECTRODE HALF-CELL

The copper-copper sulfate electrode half-cell is also called the reference electrode or the half-cell. The cell is a container that is filled with saturated copper sulfate solution. To ensure it is saturated, there should be solid blue crystals visible in the solution after mixing. Only use distilled water in the copper sulfate solution.

The cell should also have a porous base, typically made from unfired ceramic or porcelain, that remains wet through capillary action, and a copper rod or copper coil submerged in the solution at all times. The top of the copper rod is connected to a lead wire that plugs into the voltmeter.

If testing is done in cold conditions where the copper sulfate solution may begin to freeze, at approximately 5 ºC, add isopropyl alcohol (15% by volume) to the solution.

Copper sulfate, like all chemicals, should be treated as potentially hazardous. Wear gloves when directly handling copper sulfate. Do not ingest copper sulfate as it is toxic. The inspector must always have a Material Safety Data Sheet (MSDS) available for all crew members when dealing with copper sulfate.

3.2.1.1 Maintaining the Half-Cell

Check the half-cell regularly to ensure there is sufficient saturated copper sulfate solution. Examine the half-cell for leaks in the porous base and corrosion on the copper rod that is in the solution.

The solution should be changed after two months of regular use or when erroneous readings are observed. The solution should also be changed if the cell has not been used or agitated for several months.

If the copper rod requires cleaning, submerge it in a dilute solution of hydrochloric acid (HCl) for several hours, then rinse and wipe it clean. Never use steel wool or other abrasives or contaminants on the copper rod.

3.2.2 THE VOLTMETER

A high-impedance voltmeter is required for CSE testing. ASTM-C876 recommends that the voltmeter be "battery operated and have +/- 3% end-of-scale accuracy at the voltage range in use. The input impedance shall be no less than 10 million ohms when operated at a full scale of 100 mV. The division scale used shall be such that a potential difference of 0.02 V or less can be read without interpolation."

The better the specifications of the voltmeter, the less likely that it will pick up stray currents from nearby power lines or other sources. Ensure the voltmeter is calibrated as specified by the manufacturer.

3.2.3 ELECTRICAL LEAD WIRE (GROUNDING WIRE)

The electrical lead wire used in CSE testing must be such that the electrical resistance for the length used may not have an internal resistance of more than 0.0001 V. It should be coated with a flexible, direct burial type of insulation.

3.3 TEST METHOD

The CSE test methods presented here have evolved from the Department's procedure BT009 "Test Procedure for Evaluating Corrosion of Reinforcing Steel in Bridge Decks (Copper Sulfate Electrode (CSE) Testing)". This chapter presents all of the information found in BT009 in more detail, and is intended to replace it.

3.3.1 LOCATE THE CSE TEST ORIGIN

There is a very specific way to determine the origin point for CSE testing. It is important to locate the origin correctly so that the CSE test data correlates with all previous and subsequent test years.

The CSE origin is located by referring it to the north arrow. The exact direction of the north arrow is very important in locating the origin correctly. The simplest, most accurate method to get an accurate north arrow is to reference the General Layout drawing for the bridge. Orient the plan view of the deck to be tested so the traffic would travel up and down on the page, then find the north arrow on the drawing. Assume that the ‘up’ direction on the page (parallel to traffic) is 0º, right is 90º, down is 180º, and so forth. Note the angle that the north arrow is pointing. The CSE origin is located at the top-left corner of the bridge if the north arrow is from 1º to 180º inclusive. It is located at the bottom right corner of the bridge if the north arrow is from 181º to 360º inclusive. This is illustrated in Figure 3.1.

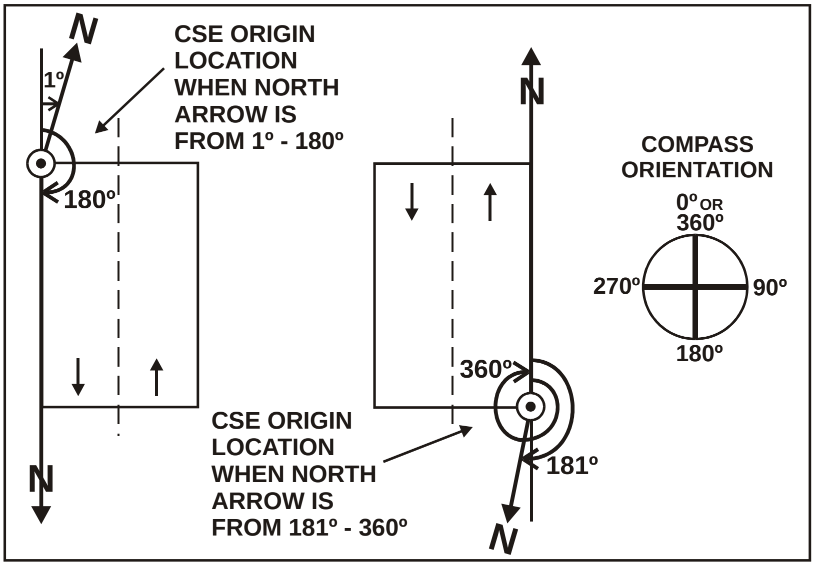


Figure 3.1 – CSE Origin in Relation to North Arrow

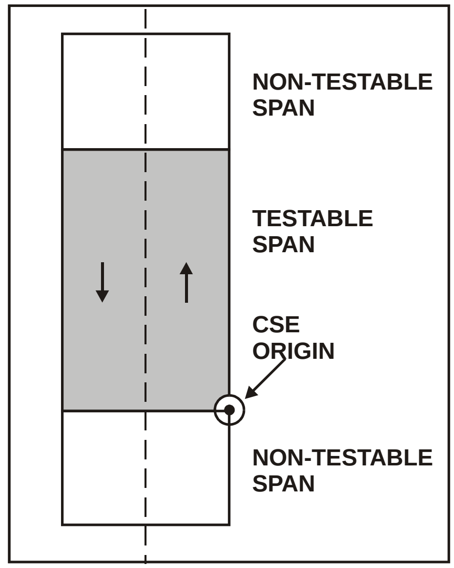


Figure 3.2 – CSE Origin with Non-Testable Spans

If the General Layout drawings are not available, and the direction of the north arrow is not known, the inspector may place a compass at one of the two possible locations for the origin (Figure 3.1). Note the direction the compass defines as north to determine which of the two corners is the CSE origin. This method is a last resort. The preferred method is to reference the drawings as described above, as the arrow on the drawing is thought to be more accurate. Previous CSE reports will also show the CSE origin.

If an end span is not testable, the CSE origin is in the corner of the span that is testable (Figure 3.2). To ensure the procedure to locate the CSE origin is clear, several examples are provided that show the location of the CSE origin in relation to several different north arrow configurations. Refer to Figure 3.4.

3.3.1.1 Skewed Bridges

The CSE origin is not always located on the deck. If the bridge has a positive skew (RHF), the origin will be located on the approach road, prior to the bridge, as shown in Figure 3.3. The origin will be on the deck for negative (LHF) skews.

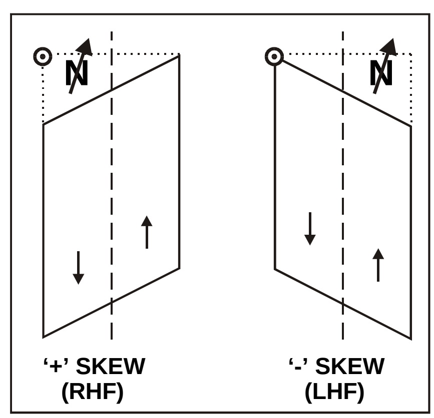
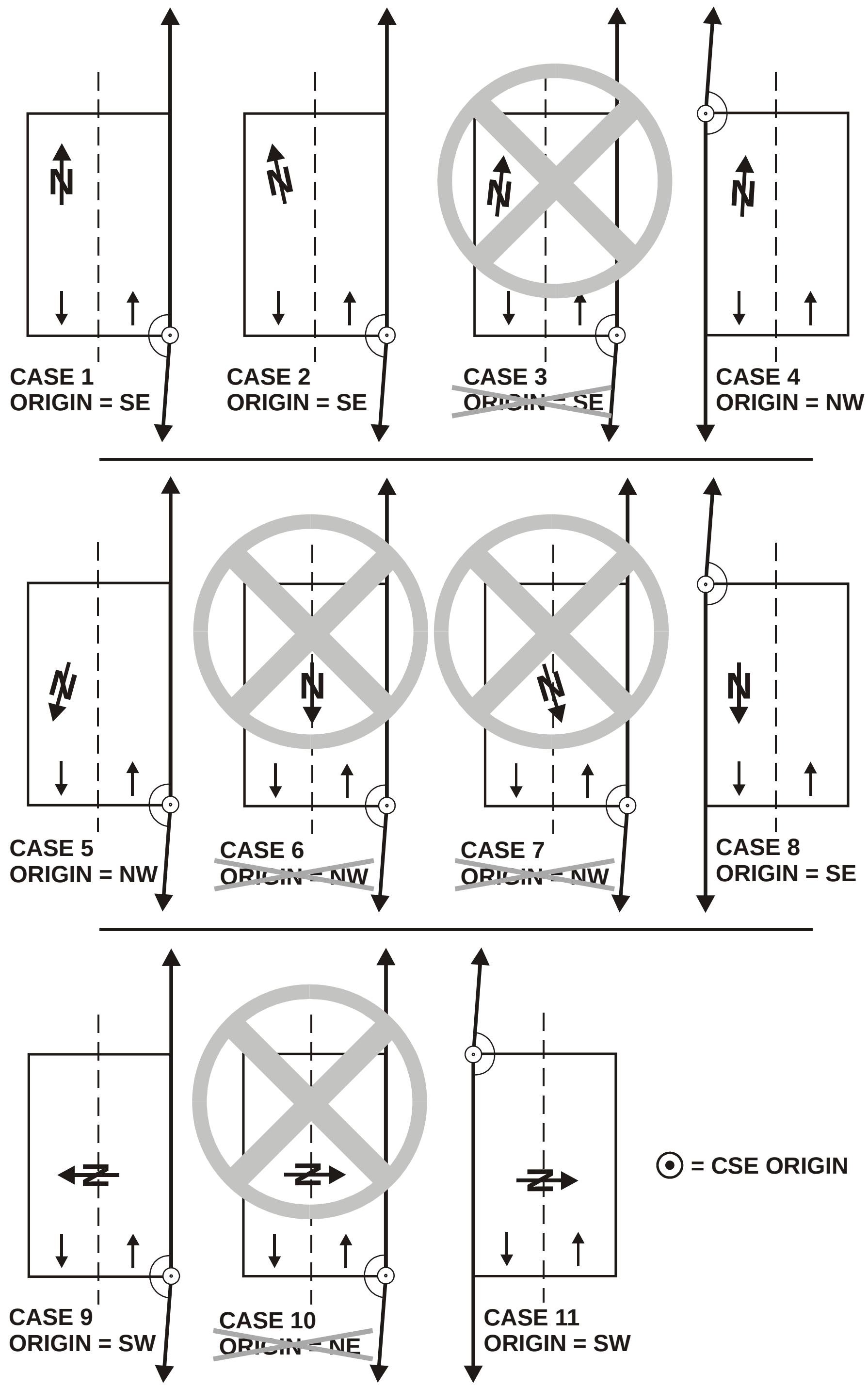


Figure 3.3 – Location of CSE Origin on Skewed Bridge Sites, Plan View



Case 1 - North arrow is parallel to curb. Origin is in SE corner, as in Case 8.

Case 2 - North arrow is slightly west of being parallel with curb. Origin is in SE corner.

Case 3 - North arrow is slightly east of being parallel with curb. Origin is **NOT** in SE corner. See Case 4.

Case 4 - North arrow is slightly east of being parallel with curb. Origin is in NW corner. Same as Case 5.

Case 5 - North arrow is slightly east of being parallel with curb. Origin is in NW corner. Same as Case 4.

Case 6 - North arrow is parallel with curb. Origin is **NOT** in NW corner, see Case 1 and 8.

Case 7 - North arrow is slightly west of being parallel with curb. Origin is **NOT** in NW corner. See Case 2.

Case 8 - North arrow is parallel with curb. Origin is in SE corner, as in Case 1.

Case 9 - North arrow is perpendicular to curb. Origin is in SW corner, as in Case 11.

Case 10 - North arrow is perpendicular to curb. Origin is **NOT** in NE corner. See Case 9 and 11.

Case 11 - North arrow is perpendicular to curb. Origin is In SW corner, as in Case 9.

Figure 3.4 – The Origin Point for CSE Testing, Detailed Examples

3.3.2 CSE TEST LOCATIONS

The CSE test locations are on the deck in a 1200 mm by 1200 mm grid, out from the origin as defined in Section 3.3.1. The last stations will be 1200 mm or less in length since the length or width of bridge decks are rarely a multiple of 1200 mm. There will always be a reading taken in each gutter along the curb.

When the bridge is skewed, the test locations are not aligned with the skew. The grid is laid out parallel to the curbs in the X direction (the length) and perpendicular to the curbs in the Y direction (the width). Therefore, the test length of a skewed deck is the length of the bridge as shown on the drawing or in BIS plus the skew length. Refer to Figure 3.5.

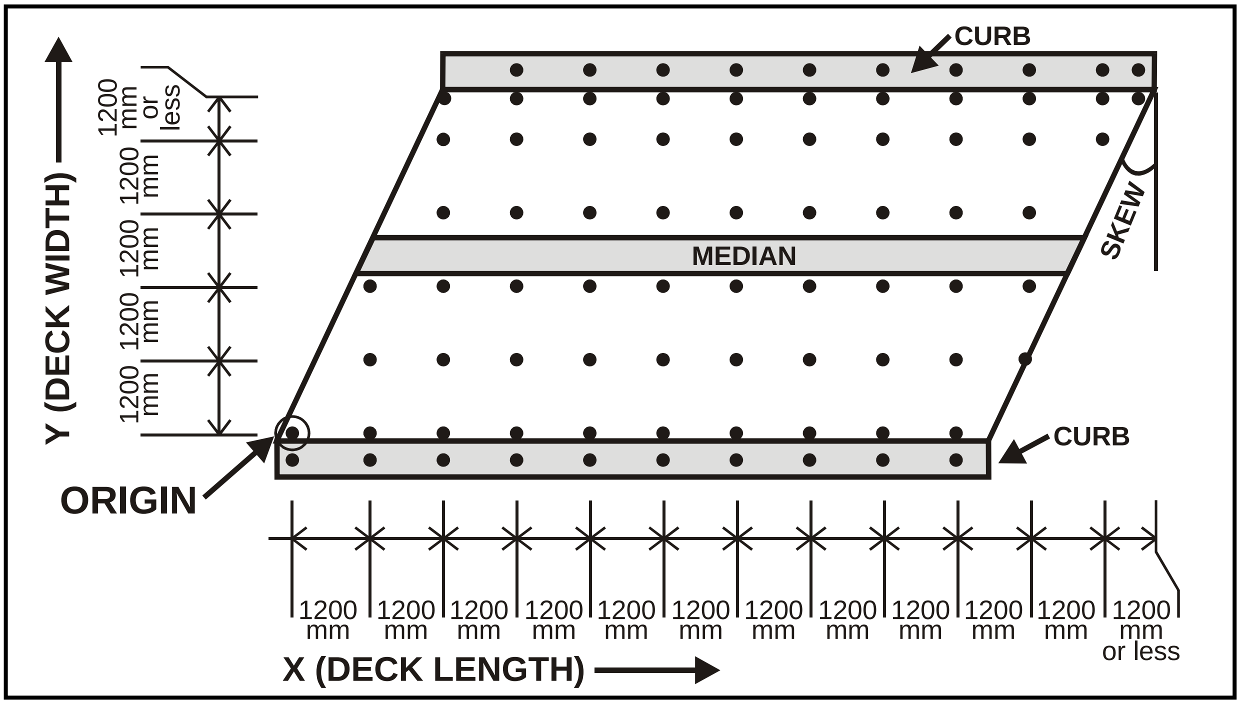


Figure 3.5 – CSE Test Locations

3.3.2.1 Marking Out Test Locations

Mark the test location grid points clearly on the deck with spray paint or similar markings. Ensure the grid points are accurate to a tolerance of 100 mm.

3.3.2.2 Test Locations on Curbs, Medians, and Parapets

Curb tops are tested, while the vertical face of the curbs is not tested. The CSE test locations on curbs are in-line with the grid pattern as shown in Figure 3.5. The test location should be in the center of the curb top when possible. However, bridgerail posts and the rail itself can make it difficult for the test to be in the centre of the curb. In this case, the test location should be just inside of the rail or rail post.

Medians are generally not tested. The presence of a median does not affect the grid layout on the deck. The test grid is still based on the single origin point. If the median is wide enough that more than one test location falls on the median in the Y direction (width), then readings can be taken from the median if desired. If readings are taken from the median, they should not be considered in the analysis of the deck results (i.e. average deck readings), and should be kept separate from the deck readings.

Parapets are also generally not tested. Parapets are only tested if they were tested along with the last CSE deck testing or if specifically requested by the Department. The inspector is required to verify whether the parapets were previously tested. If the parapets are to be tested, readings should be taken on the same grid spacing as for the deck. Take the readings approximately 200-300 mm up from the deck surface along the inside parapet face. Ensure that the surface is wet and that the parapet is connected to the deck electrically or else the readings will not be valid.

Sidewalks are not tested unless specifically requested by the Department.

3.3.3 CLEANLINESS OF TEST LOCATIONS

On primary highway bridges the curb tops and gutter lines can accumulate debris. On more remote local roads, the entire deck may be covered. All test locations must be cleaned down to the wearing surface. The half-cell must contact the wearing surface for accurate test results.

When the gutters have debris in them, they must be cleaned down to the wearing surface using a shovel at each test location. If the deck is covered in debris then it should be cleared of excessive dirt prior to laying out the testing grid. If the site is known to be covered in dirt well in advance of testing, it should be cleaned using mechanical means and then washed using a low pressure, high volume water spray.

3.3.4 WETTING THE DECK

Moisture content in a concrete bridge deck is constantly changing. Several tests were performed in the late 1970's and early 1980's, and it was noted that results (and the ability to take readings) varied depending on the moisture content of the deck. Decks with a higher moisture content such as a few days after rain, had stable CSE readings. Decks will always have different moisture contents due to weather conditions and resistance (IR) losses. Therefore the deck is to be flooded with water (and a wetting agent to speed up penetration) prior to testing. This creates constant moisture content in the deck.

The concrete deck should always be pre-wetted prior to CSE testing. When the half-cell is placed at a test location and the voltage result does not fluctuate at all, then the deck has sufficient moisture content. Do not test without pre-wetting the deck, even if the voltages do not fluctuate prior to wetting.

The concrete surface should look wet during testing. If the surface dries prior to testing, the concrete must be made wet again. Do not take CSE tests in standing or ponded water.

The time it takes for the water to penetrate into the concrete to allow for CSE testing varies. Generally 10 minutes should be sufficient for the water to penetrate into the deck enough to allow testing. It is acceptable to wet the deck several times, if necessary, during testing. The time required for water to penetrate into the deck sufficiently will vary with the amount of water used, the initial moisture content of the deck, deck protection systems, and current weather conditions. This time can be greatly decreased by using a wetting agent in the water.

3.3.4.1 Wetting Agent

Adding a wetting agent to the water will speed up the penetration of the water into the deck. Household detergents can be used, but do not use soaps that create suds when agitated. There is no formula for the amount of wetting agent to use since the properties of different products vary, although ASTM–C876 does provide some guidelines. However, more wetting agent should be used if the water is beading on the deck, and less wetting agent should be used if there are suds or white soap visible on the deck after wetting.

3.3.5 Electrical Continuity

The main components necessary for CSE testing in bridge decks are a mat of reinforcing steel in the concrete, and the means to connect to this mat electrically. CSE testing is based on the reinforcing steel mat being in tight contact to conduct the voltage readings.

Decks with asphalt, chip seal, and polymer (epoxy) wearing surfaces are deemed to be testable. Polymer overlays have been designed to be breathable and are therefore sufficiently permeable to be tested with CSE.

Small gaps between bars can introduce errors in the CSE test results. This can occur with precast girders with longitudinal grout keys. Waterproof deck protection systems such as membranes, polymer modified asphalt, and epoxy coated steel can also make decks non-testable. CSE cannot be used with watertight barriers until the barrier starts to break down. Therefore the electrical continuity of the steel has to be verified prior to CSE testing.

Some potentially non-testable situations include:

- Decks with impermeable membranes and/or epoxy coated reinforcement. If the membrane or coating is in good condition, these sites will not be testable because of the barrier between the steel and the electrode.
- Many precast girders are not testable because the reinforcement is not electrically continuous between multiple girders.
- Decks with cathodic protection systems are not testable due to the presence of the current from the cathodic protection system.
- Bridges with galvanized reinforcement are testable. However, the results must be interpreted differently due to the presence of the zinc.

Examples of where the non-testable situations listed above may be testable include:

- Decks can become testable if membranes that were originally impermeable have been placed incorrectly or have aged.
- Decks with epoxy coated reinforcement where the epoxy coating has deteriorated sufficiently to allow continuity to exist in the reinforcing steel can be testable. Epoxy coated bars where the epoxy has chipped at bar intersection points due to construction practices have also been found to be testable on some sites.
- Precast girders that are electrically connected through deck joints that are connected to the reinforcing steel in the girders can be testable.
- Decks with cathodic protection can be tested if the cathodic protection has been turned off for at least a month prior to testing.

3.3.5.1 Verifying the Electrical Continuity

Verify the electrical continuity with resistance measurements from one end of a deck span to the opposite end, typically corner to opposite corner. To validate electrical continuity, perform continuity checks on each span for simple span bridges, and at each deck joint for continuous bridges. A measured resistance of less than 0.004 ohms indicates good continuity, while 0.003 ohms or less is ideal.

The ultimate source for continuity checks are at the deck rebar itself. This is not practical however since the rebar is embedded in the concrete. Verify continuity using steel elements that may be electrically connected to the reinforcing steel. Possible locations include anchor bolts at bridgerail posts, deck joints (gland or fingerplate), or deck drains. Testing directly to the reinforcing steel is considered a last resort, used when other locations have failed. Refer to Section 3.3.6.2, 'Verifying CSE Test Results', for additional information.

3.3.5.2 The Ground Connection

A proper electrical connection between the voltmeter and the reinforcing steel in the deck is one of the most important aspects of CSE testing. Without establishing a proper ground connection, testing will not produce accurate results, if any.

A ground connection that is connected directly to the reinforcing steel would be ideal, however the deck reinforcement is not readily accessible. Chipping down through the concrete to connect directly to the steel is used only as a last resort as it is time consuming and destructive. A non-destructive method of electrically connecting to the steel is to ground to another steel element that is electrically connected to the rebar.

The ground connection point must be a location that has an electrical resistance below 0.004 ohms, as described in Section 3.3.5.1. Any location that meets this criteria can be a valid ground connection location. Thus bridgerail anchor bolts, drains, expansion assemblies, exposed rebar, and snow grates are all possible ground connections.

Tight, solid connections are required between the voltmeter's grounding cables and the ground connection. A clamp at the end of the grounding cable is typically used. Ensure that the connection between the clamp and the ground location is free of rust and other debris. Verify the connection is solid by checking the resistance of the clamp.

3.3.5.3 Multiple Ground Connections

If the entire length of the bridge is not electrically continuous, but each separate span has electrical continuity within itself, then multiple ground connections can be used to CSE test the bridge. If this is the case, verify each ground connection prior to testing and pay special attention to ensure that no parts of the bridge are tested using the incorrect ground location.

3.3.5.4 Connecting the Voltmeter

A high-impedance voltmeter should be used to collect the CSE readings as described in Section 3.2.2. The better the equipment used, the less chance of picking up stray current from nearby power lines or other influences.

Alberta Transportation has modified the voltmeter connection procedures described in ASTM-C876. The inspector is to connect the negative terminal of the voltmeter to the grounding cable and the positive terminal of the voltmeter to the half-cell. This will result in negative CSE test results.

3.3.6 CSE Testing

Watch for significant variation in the CSE readings. If suddenly the readings become higher, lower, or do not settle at the same rate, the ground connection may be broken, the voltmeter connections may have worked loose, or the grounding wire may be broken. Stop and verify the validity of the ground connection whenever this situation occurs.

Other causes of erroneous readings include, but are not limited to: the half-cell solution not being saturated, an insufficient amount of solution in the half-cell, the copper in the half-cell is dirty or corroded, or the deck is not wet enough for accurate results.

3.3.6.1 Concrete Patches

The inspector should attempt to avoid testing on small patches in the concrete deck. Whenever possible, take the CSE reading approximately 150 mm from the patch, but as close to the grid point as possible. This is to avoid high point readings that can be associated with concrete patches. CSE testing can be done on larger patches that have several grid points on them. The patches will generally have higher CSE readings, but this is an accurate representation of the deck condition since macro corrosion cells can be set up between the patched and unpatched areas.

3.3.6.2 Verifying CSE Test Results

In situations where the CSE readings are questionable or require additional verification due to protection systems such as very thick asphalt or polymer modified asphalt, the inspector can perform CSE tests on a few representative points through the protection system. The CSE results may then be verified by drilling through the protection systems at these locations and re-testing them. If the readings at the representative locations are the same as those obtained before drilling then the deck is considered testable.

ACP is considered to be testable even when over 50 mm thick, as long as sufficient water is used. Test holes should be drilled in the ACP to verify the results whenever verification is requested, the CSE readings look incorrect, or the values do not settle quickly.

This verification method can also be used when it is suspected that a membrane is interfering with CSE readings. However, the inspector must receive permission or clarification from the Department prior to drilling any holes in the membrane.

All holes must be patched with a Department approved patching material, consistent with the protection system that was drilled into.

3.4 THE CSE2 FORM – STRUCTURE INVENTORY INFORMATION

The inventory information found at the top of the Level 2 CSE Testing form (CSE2) contains the same inventory data found on the typical Level 1 and other Level 2 bridge and culvert inspection forms. Descriptions of these fields are found in Section 1.3.2 of the Level 2 Inspection Manual or Section 4 of the Level 1 BIM Inspection Manual.

Ensure the date of the Level 2 inspection is recorded in the header information on the first page. This date will be echoed onto the last page of the CSE2 form.

3.4.1 ADDITIONAL STRUCTURE INVENTORY INFORMATION

In addition to the inventory data in the header of the form, the CSE2 form provides additional information about the bridge structure. This section is located immediately below the header information on page one of the CSE2 form and is shown in Figure 3.6. Refer to Section 1.4 for a complete description of the Structure Information fields.

```
STRUCTURE INFORMATION:

No. of spans: ..    Span Types: .../...  Substructure Types: .../...
Span Lengths: ....-.....-.....-......m    Total Length: .....m
```

Figure 3.6 – CSE2, Additional Structure Information

3.5 WEATHER INFORMATION (WEATHER CONDITIONS, TEMP __ ºC)

Enter the weather conditions at the time of testing in the Weather Conditions field as shown below in Figure 3.7. Record the general weather (i.e. sunny, overcast with high winds, light rain, etc.). Also record the ambient temperature in degrees Celsius.

```
Weather Conditions: ______________________________________________ Temp: __ ºC
```

Figure 3.7 – CSE2, Weather Conditions at Time of Testing

3.6 SITE AND TESTING EQUIPMENT INFORMATION

Immediately below the Weather Condition field on page one of the CSE2 form, there is a section for the inspector to input specific information on the bridge site and the test equipment, as shown in Figure 3.8.

```
Equipment Make and Model No.: ___________________________________________________

X Increments (Length):  Number: ___  Length of Each: ___ m  Length of Last: ___ m
Y Increments  (Width):  Number: ___  Length of Each: ___ m  Length of Last: ___ m

Origin For Data: ________________________________________________________________

Electrical Ground Location and Type: ____________________________________________
```

Figure 3.8 – CSE2, Site and Testing Equipment Information

3.6.1 TEST EQUIPMENT MAKE AND MODEL NUMBER (EQUIPMENT MAKE AND MODEL NO.)

This text field allows the inspector to describe the test equipment used in obtaining the CSE test results. Specific information on the voltmeter is required in this field, including the model number.

3.6.2 X INCREMENT (LENGTH) INFORMATION (NUMBER, LENGTH OF EACH, LENGTH OF LAST)

There are three numeric fields in this section that describe the dimensions of the deck area that was tested. The X increments describe the length of the test area (parallel to the curbs).

Number - The total number of X increments (full or partial length increments).

Length of Each - The length of a full X increment in metres to the nearest 0.1 m. This increment will always be 1.2 m, unless specifically directed by the Department prior to CSE testing.

Length of Last - The length of the last X increment in metres to one decimal point. It will always be less than or equal to the 'Length of Each' field. To be consistent with historical data, this is given to the nearest multiple of 0.3 m (the nearest foot).

3.6.3 Y Increment (Width) Information (Number, Length of Each, Length of Last)

The three numeric fields found in this section are the same as the X increments defined in Section 3.6.2 above, except these fields are for Y increments (width), perpendicular to the curbs.

3.6.4 Origin for Data

This is a text field for the inspector to define which corner of the bridge is the CSE origin. The number of increments and the length of the last X and Y increments are based on this point. The method to locate the origin is defined in detail in Section 3.3.1. This field describes the origin point that was used so future testing can start at the same point.

The inspector may describe the origin by relating it to the compass direction. For example, the origin may be defined with respect to the southeast corner. The origin may also be defined with respect to the river flow, such as 'The origin is in the back-right corner when facing downstream'. Do not relate the origin in terms of a landmark that could be moved or changed, such as a sign.

3.6.5 Electrical Ground Location and Type

The inspector records the location of the electrical ground connection and the type of bridge element that the ground is connected to in this text field. For example, the ground connection may be described as 'Clamp on to deck joint over Abutment 2' or ' South curb anchor bolt, 5th rail post from east end'.

If more than one ground connection is used, identify all ground locations.

3.7 CSE Readings and Results

The CSE Readings and Results section is found at the bottom of page one of the CSE2 form. This section shows summaries and calculations from the recorded test data. The raw data is not presented in this section.

3.7.1 Span Information (Span Group, Span Type, and Span Numbers)

The span information fields are at the top of the CSE Readings and Results section of the CSE2 form as shown in Figure 3.9.

```
CSE READINGS AND RESULTS:
Span Group: _      Span Type: ___    Span Numbers: _____________________
```

Figure 3.9 – CSE2, Span Information

The Span Group is a numeric field. If the Department makes a special request to subdivide the CSE test results into different groups of spans, this field would define each group numerically, beginning with number 1. Typically all CSE results at a bridge site are presented in one analysis group, even if there are different span types within the group. Therefore the Span Group is typically the number 1. If the Department identifies the need to present multiple span groups, an additional CSE Readings and Results section is required for each group.

Identify all Span Types that are included in the Span Group. This is only the Span Types that were actually tested. For example, if CSE tests were performed on the welded girder (WG) main span and not the HC girder approach spans, the Span Type field would only be WG. If multiple Span Types were tested in the Span Group, then all Span Types would be identified, with the main span first and each following span separated by a slash.

All of the spans are numbered from south to north or from west to east, beginning with number 1. Note that span number 1 is not necessarily the same span as the CSE test origin. The origin location is defined in Section 3.3.1. Identify all of the span numbers that were tested in the Span Group in this field, separated by commas. For example, if the site had 3 spans, and all of them were tested, the Span Number field would be ‘1, 2, 3’.

Year	Wearing Surface Type	Percentage of Deck Area In The Range Indicated				
		Inactive Area			Transition	Active
		0.00-0.10	>0.10-0.20	>0.20-0.30	>0.30–0.40	>0.40

Figure 3.10 – CSE2, Percentage of Deck Area In The Range Indicated

3.7.2 CSE TEST YEAR (YEAR)

Identify the year that CSE testing is completed at the bridge site. The inspector is to use the first blank row. The additional rows are for historical data if the Department requests that it be brought forward.

3.7.3 WEARING SURFACE TYPE

Identify the wearing surface of the span group using the typical BIS codes. If multiple layers of wearing surfaces have built up over time, identify all wearing surfaces that have been placed (and are still present) on the concrete deck. The first wearing surface listed is the newest or top wearing surface.

For example, if the concrete deck had a high density concrete overlay placed on it, followed by an epoxy wearing surface and a chip coat, the Wearing Surface Type would be ‘R/E/H’.

3.7.4 PERCENTAGE OF DECK AREA IN THE RANGE INDICATED

Show the percent of deck area in the Inactive (0.00 to 0.30 V), Transition (>0.30 to 0.40 V), and Active (>0.40) fields. The Inactive range is further subdivided into three ranges; 0.00 to

0.10 V, >0.10 to 0.20 V, and >0.20 to 0.30 V. Keep in mind that these are just numerical ranges, as the true ranges would be negative values.

Because the values that go in these fields are percent areas, the values are more complicated than one would think. It is **not** just a matter of dividing up the test results into the separate categories and dividing the number of readings in the category by the total number of test points.

Additional test results are interpolated between the grid points at 0.3 m intervals using a linear distribution, thus creating a 0.3 m by 0.3 m grid of values. Once this is done, then the total number of test values in each range can be determined. The total number of values in a particular CSE range (based on the 0.3 m by 0.3 m grid spacing) are then divided by the total number of values to determine the percent of deck area in each range.

Do not include any curb readings or median readings in this calculation. Also take care not to interpolate test points that are located off of the bridge deck due to a skewed end.

Year	Wearing Surface Type	Average Deck Reading (Volts)	Standard Deviation of Deck Reading	Average Curb Reading (Volts)	Standard Deviation of Curb Reading
Comments:					

Figure 3.11 – CSE2, Average Reading and Standard Deviation for Deck and Curbs

3.7.5 AVERAGE READINGS AND STANDARD DEVIATION FOR DECK AND CURBS

The bottom section of the CSE2 form, page 1 contains fields for the Average Deck Reading, the Standard Deviation of Deck Reading, the Average Curb Reading, and the Standard Deviation of Curb Reading as shown in Figure 3.11. There are also columns for the test Year and the Wearing Surface Type. The values in these two columns will be the same as described in Section 3.7.2 and 3.7.3.

To obtain the Average Deck Reading, add the values from the actual test results (no interpolated results) from the deck and divide by the total number of readings. Do not include any curb or median readings. Record the Average Deck Reading in volts to 3 decimal places. The value is a negative.

Calculate the Standard Deviation of the Deck Readings and record it in the proper field. This is also given to 3 decimal places. Only use actual test results in this calculation, no interpolated values. Do not include any curb or median results.

Calculate the Average Curb Reading, and the Standard Deviation of Curb Reading as described in the previous two paragraphs, only using the curb readings instead of the deck readings.

3.7.5.1 Comments

At the bottom of the page there are four lines provided for the inspector to make any additional comments that relate to the testing or the results.

3.8 OTHER CSE2 DATA – LAST PAGE

Refer to Section 1.5 for instructions on completing the last page of the CSE2 form. The last page shares a common format with the other Level 2 forms.

3.9 SUPPLEMENTARY INFORMATION

The CSE test method used by the Department is very similar to ASTM-C876 “Standard Test Method for Half-Cell Potentials for Reinforcing Steel in Concrete”. There are subtle differences in the procedures, but the ATSM document can be referenced for additional background information.

In addition to the Level 2 CSE2 form, contour maps are an effective visual method of presenting the CSE test results. When the Department requests a contour map to be submitted with the CSE test results, it should have contour lines at 0.100 V intervals. The area between the contour lines should have solid colour backgrounds. The Inactive range should be white or light yellow, the Transition range is coloured bright yellow, and the Active range is red.

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Bridge File Number : ....
Legal Land Location: ...-..-...-..-.
Latitude/Longitude : ..../.........
Road Auth./Region : .../R.
Bridge or Town Name: ....
Stream Name : ....
Highway #:Cntrl Sec: ....:...
Road Classification: ....-...
AADT/Year : .-....../..
Detour Length : ...km

Structure Usage : ..
Year Built : ../..
Clear Roadway/Skew: ....m/...Deg

Prev. Insp. Date : ____/__/__ (YMD)
Insp. Req'd Date : ____/__/__ (YMD)
(based on ____________________)

Current Insp. Date: ____/__/__ (YMD)
Inspector's Code : ____

STRUCTURE INFORMATION:

No. of Spans: .. Span Types: .../... Substructure Types: .../...
Span Lengths: ....-....-....-....-.....m Total Length: .....m

Weather Conditions: ____ Temp: __ °C

Equipment Make and Model No.: ____

X Increments (Length): Number: ___ Length of Each: ___ m Length of Last: ___ m
Y Increments (Width): Number: ___ Length of Each: ___ m Length of Last: ___ m

Origin For Data: ____

Electrical Ground Location and Type: ____

CSE READINGS AND RESULTS:

Span Group: _ Span Type: ___ Span Numbers: ______________________

Year	Wearing Surface Type	Percentage of Deck Area In The Range Indicated				
		Inactive Area			Transition	Active
		0.00-0.10	>0.10-0.20	>0.20-0.30	>0.30–0.40	>0.40

Year	Wearing Surface Type	Average Deck Reading (Volts)	Standard Deviation of Deck Reading	Average Curb Reading (Volts)	Standard Deviation of Curb Reading

Comments:

LEVEL 1 INSPECTION (INFORMATION ONLY)   Level 1 date: ____/__/__

Structural Condition Rating: __%   Sufficiency Rating: __% Estimated Remaining Life of Structure: __ years Special Comments for Next Inspection:
Next Scheduled Level 1 inspection: ____/__/__   Current Cycle: __months

ITEMS REQUIRING IMMEDIATE ATTENTION:

LEVEL 2 INSPECTION SPECIAL REQUIREMENTS:

Y => Snooper: __   Lift: __   Traffic control: __   Boat: __   Ladder: __ Other: ____

INSPECTOR:

Recommended Cycle __ months OR Next Insp. Date ____/__/__ (blank for default) Recommended Additional Cycles: _ (blank for default, 0 for discontinue)		
Inspector’s Code: ___	Inspector’s Name: __________________________	Class: _
Assistant’s Code: ___ Assistant’s Code: ___	Assistant’s Name: __________________________ Assistant’s Name: __________________________	Class: _ Class: _
Comments: ____ ____		

REVIEWER: Review Date: ____/__/__

Approved Cycle __ months OR Next Insp. Date ____/__/__ (blank for default) Approved Additional Cycle: _ (blank for default, 0 for discontinue)\		
Reviewer’s Code: ___	Reviewer’s Name:____________________________	Class: _
Comments: ____ ____		

Default No. of Inspections: _ Default Cycle: __ months	Number completed to date: __ Next Inspection Required Date ____/__/__

4.0 CHAPTER 4 – CHLORIDE TESTING (CHL2)

4.1 INTRODUCTION

The Level 2 Chloride Test is a field test to determine the chloride content of concrete. In bridge applications, it is most often performed on a deck or curb because these are the areas of the bridge that are commonly exposed to the application of de-icing salt.

Chlorides diffuse into concrete surfaces. Horizontal concrete surfaces are more likely to have higher chloride concentrations than vertical concrete surfaces since a horizontal surface allows the applied chloride build up and permeate into the concrete, while a vertical surface allows the chloride application to 'run-off'. The chloride test method can also be used on other concrete areas which are exposed to deicing salt, such as the splash zone of piers on underpasses, substructure elements exposed to leakage from the deck, or superstructure elements which project above the deck and may be exposed to road splash.

4.1.1 BACKGROUND - THE NEED TO DETERMINE CHLORIDE CONTENT

Concrete is a permeable material. It is also typical for concrete components to have some cracks. Therefore, two of the elements necessary for corrosion to occur, oxygen and water can readily penetrate into concrete and reach the embedded steel reinforcement. Water acts as the electrolyte in this corrosion process.

Concrete's alkalinity acts to protect the embedded steel from corroding. In new concrete, the pH is greater than 12. This highly alkaline environment causes a protective layer to form on the steel reinforcement and the rebar is said to be in a passivated state. When the concentration of chloride ions at the rebar is high enough or when the carbonation front reaches the rebar, this passive layer is destroyed and corrosion begins. The concentration of chloride ions necessary to initiate corrosion is about 0.030% by weight of concrete (or approximately 0.7 kg/m^3).

In non-marine environments, the primary source of chloride in concrete is in the form of applied de-icing salts. However, there are other sources such as calcium chloride used as dust control or as an admixture in concrete. Corrosion occurs in areas that are exposed to the application of chlorides - decks, curbs, splash zones and areas subjected to leakage.

There are also some chlorides that occur naturally in aggregates. These chlorides are considered 'locked in' and do not contribute to the corrosion process. However, during the sampling process the concrete is pulverized and the 'locked-in' chloride concentration in the aggregate is measured along with the chlorides in the surrounding paste. Although these are generally trace amounts of chlorides, the inspector should try to account for these background chlorides to determine the 'active' chloride concentration of the concrete whenever possible.

4.2 TEST METHOD

The extraction of the concrete powder samples has evolved from SHRP-S-328, Volume 6: 'Method for Field Determination of Total Chloride Content' and SHRP-S-330, Appendix F: 'Standard Test Method for Chloride Content in Concrete Using the Specific Ion Probe'. Although very thorough, the methods described in this procedure were not practical for a mobile field application. In Alberta, the samples are generally collected quickly such that the bridge site can be promptly reopened to traffic. The following outlines a practical test method:

4.2.1 MARK OUT THE TEST LOCATIONS

- Measure or reference test locations and mark the surface to be tested using temporary markers.
- Samples are taken *beside* the temporary mark so the mark itself does not contaminate the sample.
- Choose locations that will avoid cracks, delaminations, rebar, voids, and strands. Refer to Section 4.3.1 for more information.

4.2.2 PULVERIZE THE CONCRETE SAMPLE

- Drill into the concrete and create a pulverized sample.
- Use a 15-45 mm diameter drill bit. Smaller drill bits will not create sufficient powder to allow for rapid chloride tests, lab tests or any further duplicate tests. The powder from these smaller holes is also more difficult to collect than that from larger diameter holes. Larger drill bits generate a greater amount of powder sample that is easier to collect. Further, larger drill bits are less susceptible to local sampling errors that can be caused by drilling into concrete samples where the average aggregate diameter is larger than the diameter of the drill bit. However, a larger bit is more difficult to control during drilling.
- Measure the depth of the drill bit. Sample depth ranges should be accurate to 3-5 mm. The tip of the drill bit is cone shaped and accounts for the variance.

4.2.3 COLLECT THE CONCRETE SAMPLE

- After drilling down to the required depth, use the drill bit to bring the concrete powder out of the hole by allowing the drill bit to spin in the hole without applying any downward pressure. Scrape this powder into a container.
- Collect the powder that remains in the hole using a vacuum device or small scoop.
- Once the sample has been collected, seal the container and label the sample as described in Section 4.3.3.

4.2.4 PREVENT CROSS-CONTAMINATION

- Take care not to cross-contaminate the powder samples.

- Sources of cross contamination are :
    - Powder left in the test hole between samples
    - The drill bit
    - The powder collection vacuum or scoop
- Help prevent cross contamination by using compressed air to blow out the test hole, cleaning the drill bit, and cleaning the vacuum or scoop between samples.

4.2.5 FILL TEST HOLES

- After all samples are collected and the holes blown out with compressed air, they are to be filled using an approved patching material, generally a rapid setting concrete.
- Avoid trapping voids or large air pockets when filling the test holes.
- Ensure that the patching material is mixed to the manufacturer's specifications. Do not add more water to an approved material to make it more fluid.

4.2.6 RAPID CHLORIDE TESTS

Rapid chloride tests are performed on all of the powder samples to determine the chloride content (percent chloride per unit weight of concrete). Currently only two rapid chloride test systems have been approved for use. They are:

- James Instruments CL-1000
- Germann Instruments Rapid Chloride Test (RCT), acid soluble test method

Each set of equipment will have its own specific test procedure for the samples. The inspector is to follow the manufacturer's instructions to test the samples accurately. The basic steps are to:

- Calibrate the rapid chloride test using calibration solutions of known chloride concentration. The results will be in mV. This will be used to correlate mV readings to chloride contents.
- Plot the calibration solution test results on the provided graph included in the RCT kit.
- Weigh or measure the necessary amount of concrete powder sample.
- Add the concrete powder sample to the known amount of test solution.
- Shake the powder mixed into the test solution for at least 5 minutes.
- Measure and record the mV reading of the test solution with the concrete powder.
- Plot the mV readings on the provided graph with the calibration results on it to convert the mV reading to a chloride concentration.
- Clean all of the test equipment prior to testing another sample.

4.3 TESTING LOCATIONS

Chloride testing is destructive because holes are drilled into the component that is being tested. This testing is also time-consuming as the samples must be extracted and tested and the holes re-patched. The destructive and time-consuming nature of the test means that only a limited number of samples can be gathered and tested. Testing on these samples will reveal the chloride content only at the locations where the samples were gathered. Therefore, it is essential that the test locations be representative of the entire component being tested.

4.3.1 REPRESENTATIVE TEST LOCATIONS

The chloride sample locations are to be taken from representative areas showing the average condition of the component. Do not take samples from delaminated areas, patched areas, birdbaths, the top of cracks, or from any other non-representative location. Chlorides will generally be higher in these deteriorated areas and will therefore not be representative of the entire component being tested.

Take special care to avoid reinforcing steel, prestressed tendons, or drilling completely through the deck or through box girders into the void as the sample will be lost.

On concrete decks, the standard practice is to obtain samples from 12 test locations for each span type. Therefore a bridge that has 5 spans, all of the same type, will only have a total of 12 test locations. A bridge that has a main span of one type, and approach spans of another type will have a total of 24 test locations or 12 test locations for each span type.

The sample locations for each span type are spread out across the deck in a diagonal line from one corner of the deck to the other opposite corner. The samples should be approximately equidistant from each other. This ‘template’ approach allows samples to be taken from the gutters, deck interior, and the wheel paths. Avoid deteriorated areas as described above. Figure 4.1 shows typical representative chloride testing sample locations.

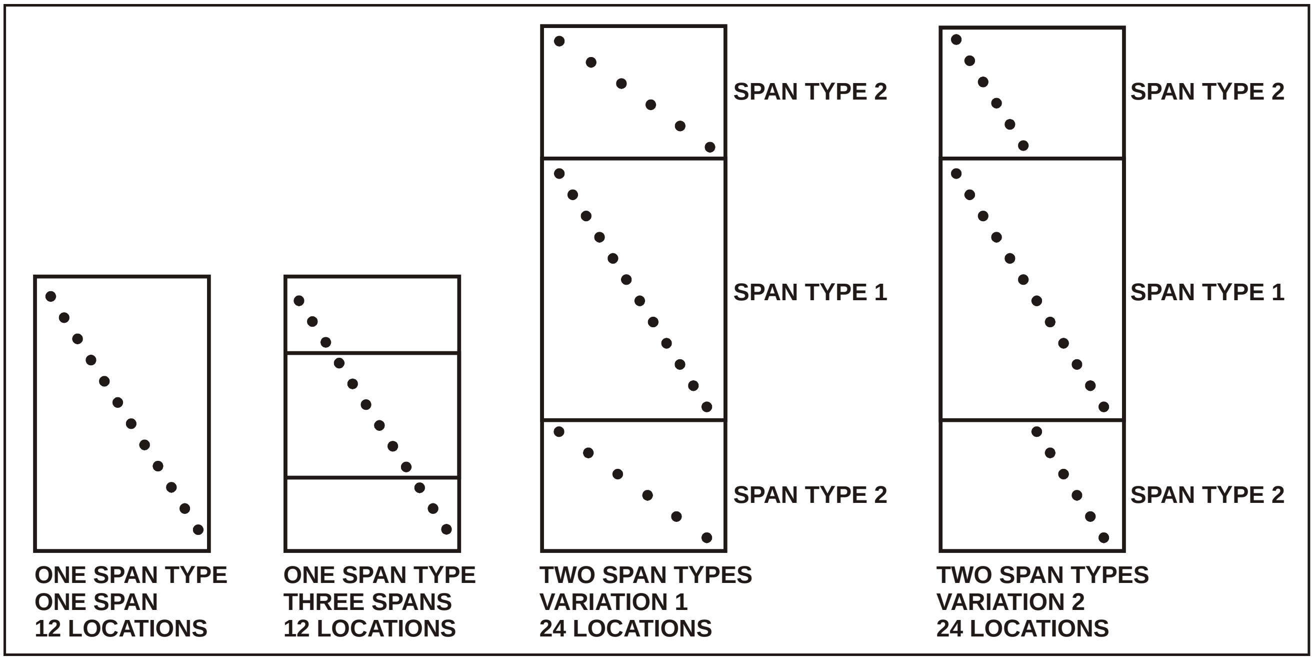


Figure 4.1 – Sample Chloride Test Locations for Various Span Configurations

4.3.1.1 Testing Through a Waterproof Membrane

Do not perform chloride testing on any bridge decks with a waterproof membrane under an asphalt wearing surface unless specifically directed by the Department. The destructive nature of the test will create several holes in the membrane and greatly reduce its functional life. If the presence of a waterproofing membrane is suspected or discovered unexpectedly on the first test hole, the inspector is to contact the appropriate Department representative for further instructions. When unsure, do not drill holes in the membrane.

It is acceptable to test through a polymer (epoxy) wearing surface as these are designed to be breathable. They are not watertight like membranes placed under the asphalt, and they contain pinholes throughout.

4.3.2 SAMPLING DEPTHS

Chlorides in contact with the exposed surface of the concrete can diffuse into the concrete. Over time, this produces a gradient of chloride concentration within the concrete. At the exterior of the concrete, the concentration of chlorides is highest. This concentration decreases with increasing depth towards the interior of the concrete.

It is currently accepted that there is a high probability of corrosion developing on uncoated reinforcing steel when there is a chloride concentration of 0.030% by unit weight in the concrete at the depth of the rebar. Therefore, it is desirable to know the concentration of chlorides at the surface of the concrete. This chloride concentration, when used in conjunction with chloride diffusion models, provides information as to when it is possible to reasonably expect the concentration of chloride at the rebar to reach the concentration necessary to initiate corrosion.

4.3.2.1 Typical Sample Depths

To develop a better understanding of the changing chloride concentration with depth in the concrete, chloride samples must be collected at various depths at the same test location.

In the field, chloride samples are typically taken at three depths: surface, mid-depth and the third or deepest sample depth. The top or surface sample depth should have the highest chloride concentration. This highest concentration compels the diffusion of chlorides into the concrete. The middle sample depth shows how the chlorides have penetrated into the deck over time. The third and deepest chloride sample depth can usually be used as an indication of the background or ‘locked in’ chloride concentration. However, it should be noted that chloride ions may have actually diffused to this third, deepest depth from the surface. Also, if chlorides were added to the concrete in the form of an admixture or with the mixing water used in making the concrete, they will be present throughout the concrete. Although chlorides from admixtures or the mixing water are not ‘locked in’ chlorides, they will nonetheless contribute to the corrosion of the reinforcing steel.

The three sample depths have been standardized by Alberta Transportation to allow for consistent test results that can be monitored at each particular site over time. The sample depths are referred to as nominal depths since the powder sample is actually taken from a range of depths. A depth of 0 mm is at the top of the concrete surface, below any ACP or polymer overlays. The standard sample depths taken at each test location are as shown in Table 4.1 below:

Sample	Nominal Depth	Actual Range of Sample Depth
A	12 mm	5 - 20 mm
B	50 mm	40 - 60 mm
C	100 mm	90 - 110 mm

Table 4.1 – Typical Chloride Sample Depths

Chloride sample depths and ranges other than those suggested in Table 4.1 may be requested by the Department in specific situations.

When obtaining the sample the inspector must ensure that the depth is measured accurately to 3-5 mm. The inspector must also ensure that the depths of powdered sample that are not required, such as from 0-5 mm, 20-40 mm and from 60-90 mm are not inadvertently collected. This added attention to detail when collecting powder samples will help prevent the sample from being cross-contaminated with powder from depths outside the intended range. Note that the top or surface 5 mm of the concrete surface is discarded because chlorides on the surface have not yet penetrated into the concrete.

4.3.2.2 Additional Sample Depths

There are cases when the Department requests a fourth chloride sample depth at each test location. This fourth sample typically has a nominal depth of 120 mm or an actual range of sample depth of 115 to125 mm. This forth sample depth is generally taken from bridge decks where the depth of the top mat of reinforcing steel is approximately 100 mm. This can occur when a concrete overlay has been placed on top of the existing concrete wearing surface without removing any, or very little of the original concrete first. The fourth depth in this case, would be used to collect 'background' chloride content readings.

4.3.3 LABELING OF SAMPLES

The samples are to be labeled with the bridge file number, sample number (location), sample depth, and the date the test sample was taken, as shown in Figure 4.2.

If the inspector chooses to number the test location of their sample as shown in Figure 4.2, the inspector must also record the actual location on the bridge that the test sample number corresponds to. The actual location of the sample is required and will be recorded on page 2 of the CHL2 inspection form. Refer to Section 4.7.2.1 for more details.

BRIDGE FILE:	**12345W**
TEST SAMPLE:	**1B**
SAMPLE DEPTH:	**50 mm (40 – 60 mm)**
TEST DATE:	**July 15, 2003**

Figure 4.2 – Sample Label for a Chloride Test Sample

4.4 QUALITY ASSURANCE

When the rapid chloride tests are completed, the results should be reviewed to determine if re-testing is necessary due to irregularities in results. When results are not in a typical pattern of the higher chloride concentrations nearer the surface and the lower chloride concentrations from the deeper samples, determine the reason for these irregularities. A typical cause of deviation from the expected results is when a concrete overlay was placed on the original deck and the 50 mm samples contain more chlorides than the newly placed concrete at the 12 mm depth.

Outliers that do not follow the pattern for the specific site should be re-tested. Perform an additional rapid chloride test on the remaining powder sample obtained from that location. If the results are the same, an additional sample may have to be collected from a new test location beside the previous location.

4.4.1 LABORATORY TESTING

It is also desirable to provide an independent check on the field testing procedure. Therefore, a minimum of 1 in 6 sample locations, selected at random, is to be sent to an independent, Department approved, laboratory for further tests. All sample depths collected at the location are to be sent to the lab. Therefore, if sample locations 2 and 8 were selected for lab testing, the 12, 50, and 100 mm samples would be sent from each location. Lab results are later recorded on page 2 of the CHL2 form as described in Section 4.7.3.

The lab samples are to be tested in accordance with the Department's test procedure TLT-520, 'Alberta Test Procedure for Total Chloride Content in Cement, Mortar and Concrete'. TLT-520 is a titration method that determines the chloride content of a dry powder concrete sample by a potentiometric titration of chloride with silver nitrate. This method is included in the supplemental information at the end of this chapter, Section 4.10.

TLT-520 is similar to AASHTO Method T-260, but TLT-520 requires duplicate testing of all chloride samples. Both results must be within 0.007% chloride per unit weight of concrete of each other. If the two test results from a single sample are apart by more than 0.007% chloride, a 3rd test is required. If the 3rd test is within the +/-0.007% chloride tolerance with one of the previous tests, then these two are considered to be correct and the outlier result is discarded. Ensure that sufficient sample, a minimum of 6 g, has been collected at each test location to accommodate two rapid tests and three lab tests.

4.4.2 PERIODIC CHECKS WITH KNOWN CHLORIDE CONCENTRATIONS

Rapid chloride tests should be performed on powder samples of known chloride concentrations after every 2-3 months of use or whenever problems are suspected with the test equipment. These samples of known concentration can be purchased from the RCT kit suppliers. These known samples should also be sent to the lab for quality assurance testing at least once per test season or if problems are suspected with the lab.

4.5 THE CHL2 FORM – STRUCTURE INVENTORY INFORMATION

The inventory information found at the top of the Level 2 Chloride Inspection form (CHL2) contains the same inventory data found on the typical Level 1 and other Level 2 bridge and culvert inspection forms. Descriptions of these fields may be found in Section 1.3.2 of the Level 2 Inspection Manual or Section 4 of the Level 1 BIM Inspection Manual.

Ensure the date of the Level 2 inspection is recorded in the header information on the first page. This date will be echoed onto the last page of the CHL2 form.

4.5.1 ADDITIONAL STRUCTURE INVENTORY INFORMATION

In addition to the inventory data in the header of the form, the CHL2 form provides additional information about the bridge structure. This section is located immediately below the header information on page one of the CHL2 form, and is shown in Figure 4.3. Refer to Section 1.4 for a complete description of the Structure Information fields.

```
STRUCTURE INFORMATION:

No. of spans: ..    Span Types: .../...  Substructure Types: .../...
Span Lengths: ....-....-....-....-.....m    Total Length: .....m
```

Figure 4.3 – CHL2, Additional Structure Information

4.6 LEVEL 2 CHLORIDE TESTING SUMMARY – PAGE 1

The chloride test results are summarized on page one of the CHL2 form, as shown in Figure 4.4.

CHLORIDE TESTING SUMMARY INFORMATION:

Test equipment make and model:____

Number of components tested: __

Comp No.	Comp Type	Component Description	Depth (mm)	Avg. % Cl	Depth (mm)	Avg. % Cl	Depth (mm)	Avg. % Cl	Depth (mm)	Avg. % Cl
__	_____	___________	_____	_____	_____	_____	_____	_____	_____	_____
__	_____	___________	_____	_____	_____	_____	_____	_____	_____	_____
__	_____	___________	_____	_____	_____	_____	_____	_____	_____	_____

Figure 4.4 – CHL2, Chloride Testing Summary Information

4.6.1 TEST EQUIPMENT MAKE AND MODEL

This text field is used to describe the test equipment used in obtaining the Rapid Chloride Test results. Additional information on Rapid Chloride Tests is found in Section 4.2.6.

4.6.2 NUMBER OF COMPONENTS TESTED

This is a numeric field for the total number of components tested. A maximum of three components can be summarized on this page.

4.6.3 COMPONENT NUMBER (COMP NO.), TYPE (COMP TYPE), AND DESCRIPTION

These fields are brought forward from the inspection data pages that follow. List the component number, type and description for each row. Detailed information regarding bridge components is found in Section 4.7.1.

4.6.4 SAMPLE DEPTHS AND AVERAGE CHLORIDE CONCENTRATIONS (DEPTH (MM) AND AVG. % CL)

These numeric columns are for the inspector to summarize the chloride test results. There are four columns in this summary, each column has a Depth and Average Percent Chloride

(Avg. % Cl) field. The leftmost column is for the shallowest depth, and the depths increase with each column to the right.

The Average Percent Chloride column is the average of all of the test results at a specific depth, for each component type. These values are the same as calculated at the bottom of page 2 of the CHL2 form as described in Section 4.7.4.

4.6.5 COMMENTS

At the bottom of the page there are four lines provided for the inspector to make any additional comments that relate to the testing or the results.

4.7 REPORTING CHLORIDE TEST RESULTS – PAGE 2

The second page of the CHL2 form is for the inspector to record all information regarding the chloride test results. Field test results, quality assurance results and summary information are all shown on this data page.

A separate data page is to be used for each different component that is tested. Note that different span types are considered to be different components. More than one data page may be used for a particular component if required.

4.7.1 CHLORIDE TEST DATA – HEADER INFORMATION:

The following header information shown in Figure 4.5 appears at the top of each page of inspection data. It serves as a summary for the component that is being tested for chlorides.

```
CHLORIDE TEST DATA:

Component No. __  Component Type: ______  Component Description: _______________
```

Figure 4.5 – CHL2, Chloride Test Data Component Information

4.7.1.1 Component Number (Component No.)

If chloride tests are performed on multiple bridge components at a particular site, a separate CHL2 page is used to record the test results for each component. Assign a number to each of the different components and record the component number in this field. Begin numbering with component 1.

4.7.1.2 Component Type

Identify the name of the component category that is being tested in this field. Examples of some different component types are deck, curbs, piers, and abutments. Only record one component type per page. Different span types are considered to be separate components and require their own page.

4.7.1.3 Component Description

The component description is a text description of the component being tested. This field should describe the Component Type in more detail. For example, if the Component Type was ‘deck’ then the Component Description would be the span type and the span numbers if there was more than one span type.

4.7.2 RAPID CHLORIDE TEST RESULTS

The main body of the form as shown in Figure 4.6 is where the inspector records the location and the results of the chloride tests for each component. Rapid Chloride Test (RCT) results are presented first near the top of the form. Quality Assurance (laboratory test results) follow the RCT results, and average results are at the bottom of the page.

On the CHL2 form there is the Test Location column, followed by four sets of three columns across the page. The three columns are the Sample Number, the Sample Depth, and the Chloride Concentrations, and they are repeated four times across the page.

Each row on the CHL2 data page is only used for samples that are taken at the same location and include the different depth samples taken at the location. The leftmost column is for the test sample that is closest to the surface. The samples become deeper with each set of columns to the right.

There are 24 rows for rapid chloride tests on each inspection data page. Only show results from a single component on a data page. The inspector may use additional pages for a single component if required.

TEST LOCATION	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL
RAPID (RCT) RESULTS												

ROWS CONTINUE…

Figure 4.6 – CHL2, Rapid Chloride Test Data

4.7.2.1 Recording Chloride Test Location (Test Location)

Record the chloride test location in the far-left column to the nearest 0.1 m.

In order to describe where the samples were taken from, the inspector may want to reference the chloride test locations to obvious reference points at the site. For example, ‘5.0 m N of S abut, 2.3 m W of E curb’.

Another method to describe chloride test locations on a bridge deck is to define a corner of the bridge as the origin for an X-Y coordinate system of length and width in the Comments section at the bottom of the page. Any corner could be selected as the origin, but for consistency, the origin from CSE testing should be used whenever possible. Refer to Section 3.3.1 for additional information.

Once the origin is clearly defined in the comments, then the inspector can record the two coordinates of length and width in the Test Location field for each row on the CHL2 form, as shown in Figure 4.7.

4.7.2.2 Sample Number and Chloride Concentration (No., Depth (mm), % CL)

The Sample Number columns simply provide a numbering system to label the samples. The samples at different locations are numbered down the page with a different row for each different location. Number the locations using integers such as 1, 2, 3, and so on.

Samples that are taken from different depths at the same location are labeled alphanumerically, as in A, B, C, and so forth, with ‘A’ being the most shallow depth at that location.

Therefore the columns across the page for four depths are sample numbers 1A, 1B, 1C, and 1D. The next row would be the second location and the samples would be labeled 2A, 2B, 2C, and 2D across the page. Refer to Figure 4.7 for a detailed example.

4.7.2.3 Sample Depth (Depth (mm))

The Depth columns are for the inspector to record the nominal depths of all of the test samples. Again the depths are recorded across the page with one test location per row from shallowest to deepest. Therefore if there were four chloride depths at the sample location, they would be 12 mm, 50 mm, 100 mm, and 120 mm, as shown in Figure 4.7.

4.7.2.4 Chloride Concentration (% CL)

The Chloride Concentration (% CL) column is where the rapid chloride test results are recorded for each sample. It is recorded as a percent of chloride per unit weight of concrete to 3 decimal places.

TEST LOCATION	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL
RAPID (RCT) RESULTS												
(5.2 m, 0.7 m)	**1A**	**12**	**0.126**	**1B**	**50**	**0.032**	**1C**	**100**	**0.022**	**1D**	**120**	**0.004**
(25.4 m, 1.8 m)	**2A**	**12**	**0.112**	**2B**	**50**	**0.025**	**2C**	**100**	**0.021**	**2D**	**120**	**0.009**
(41.3 m, 2.9 m)	**3A**	**12**	**0.096**	**3B**	**50**	**0.029**	**3C**	**100**	**0.015**	**3D**	**120**	**0.007**
Comments:												
The origin (0,0) used to locate sample locations is the SE corner of the deck, same as the CSE origin.												
The format is (length, width) away from the origin in metres.												

Figure 4.7 – CHL2, Sample of Completed Section, Page 2

4.7.3 RECORDING LABORATORY CHLORIDE TEST RESULTS

The inspector records the laboratory chloride test results in this section, as shown in Figure 4.8. All of the same fields and formatting are used as in the Rapid Chloride Test Results section as described in Section 4.7.2.

The samples from 1 of every 6 test locations are sent to an approved laboratory for further testing. All sample depths collected at the test location are sent to the lab, for example the 12, 50, and 100 mm samples from the same location would be sent to the lab. The laboratory performs 2 tests on these samples, and the results from both of these tests are recorded in the Laboratory Results section of the CHL2 form.

If a third laboratory test is required to verify results only record the two confirmed results in this section. The third result, the outlier, is not recorded on the Level 2 form. Refer to Section 4.4.1 or TLT-520 for more information on using a third laboratory test to verify results.

TEST LOCATION	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL
LABORATORY RESULTS												

Figure 4.8 – CHL2, Laboratory Chloride Test Results

4.7.4 AVERAGE OF CHLORIDE TEST RESULTS

Calculate the average rapid chloride test results for each test depth and record them at the bottom of the CHL2 form, as shown in Figure 4.9. Repeat the process with the lab results. All of the same fields and formatting are used as described in Section 4.7.2, Rapid Chloride Test Results.

TEST LOCATION	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL
AVERAGES												
LAB AVERAGES	***		***			***			***			
RCT AVERAGES	***		***			***			***			

Figure 4.9 – CHL2, Average Chloride Test Results

4.8 OTHER CHL2 DATA – LAST PAGE

Refer to Section 1.5 for instructions on completing the last page of the CHL2 form. The last page shares a common format with the other Level 2 forms.

4.9 ADDITIONAL INFORMATION TO PROVIDE TO THE DEPARTMENT

The inspector is required to submit a copy of the rapid chloride test field worksheet with the Level 2 CHL2 form. This is the sheet that has the calibration chart that was used as well as the field results in mV. The inspector should also consider submitting the following:

- A visual record of sample locations such as a plan view of the bridge with sample locations marked.
- A bar chart showing the chloride concentration at the various locations and depths.

4.10 ALBERTA TRANSPORTATION TLT-520 TEST PROCEDURE

The following two pages contain the Alberta Transportation test procedure for chloride content in cement, mortar, and concrete (TLT-520). These are the guidelines that the approved laboratory must follow to determine the chloride content of the test samples.

GOVERNMENT OF THE PROVINCE OF ALBERTA
ALBERTA TRANSPORTATION

TECHNICAL STANDARDS BRANCH

TEST PROCEDURE TLT-520

ALBERTA TEST PROCEDURE FOR TOTAL CHLORIDE CONTENT IN CEMENT, MORTAR AND CONCRETE

1.0 SCOPE

1.1 This method describes the procedure for the determination of the total chloride content of dry hydrated portland cement, mortar or concrete. The method is limited to materials that do not contain sulfide, but the extraction procedure may be used for all such materials.

1.2 Total chloride content is determined by the potentiometric titration of chloride with silver nitrate.

2.0 APPLICABLE DOCUMENTS

2.1 ASTM C114 Standard Test Methods for Chemical Analysis of Hydraulic Cement, Section 19, Chloride.

2.2 H. A. Berman, Research Chemist, FHA, DOT Wash. D.C., "Determination of Chloride in Hardened Portland Cement Paste, Mortar and Concrete."
(This paper is based on Report FHWA-RD-72-12)

3.0 APPARATUS

3.1 Chloride Ion Selective Electrode with appropriate reference electrode.
Note: Carefully follow the instruction manual for set up, storage and maintenance of the electrodes as described by the manufacturer.

3.2 Potentiometer with millivolt scale readable to 1 mV or better.

3.3 Buret with 0.1 mL divisions.

3.4 Magnetic stirrer and Teflon stirring bars.

3.5 # 41 Filter Paper.

4.0 REAGENTS

4.1 Concentrated HNO_3 (specific gravity 1.42, Nitric Acid)

4.2 Standard 0.01 Normality NaCl (Sodium Chloride) solution; Oven dry reagent grade NaCl at 105 ºC for 1 hour, air cool, weigh out 0.5844 g, dissolve in distilled water and transfer to a 1 litre volumetric flask. Fill up to the mark with distilled water and mix.

4.3 Standard 0.01 Normality $AgNO_3$ (Silver Nitrate) solution; weigh 1.7000 g of reagent grade Silver Nitrate into a 250 mL beaker. Add about 50 mL distilled water to dissolve the Silver Nitrate, stir with glass rod until crystals dissolve. Add the mixture to a 1 litre volumetric flask, wash contents of beaker with distilled water into 1 litre flask. Fill flask to mark, stopper and mix to make homogenous.

To standardize the Silver Nitrate, titrate against 20 mL of 0.01 N NaCl prepared in 4.2 using millivoltmeter as described in procedure and calculate using the following formula:

$$N_1V_1 = N_2V_2$$

N_1 - Normality of Sodium Chloride
V_1 - Volume of Sodium Chloride Titrated
N_2 - Normality of Silver Nitrate

V_2 - Volume of Silver Nitrate needed to reach end point of Titration

$$N_2 = 0.2 / V_2$$

for 20 mL 0.01 N NaCl .

4.4 Fill Buret with $AgNO_3$ (Silver Nitrate).

5.0 PROCEDURE

5.1 Weigh duplicate 1 gram representative samples of powdered material under test into tared 250 mL beakers. Record exact weights to nearest 0.0001 g.

5.2 Add 10 mL of distilled water, swirling to bring powder into suspension.

5.3 Add 3 mL of 70% HNO_3 (Nitric Acid). Use a glass stir rod to mix and break up any lumps to form a slurry.

5.4 Heat the slurry rapidly to boiling. Do not allow to boil for more than a few seconds. Remove from heat.

5.5 Filter slurry into a 250 mL beaker using filter paper. Wash residue from beaker and stir rod through filter using hot distilled water. Wash contents of filter paper thoroughly with hot distilled water letting it drain. Repeat washing until a volume of about 75 mL is obtained. Allow filtrate to air cool to room temperature.

5.6 Fill the electrode(s) with the solutions recommended by the manufacturer. Connect electrodes to the millivoltmeter and determine the approximate reading of the equivalence point by immersing the electrode(s) in a beaker of distilled water. Allow to stabilize and record. Remove the beaker and wipe electrodes with absorbent paper.

5.7 Rinse with distilled water a magnetic stirring bar and add to the sample prepared in 5.5. Place the beaker on the magnetic stirrer. Immerse the electrodes into the solution taking care that the stirring bar does not strike the electrodes; begin gently stirring.

5.8 Begin titration, recording the volume of standard $AgNO_3$ (Silver Nitrate) verses the millivolt readings to bring the readings to about 40 mV below the equivalence point. Continue the titration with smaller increments (0.2 mL). As you reach the equivalence point, reduce increments to 0.1 mL, recording all mV readings after each addition. As the titration proceeds, equal additions of $AgNO_3$ will cause larger changes in the mV readings. When the titration passes the equivalence point the change per increment will then decrease. Continue titration long enough to the establish that the meter readings are progressively decreasing. The endpoint of the titration is reached when the maximum difference in the mV readings occurs for equal volumes of $AgNO_3$. This can usually be determined without plotting a curve and occurs at the approximate equivalence point of the electrode(s) in distilled water. (In practice, with Alberta Transportation equipment, distilled water reads somewhere between 230 to 250 mV).

6.0 CALCULATIONS AND REPORT

6.1 Calculate and report the percent chloride to the nearest 0.001 % as follows:

$$Cl, \% = (3.5453 * V * N) / W$$

Where:

V = millilitres of 0.01 N $AgNO_3$ solution used for titration of the sample (equivalence point).
N = exact normality of 0.01 N $AgNO_3$ solution.
W = weight of sample, grams.

6.2 The results of two properly conducted tests by the same operator on the same sample shall not differ by more than 0.007 percent chloride.

Bridge File Number : ....
Legal Land Location: ...-..-...-..-.
Latitude/Longitude : ..../.........
Road Auth./Region : .../R.
Bridge or Town Name: ....
Stream Name : ....
Highway #:Cntrl Sec: ....:...
Road Classification: ....-...
AADT/Year : .-....../..
Detour Length : ...km

Structure Usage : ..
Year Built : ../..
Clear Roadway/Skew: ....m/...Deg

Prev. Insp. Date : ____/__/__ (YMD)
Insp. Req'd Date : ____/__/__ (YMD)
(based on ___________________)

Current Insp. Date: ____/__/__ (YMD)
Inspector's Code : ____

STRUCTURE INFORMATION:

No. of Spans: .. Span Types: .../... Substructure Types: .../...
Span Lengths: ....-....-....-....-.....m Total Length: .....m

CHLORIDE TESTING SUMMARY INFORMATION:

Test equipment make and model:____

Number of components tested: __

Comp No.	Comp Type	Component Description	Depth (mm)	Avg. % Cl	Depth (mm)	Avg. % Cl	Depth (mm)	Avg. % Cl	Depth (mm)	Avg. % Cl
__	______	_____________	______	______	______	______	______	______	______	______
__	______	_____________	______	______	______	______	______	______	______	______
__	______	_____________	______	______	______	______	______	______	______	______

Comments:

CHLORIDE TEST DATA:

Component No. __ Component Type: ______ Component Description: _______________

TEST LOCATION	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL	No.	DEPTH (mm)	% CL
RAPID (RCT) RESULTS												
LABORATORY RESULTS												
AVERAGES												
LAB AVERAGES	***			***			***			***		
RCT AVERAGES	***			***			***			***		

Comments:

* For deck chloride samples, different span types are considered to be different components. Therefore each span type requires a separate page.

LEVEL 1 INSPECTION (INFORMATION ONLY)   Level 1 date: ____/__/__

Structural Condition Rating: __%   Sufficiency Rating: __% Estimated Remaining Life of Structure: __ years Special Comments for Next Inspection:
Next Scheduled Level 1 inspection: ____/__/__   Current Cycle: __months

ITEMS REQUIRING IMMEDIATE ATTENTION:

LEVEL 2 INSPECTION SPECIAL REQUIREMENTS:

Y => Snooper: __   Lift: __   Traffic control: __   Boat: __   Ladder: __ Other: ____

INSPECTOR:

Recommended Cycle __ months OR Next Insp. Date ____/__/__ (blank for default) Recommended Additional Cycles: _ (blank for default, 0 for discontinue)		
Inspector’s Code: ___	Inspector’s Name: __________________________	Class: _
Assistant’s Code: ___ Assistant’s Code: ___	Assistant’s Name: __________________________ Assistant’s Name: __________________________	Class: _ Class: _
Comments: ____ ____		

REVIEWER: Review Date: ____/__/__

Approved Cycle __ months OR Next Insp. Date ____/__/__ (blank for default) Approved Additional Cycle: _ (blank for default, 0 for discontinue)\		
Reviewer’s Code: ___	Reviewer’s Name:____________________________	Class: _
Comments: ____ ____		
Default No. of Inspections: _ Default Cycle: __ months	Number completed to date: __ Next Inspection Required Date ____/__/__	

5.0 CHAPTER 5 – ULTRASONIC TRUSS INSPECTIONS

5.1 INTRODUCTION AND BACKGROUND

Alberta Transportation's bridge system has approximately 340 sites with steel truss span types, for a total of approximately 450 truss spans. A truss is made up of individual straight members connected to form a series of adjoining triangles. The triangular shape of the truss is effective at carrying loads since the shape cannot be altered without changing the length of its sides.

The common types of truss bridges are:

- Through truss - the deck rests on the bottom chords and traffic goes under the upper bracings.
- Pony truss - similar to the through truss, but has much lower top chords and there are no upper bracings over the roadway.
- Deck truss - the deck is located on the top chords.

There are several geometrical configurations used in truss bridges, and these are outlined in more detail in Section 7.15 of the Level 1 BIM Inspection Manual.

Steel truss bridges in Alberta are generally quite old. The majority of these trusses were fabricated and erected in the 1920's, with some dating back to 1901. Approximately 75 trusses are located on major highways. The majority are on local and secondary highways that have lower traffic volumes. Many spans are nearing the end their useful life.

5.1.1 THE HISTORY OF ULTRASONIC TRUSS INSPECTIONS

The first round of ultrasonic inspections in Alberta began in the early 1970's. The majority of the trusses were inspected in a 3 to 4 year period. In 1983, a second round of inspections was initiated and all trusses in the province were subsequently inspected within a five-year period. Several fatigue-damaged members were identified during this round of inspections. The damaged members were subsequently replaced.

The results of these inspections triggered the need to have a regular Level 2 Ultrasonic Truss Inspection program.

Currently, the trusses on various highways are inspected on the following cycle:

Primary Highways	- every 4 years
Secondary Highways	- every 5 years
Local Roads	- every 6 years

For certain bridges, this cycle has been reduced to monitor known deficiencies.

5.2 GENERAL ULTRASONIC TESTING INFORMATION AND TRUSS BEHAVIOUR

Ultrasonic testing is a non-destructive test method that allows a skilled operator to detect the location and depth of defects in structural steel behind steel fasteners in truss connections. Ultrasonic testing uses high frequency sound waves to detect flaws in the steel. The ultrasonic frequency used is 2 MHz or an approximate velocity of 2900 m/s (9500 ft/s).

A portable ultrasonic wave generator produces the sound waves, which are transmitted by contact through an oscillating crystal into the steel. Sound waves are impeded by air, so a coupling fluid is used between the crystal and the steel to ensure proper sound wave transmission. Discontinuities in the steel reflect the high frequency waves back. Receiving pulses are then displayed on a cathode ray oscilloscope. The signal corresponds to the elapsed time between the initial sound transmission and the subsequent reception.

The depth, size, and nature of the defect in the steel is determined from the return signal on the oscilloscope. The ultrasonic machine generally uses 60º or 70º probes. Since the angle and velocity of the ultrasonic waves are known, the time for the signal to reflect back can be used to calculate the distance to the deficiency. Therefore, the location and depth of defects in the steel can be determined. In fact, oscilloscope calibration can allow the operator to make direct distance readings on the horizontal axis. The sensitivity is influenced by the sound frequency, design of the unit, instrumentation processing of the return signal on the oscilloscope and operator skill.

Fatigue damage in the steel truss members normally occurs at the connections or around bolt or rivet holes. Ultrasonic test equipment is able to detect fatigue cracks in the steel that are located under the head of the rivet or the bolt, and therefore cannot be seen. Past experience has shown that cracks that develop in tension members are generally initiated in the first line of rivets on the outer edge of the rivet group. The end rivet transmits a more than average shared load, causing it to exhibit fatigue stress. It continues from the rivet hole to the edge of the member, then to the edge of the leg and through the other leg.

5.3 TRUSS AND MEMBER IDENTIFICATION

When inspecting a truss, it is essential that a common method of identifying members and locations be used such that different inspectors and maintenance crews can ensure they are all referring to the same location. This can be as general as the span number or as detailed as the specific truss member. The standard methods used by Alberta Transportation are described in the following sections.

5.3.1 SPAN NUMBERING

Truss spans are numbered in the direction of increasing chainage, if known. If the direction of chainage is not known, then label the spans from west to east or from south to north. When numbering the spans, ensure that all spans are counted. This includes timber and concrete approach spans. See Figure 5.1.

5.3.2 TRUSS MEMBER NOTATION

Use truss notation to label all of the truss members. Truss notation always begins with L0 at the panel point on the far left when looking downstream. Then the remaining panel points are numbered L1, L2, and so on along the bottom chord connections as they increase in distance to the right, from L0. The top chord panel points are numbered in a similar fashion, but they begin with U1 on the left and continue with U2, U3, and so forth along the top chord connections. See Figure 5.1.

The panel points on both trusses, upstream and downstream (near and far) are numbered from left to right when facing downstream.

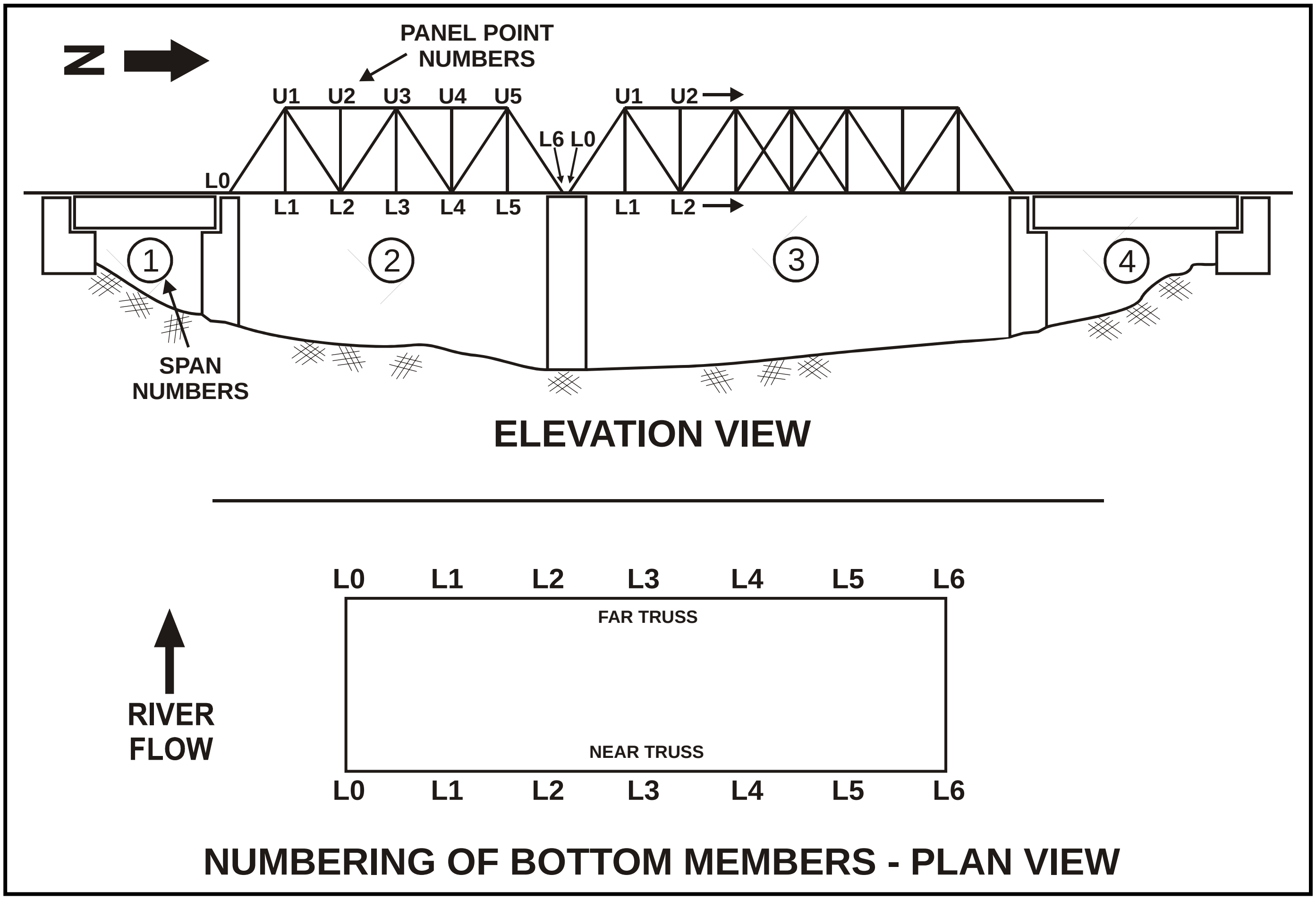


Figure 5.1 – Span and Member Numbering for Trusses

To describe members on a particular span, use the panel points at each end of the member such as U3-L4 or L4-L5. When additional clarification is required to describe whether the member is part of the near truss or the far truss, add an additional letter to the notation for the compass direction of the truss. In Figure 5.1, the near truss would be 'E' for 'east', and the far truss would be 'W' for 'west', for example U3-L4E or L4-L5W.

5.3.3 TRUSS MEMBER REFERENCES RELATIVE TO STEEL DESIGN DRAWINGS

When the inspector needs to reference steel members for replacement and fabrication, they must reference the members relative to the steel design drawings. When looking at a truss design, the truss is actually divided into two halves down the vertical centreline of the truss. There is a left side and a right side and these are a mirror image of each other.

It is important to correctly identify the proper member whether right or left. The members are identified as if the inspector is standing in the middle of the span and on the centreline of the road, facing an end. When the inspector is in this position, half of the truss will be on the inspector's left, the other half will be on the inspector's right. The right and left halves are very similar, but they are not identical. These halves are reversed. If the inspector, still standing in the middle of the span, was to turn 180º and face toward the opposite span end, the members currently on the inspector's left would be the same member types that were on the inspector's left when they were facing the other end. This is detailed in Figure 5.2 below.

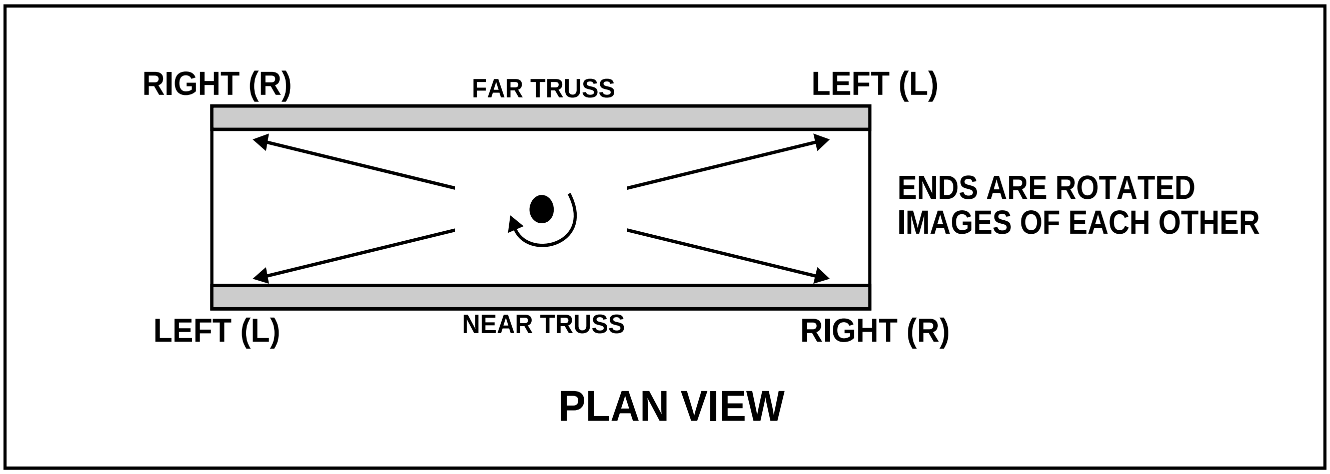


Figure 5.2 – Member Notation Relative to Steel Design Drawings

5.3.4 BRIDGE FILE NUMBER

Every bridge and culvert in the Alberta Transportation inventory has a unique five-digit number that identifies a specific bridge site.

5.3.5 TRUSS IDENTIFICATION NUMBER ('A' NUMBER)

All existing steel truss spans have a unique identification number. The format of the number is:

Axxxx-yy

The Truss Identification Number begins with an 'A' and is followed by a four-digit number in the form of 'xxxx'. This four-digit number represents a specific steel design configuration from a master Alberta Transportation list, such as truss type, truss dimensions, or span lengths. A hyphen and a two-digit number follow this four-digit number. The two-digit number (yy) is a sequential number that identifies the specific bridge that has that configuration. Thus, if there are truss bridges or spans that are exactly the same, the first span of the first bridge would be A0034-01 and the next span would be A0034-02, and so on. Another site with the exact same span configuration would be the next sequential number, A0034-03. Each steel bridge span can be referenced by this unique Truss Identification Number.

This same number can also be found near the top of Page 2 on the BIM Level 1 Inspection forms for steel bridges.

5.4 PREPARATION FOR LEVEL 2 TRUSS INSPECTIONS

Careful planning and preparation is essential for a safe and effective bridge inspection. Prior to any Level 2 truss inspection, the inspector should ensure they have prepared by reviewing the following documentation:

- Ultrasonic inspection forms, truss line diagrams, and truss drawings. Ensure the line diagrams have the proper number of panels for the specific truss to be inspected. Be sure to check if a unique form has been created for that particular structure.
- The Level 1 BIM Inspection form.
- The bridge correspondence files.
- Printed hard copies of computer data for previously reported damage to truss members and any special monitoring information.

Further, the inspector should insure they have the following equipment required for Level 2 truss inspections:

- Inspection tools and equipment as outlined in Section 3.2 of the Level 1 BIM Inspection Manual, including a camera, scrapers, brushes, a mirror, wrenches, and an assortment of high tensile bolts.
- An ultrasonic machine with 60º or 70º probes. Also include straight probes for corrosion measurements. Bring spare probes and extra leads.
- A sufficient supply of water-soluble coupling fluid.
- At least one extra battery and a charging unit.
- Personal protective equipment (PPE) including safety harness and lanyard, safety lines, safety vests, coveralls, hardhats, and CSA approved footwear.
- Approved traffic accommodation strategy and appropriate signs.
- A ‘snooper’ truck may be required for deck trusses while an aerial truck is likely necessary for through trusses.

5.5 GENERAL SAFETY PRECAUTIONS

The inspector and any assistants or crew members must maintain strict safety practices and be alert at all times when completing any truss inspection. The following general practices should be followed:

- Work site safety. Safety is the top priority.
- Be courteous and show proper etiquette towards the traveling public at all times.
- Perform a hazard assessment for each site and review the responsibilities of each of the workers.
- Set-up an approved traffic accommodation signing at each site before commencing with inspection.
- Wear a fall protection harness where there is a potential of falling more than 3.5 m or where the possibility of drowning exists.
- Install fall arrest lines where worksite access is beyond limits of only a harness and its lanyard.
- Personal protective equipment (PPE) such as hardhats, safety vests, gloves, and steel-toed safety boots must be used when at the bridge site.

A list of general site safety precautions is found in Section 3.3 of the Level 1 BIM Inspection Manual.

5.6 VISUAL INSPECTION

The visual inspection is important in assessing the condition of the elements of a truss bridge. Visual inspection items are listed below:

- Check the truss designation sign, the ‘A’ number, on the truss and record it on the inspection forms. Also locate, verify and record the bridge file number.
- Number all verticals with a lumber crayon, away from the traffic side of the member. This will help to orient the inspector while moving along the truss during inspection.
- Determine if the bearings are expansion or fixed bearings at each end of the span. Examine the bearings for signs that they are functioning and record the temperature and the position of the expansion bearings.
- Complete a BIM Level 1 inspection.
- Visually inspect all connections and members. Check connections for cracks, missing or loose bolts or rivets. Check the members for distortions.
- Note any strain indications and follow these up with an ultrasonic inspection.
- Note any collision damage and follow up with ultrasonic inspection on the distorted members and any members with common connections. Measure and record deformations and photograph the damage. Refer to Figure 5.3.
- Record any delaminations, scabs, gouges and elongated holes.
- Check any welds. However, trusses were generally built before weldable steel.
- Check floor beams and bottom laterals while on the bottom chord. Record any high water damage to the bottom chord and bottom laterals. Record any distortions. Check floor beam copes for cracks.
- Check the condition of the subdeck.

- Record the cleanliness of the bottom chord and bearings such as for gravel or dirt build-up.
- Record any corrosion and follow-up with ultrasonic testing to determine the degree of pitting and section loss. Document the test results.
- Note the condition of the paint in the protected area, the splash zone and the top chord.
- Check the connections at the top chord.
- Check the portals and sway bracing for high load damages. Record the extent of any distortions and follow-up with an ultrasonic inspection of the connections of damaged members and members with common connections.
- Check verticals and top chords for buckling characteristics while checking upper connections. Pony trusses are prone to out of plane bending in the top chord due to heavy loads. Measure and report any sweep - determine if the trusses were erected or strengthened in a questionable manner, or if the trusses are bending due to overloads. Photograph bending for future comparison.
- Check the bottom chords, bottom lateral bracing, floor beams, stringers and subdeck from the ground. Note any high water damage to bottom chords and bottom laterals. Check stringers and floor sags and cracks, and view the subdeck for indications of decay.
- Identify member connections that have been previously noted for monitoring by ultrasonic testing, such as rough holes.
- Check railing connections to the truss.
- Check the clearance of through trusses and verify posting.
- Check and record the condition of the strip deck and wheel guards.
- Photograph all problem items.

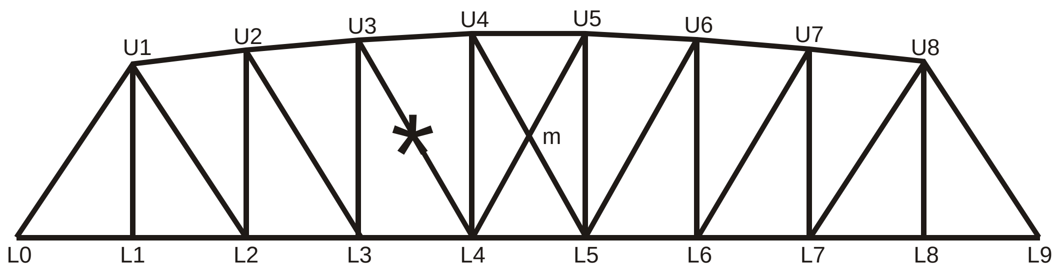
The inspector shall identify any additional testing that is required for the ultrasonic technician.

5.7 ULTRASONIC INSPECTION

The following general guidelines should be used when completing the ultrasonic inspection:

- Ensure that any coupling fluids that are used for testing are water-soluble.
- Check the following members:
    - ♦ Bottom chords adjacent to the bearings.
    - ♦ Both ends of all hanger members.
    - ♦ Both ends of all tension diagonals.
    - ♦ The cross connections of all diagonals and truss struts.
    - ♦ Any welds in main members.
    - ♦ Bottom chord and bottom lateral bracing members that have distortions due to high water.

- ♦ Both ends of any members showing accident damage and all common member connections. Measure and record deformations and take photographs of the damage. For example in Figure 5.3, if U3-L4W has collision distortion, ultrasonic inspection is required on all members that connect at U3, including the vertical, U3-L3 which is a compression member, U4-L4 at L4 which is a compression member, U5-L4, and any struts that are connected to the diagonal.



* = COLLISION DISTORTION - IN MEMBER U3-L4

UT INSPECTIONS REQUIRED IN U3-L4 (BOTH ENDS),
U3-L3 (AT U3) AND U4-L4 & U5-L4 (AT L4)

Figure 5.3 – Example: Ultrasonic Testing For Members with Collision Distortion

- Report all test results that indicate rough holes exist in a connection, and verify when possible.
- Record all ultrasonic work on the forms provided. Refer to Section 5.8.
- Mark all members that have definite cracks with a permanent mark. This mark should not be too large, nor should it be visible to traffic.
- Determine the cause of cracking whenever possible. The majority of cracks on truss members are due to fatigue or accident damage.
- Report and define the extent of corrosion damage. The extent of corrosion pitting or section loss must be investigated and recorded.

5.8 REPORTING - THE LEVEL 2 TRUSS INSPECTION FORMS

Specific forms have been designed for the different types of trusses and trusses with different numbers and configurations of members. There are currently over 100 different forms available, and the inspector should ensure that they have the correct form for the truss they are inspecting. The forms all have the same basic layout and are completed in the same way. Truss inspection forms are available from the Department.

5.8.1 THE TRUSS DIAGRAM

There is a truss diagram at the top of the first page of the inspection forms for each truss. This diagram should match the actual truss configuration of the bridge being inspected. If the diagram is correct, then the inspector knows that the form will have the proper numbers for the members making up the truss. The diagram also shows the naming convention. An example of a truss diagram is shown in Figure 5.4.

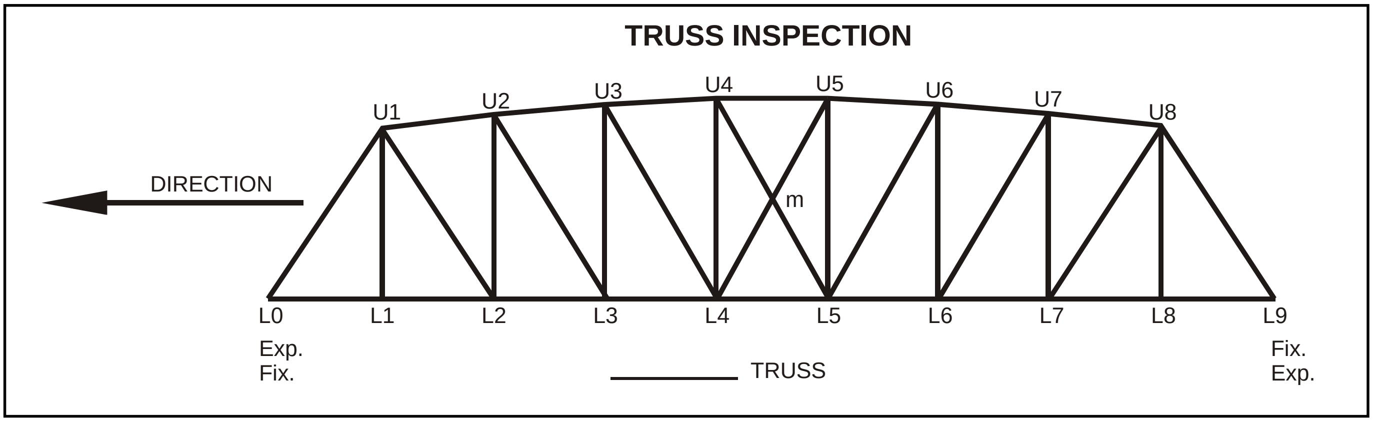


Figure 5.4 – Sample Truss Diagram from Top of Inspection Form

5.8.1.1 Direction

At the left side of the diagram at the top of the page is an arrow that points to the left edge of the page with the word 'Direction' above it. The inspector is to record the direction or end of the bridge where the L0 connection is located. This truss member notation is as defined in Section 5.3.2. The inspector can also record the nearest town or other landmark in addition to the direction as applicable.

5.8.1.2 Fixed or Expansion Bearings

There are the words 'Fix' and 'Exp' at each end of the span, immediately under the truss diagram. The inspector is to circle the type of joint that is present at each end of the span. Be sure to record whether the bearings are fixed or expansion bearings at both ends of every span.

5.8.1.3 Truss Description (______ TRUSS)

Truss bridges have two trusses per span, one on each side of the roadway. The ______ TRUSS blank that is centred and directly under the truss diagram is for the inspector to record which of the two trusses is being inspected. Valid descriptions are a geographic description of the truss, such as north truss or south truss, and the direction of flow, such as 'South/downstream TRUSS'.

5.8.2 FOOTER INFORMATION

Typical Level 2 forms have descriptive information about the bridge or culvert in the header information at the top of the first page. The Level 2 truss inspection forms have general descriptive information about the bridge in the footer of the forms. A truss inspection form footer is shown in Figure 5.5.

BRIDGE NAME: -- SPAN NO. ------------- OF --------- DATE------------------------- FILE ----------------

TRUSS IDENT: A------------------ _ PANEL TRUSS ------------------- FT./M. SPAN, INSPECTOR:-- PAGE: 1

Figure 5.5 – Truss Inspection Form Footer information

5.8.2.1 Bridge Name

Use the established name of the bridge if it exists and is commonly known. Otherwise, describe the bridge by the nearest town, the highway number and the river or watercourse that it crosses.

5.8.2.2 Span Number (SPAN NO. ___ OF ___)

The inspector records the span number that is currently being inspected and the total number of spans in this field. Refer to Section 5.3.1 for additional information on span numbering.

5.8.2.3 Inspection Date (DATE)

Record the date of the Level 2 truss inspection.

5.8.2.4 Bridge File Number (FILE)

Enter the five-digit bridge file number.

5.8.2.5 Truss Identification Number (TRUSS IDENT: A______)

The inspector is to record the unique Truss Identification 'A' Number for the truss in this field. Verify this value by confirming the same identification number appears on the truss designation sign mounted on the truss. The truss identification number is described in Section 5.3.5. If the truss identification plaque is missing, recommend a replacement.

5.8.2.6 Number of Truss Panels

If the inspector has the correct form, the number of panels the truss has will already be on the form in the footer. For example, the form would show '9 PANEL TRUSS'. Verify that this truss panel information is correct when on site.

5.8.2.7 Span Length (_______ FT./M. SPAN)

Record the length of the truss span that is being inspected in feet or metres. Cross out the system of measurement that is not used. Therefore, if the value recorded is 50 ft, be sure to cross out the 'm' for metres to avoid confusion. Original truss records are all in imperial units of measurement.

5.8.2.8 Inspector

The inspector is to record their name in this field.

5.8.3 THE BODY OF THE LEVEL 2 TRUSS INSPECTION FORMS

The truss inspection forms are specific to the particular span that is being inspected and the information is recorded on several pages for each side of each truss span. All of the Level 2 forms for the different truss configurations have a similar format, and include fields for every truss member. The Main Body of the truss inspection form is shown in Figure 5.6.

MEMBER	ULTRASONIC INS.						OTHER ITEMS	MEMBER	
	A END			B END					
A END B END	No Crack	Crack Under Rivet Head	Crack Beyond Rivet Head	No Crack	Crack Under Rivet Head	Crack Beyond Rivet Head		Acceptable Member	Reject Member
TOP CHORD									
L0 - U1									
U1 - U2									
U2 - U3									
ROWS CONTINUE, SHOWING EVERY TRUSS MEMBER . . .									

Figure 5.6 – Main Body of Truss Inspection Forms

5.8.3.1 Member, A End and B End

Each row in the body of the form is for a separate truss member. The member designations are already on the forms, and they correspond to the picture at the top of the form. This field also defines one end of the member as the ‘A End’ and the other as the ‘B End’. Similar member types are grouped together on the forms, such as Top Chord, Verticals, and Diagonals as shown in Figure 5.6.

5.8.3.2 Ultrasonic Inspections, A End and B End

There are three columns for each end of the members: No Crack, Crack Under Rivet Head, and Crack Beyond Rivet Head. The inspector shall put an ‘X’ in the column that applies for all member ends that received an ultrasonic inspection. The ‘Other Items’ field can be used for further clarification.

5.8.3.3 Other Items

This is a comment field where the inspector notes any additional, relevant information for the specific member. The inspector is not required to comment on all members, just when there are noteworthy observations. Comments may pertain to visual or ultrasonic inspections. Refer to General Reporting Notes in Section 5.8.4 for more information.

5.8.3.4 Accept/Reject Member

The inspector must either accept or reject each member of the truss based on the visual inspection. Place an 'X' in one of the two columns for *all* members. Every truss member row should have an 'X' in one of the right hand columns.

5.8.4 GENERAL REPORTING NOTES

Report the results of testing on field inspection sheets specific to the truss design characteristics, as described in the previous sections. Record the following:

- Truss design number and bridge file number.
- The structure name or location and stream.
- The span number and the truss (e.g. south truss is downstream, span 1).
- The inspector's name and date inspected.
- Whether the bearings are fixed or expansion at each end of the span.
- The extent of corrosion.
- Any rough holes; be specific.
- All ultrasonic work. Check off only the connections that are tested.
- All noteworthy observations of members.
- Whether each member is accepted or rejected.

Also identify the following:

- All cracks and all members with distortion. Record and draw information on the line diagrams for each applicable span as described in Section 5.9.
- Any recommendations to straighten or replace specific members.
- The steel plan identification for all cracked or distorted members. This is the 'A' drawing mark number for the member and the reference drawing number. Be specific, as in U1-L2W, D1R, for example. Top and bottom gussets marks 'pa' and 'dc' are not required.
- The cause of cracking. Most cracks in members are due to fatigue or accident damage; try to determine the cause.

Items requiring immediate attention shall be reported to the project coordinator and the appropriate Bridge Manager as soon as possible.

5.9 REPORTING – THE LINE DIAGRAM

An additional item that inspectors should have is a line diagram of the truss. This diagram depicts all members, including the top and bottom members as well as the bracing that connects the two trusses for the span. Figure 5.7 is a sample line diagram, complete with inspector's remarks.

The inspector is to show all members that require maintenance, straightening or replacement on the line diagram. A common approach is to highlight or colour the members and connections that require attention on the diagram. Generally, green is used for members that require straightening and red is used to denote members that should be replaced. Regardless of the colours used, a legend defining the colours is included on all line drawings.

The inspector shall give all details necessary for straightening and replacing members on the line diagram. This includes all information that describes the member, and references the member back to a specific shop drawing. When members require replacement, the inspector also decides which gussets should be replaced with the member and which should be reused. This is all to be noted in the ‘Remarks’ section of the line diagram.

Any other features that are on the shop drawings but no longer apply to the member that requires replacement are also identified. For example, the inspector would note that holes for the lattice rail are not required on a replacement member when the lattice rail at the site has been replaced by flexbeam. In this case, the lattice rail would not be required even though the shop drawings show lattice rail holes in the member. Also note any holes that are required in the member and if they are to be drilled in the field. Be aware that the original portal bracing members may no longer be applicable due to modifications in most trusses - ensure the correct drawing number is provided.

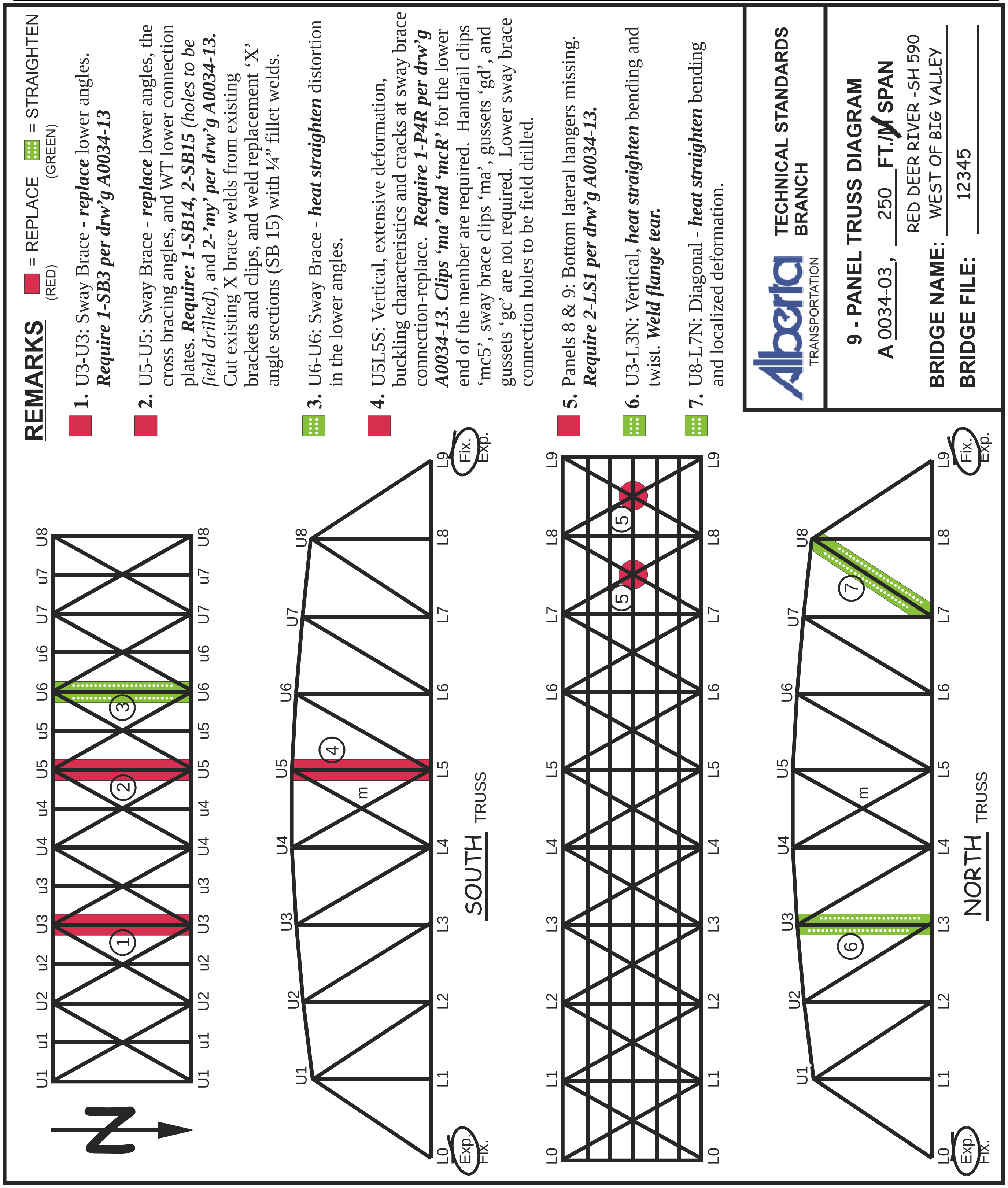


Figure 5.7 – Sample of Completed Line Diagram

5.10 INSPECTION SUMMARY AND RECOMMENDATIONS SHEETS

Ultrasonic Truss Inspection summary sheets are completed for each site that is inspected. The inspector completes the summary sheets after the inspection is done. The purpose of the sheets is for the inspector to report items that require attention and recommend solutions. The Department will decide which items will be completed and when they will be completed after the inspection report has been submitted.

The summary sheets and recommendations are based on the full inspection of the bridge, and not just the ultrasonic inspection and the inspection of the truss spans. The summary sheets provide information on recommended maintenance.

5.10.1 HEADER INFORMATION

Level 2 forms also have descriptive information about the bridge or culvert in the header information at the top of the first page. This truss inspection header is shown in Figure 5.8.

ULTRASONIC TRUSS INSPECTION

File: ______________________

Bridge Name: ______________________

Truss Ident. No's.: ______________________

Inspection Date: ______________________

Figure 5.8 – Truss Inspection Summary Form, Header Information

5.10.1.1 File

This is the bridge file number as previously described in Section 5.3.4. It is also recorded at the top of any additional summary sheets.

5.10.1.2 Bridge Name

The bridge name, as defined in Section 5.8.2.1.

5.10.1.3 Truss Identification Numbers (Truss Ident. No's.)

List all of the truss identification numbers that apply to the bridge as defined in Section 5.3.5.

5.10.1.4 Inspection Date

Record the date or dates that the bridge was inspected.

5.10.2 RECOMMENDATIONS ARISING FROM INSPECTION

This is the main body of the summary sheets, and is shown in Figure 5.9.

DATE: ____________

Recommendations Arising From Inspection

TRUSS IDENT.	PROBLEM ITEM	RECOMMENDATION	PAGE REF.	AUTHORIZED/ REMARKS
	ROWS CONTINUE…			

Attn: Bridge Manager DATE: ____________

Please return this form to the Technical Standards Branch, Edmonton, when report has been filed or when materials have been ordered.

Figure 5.9 – Truss Inspection Summary Form, Main Body

5.10.2.1 Truss Identification (Truss Ident.)

Identify the truss that has a problem. This is typically the truss identification number, span number, and specific truss location, such as 'A0139-03, Span 2 of 4 (west)'. For general problems, the area would be identified in this field, such as 'deck' or 'abutments'.

5.10.2.2 Problem Item

A brief description of the problem item. This may be a general problem, such as washing or replacing wheel guards or this may be a problem specific to a particular member. If referring to a specific member, it should be identified in this field. For example, a problem with a specific member may be noted as: U2-U2 sway bracing has 50 mm bending.

5.10.2.3 Recommendation

List the recommended action for the member. This recommended action could be 'no action', heat straighten the member, replace the member, or even paint or wash the truss.

5.10.2.4 Page Reference (Page Ref.)

Record all page numbers of photographs in the inspection report that illustrate details.

5.10.2.5 Authorized/Remarks

This field is not to be completed by the inspector. The Department will review the comments and recommendations made by the inspector and record their authorization or comments in this field after the final inspection report has been submitted to the Department.

5.10.2.6 Date

The date field located above the 'Recommendations Arising From Inspection' table is for the department to record the date that the problem items were reviewed or authorized.

The date field located below the 'Recommendations Arising From Inspection' table is for the Bridge Manager to record the date that the recommendations and the Department's remarks and authorizations were reviewed.

5.10.2.7 General Comments

The inspector may add general comments relating to the truss condition and why the inspection was necessary. These can be recorded in the area directly above the 'Recommendations Arising From Inspection' title. The inspector may take as much room as necessary for these comments when using an electronic copy of the form.

A continuation form is to be used if the inspector requires additional sheets for the 'Recommendations Arising from Inspection' table.

This page was intentionally left blank.

DO NOT
SEPARATE

ULTRASONIC TRUSS INSPECTION

File: ____

Bridge Name: ____

Truss Ident. No’s.: ____

Inspection Date: ____

DATE: ____________________

Recommendations Arising From Inspection

TRUSS IDENT.	PROBLEM ITEM	RECOMMENDATION	PAGE REF.	AUTHORIZED/ REMARKS

Attn: Bridge Manager DATE: ____________________

Please return this form to the Technical Standards Branch, Edmonton, when report has been filed or when materials have been ordered.

FILE: ______

Recommendations Arising From Inspection

TRUSS IDENT.	PROBLEM ITEM	RECOMMENDATION	PAGE REF.	AUTHORIZED/ REMARKS

6.0 CHAPTER 6 – CULVERT BARREL MEASUREMENTS (SBM2)

6.1 INTRODUCTION

For the purpose of this manual, culverts are defined as bridge structures that are completely surrounded by soil, and located below the surface of the roadway parallel to the general direction of the stream flow. Culverts are efficient and economical alternatives to conventional bridges and their use has increased significantly over the years. These advantages have encouraged an evolution in design methods that have led to thinner walls, use of new and innovative material combinations and shapes, and the development of larger span culverts.

Bridge-size culverts are defined as culverts having an equivalent diameter of 1500 mm or more. They are inspected on the same routine inspection intervals as those specified for bridges. Culverts with equivalent diameters less than 1500 mm are also routinely inspected if they are part of a low level crossing.

Corrugated metal culverts are flexible culverts that rely on ring compression and the support of the surrounding backfill to carry loads. If the backfill does not properly support the culvert, deformation of the culvert will occur. The sidewalls of the culvert will bend outward and the roof will sag. With further deformation, the roof of the culvert will flatten as it sags. Eventually, if the deformation is severe enough, the roof will curve downward into the culvert resulting in reverse curvature, and collapse may be imminent. In structural plate culverts, the longitudinal seams will often deform and crack under the action of the bending forces. In this last type of culvert, the seams are the weakest areas of the wall.

In order to assess the condition of culverts undergoing deformation, it is necessary to obtain measurements of the shape of the culvert and the extent of cracking in the longitudinal seams. The shape measurements are compared to the original design dimensions to determine the severity of the deformation. The extent of both the cracking and deformation will affect the Level 2 rating.

6.2 CULVERT INVENTORY INFORMATION

The inventory information found at the top of the Level 2 Culvert Barrel Measurement Inspection form contains the same inventory data found on the typical Level 1 and other Level 2 bridge and culvert inspection forms. Descriptions of these fields may be found in Section 1.3.2 of the Level 2 Inspection Manual or Section 4 of the Level 1 BIM Inspection Manual.

Ensure the date of the Level 2 inspection is recorded in the header information on the first page. This date will be echoed onto the last page of the SBM2 form.

In addition to the inventory data in the header of the form, the SBM2 form also provides additional information on the culvert, such as the plate arrangement, for up to three culverts. This additional inventory section of the SBM2 form is shown in Figure 6.1. The information in this section is extracted from BIS and auxiliary modules of BIS, such as the Culvert Information System (CIS). It is located immediately below the header information on page one of the SBM2 form, and is described in detail in the following sections.

CULVERT INFORMATION:

Number of Culverts ..					
Pipe Num.	Design Span (or Dia.)/Rise	Type	Length	Corrugation Profile	Plate Thickness
1	..... x ..... mm	...	.....m	....x....mm	.../.../...mm
2	..... x ..... mm	...	.....m	....x....mm	.../.../...mm
3	..... x ..... mm	...	.....m	....x....mm	.../.../...mm

Figure 6.1 – SBM2, Culvert Information

6.2.1 NUMBER OF CULVERTS

This field represents the number of culverts that are at the site.

6.2.2 PIPE NUMBER

This applies to the number assigned to the culvert pipes at a particular site. Culvert pipes are numbered in the direction of increasing chainage, starting at the lowest station and increasing from west to east or from south to north. Refer to Figure 6.2.

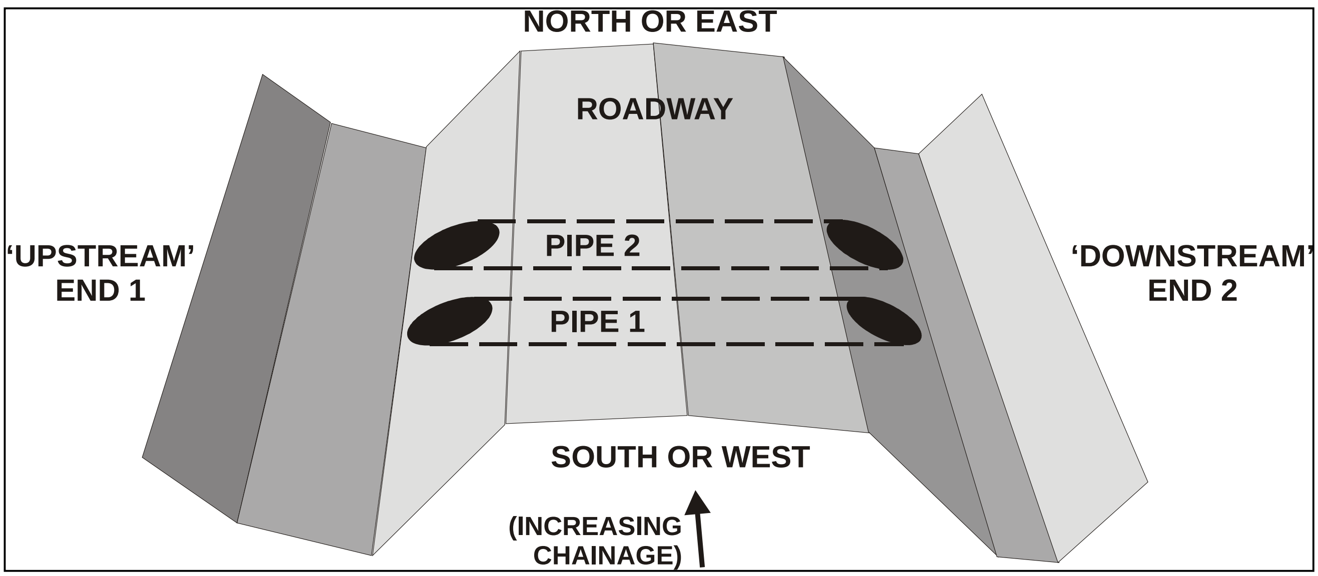


Figure 6.2 – Numbering Culvert Pipes

6.2.3 DESIGN SPAN (OR DIAMETER) / RISE

This is the original design information for the span and rise of the culvert, given to the nearest millimetre. For round culverts the design diameter of the culvert is shown in the first and second fields, representing the span and the rise. Refer to Figure 6.10 for definitions of the span and rise of a culvert.

6.2.4 CULVERT TYPE

This field represents the type of culvert structure as well as the material type. A complete list of the abbreviations used is found in the BIS Codes and Explanations Manual. The SBM2 Level 2 form is limited to corrugated metal, and flexible culverts.

6.2.5 LENGTH

This field is for the invert length of the culvert expressed to the nearest 0.1 metre. This measurement includes both bevel end lengths and the full barrel length. This value can be obtained from BIS or from the culvert design drawings.

6.2.6 CORRUGATION PROFILE

Corrugated steel pipes are manufactured with four corrugation profiles (pitch x depth): 38 x 6.5 mm, 68 x 13 mm, 76 x 25 mm, and 125 x 26 mm. Structural Plate Corrugated Steel Pipes are manufactured with a corrugation profile of 152 x 51 mm, 380 mm x 140 mm, or 400 mm x 150 mm. See Figure 6.3.

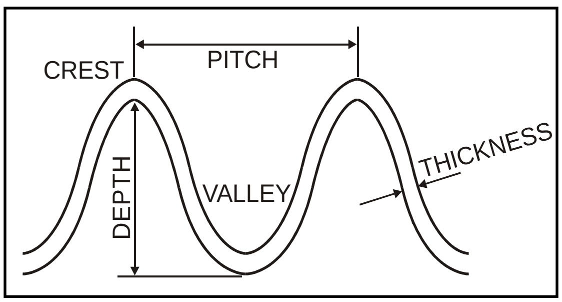


Figure 6.3 – Corrugated Steel Pipe Profile

6.2.7 PLATE THICKNESS

Corrugated steel pipes are manufactured with up to seven nominal thicknesses, depending on the corrugation profile: 1 mm, 1.3 mm, 1.6 mm, 2.0 mm, 2.8 mm, 3.5 mm, and 4.2 mm. Structural Plate Corrugated Steel Pipes are manufactured with five nominal plate thicknesses: 3 mm, 4 mm, 5 mm, 6 mm, and 7 mm. For a particular culvert pipe, the inspection form has provision to record up to three different plate thicknesses. See Figure 6.3.

The following fields shown in Figure 6.4 provide additional culvert information on the individual plate sections that make up the culvert pipe.

Pipe	# of	Top Arc		Side Arc		Bottom Arc		Corner Arc	
Num.	Rings	Radius	N	Radius	N	Radius	N	Radius	N
1	...	.....mm	...	.....mm	...	.....mm	...	.....mm	...
2	...	.....mm	...	.....mm	...	.....mm	...	.....mm	...
3	...	.....mm	...	.....mm	...	.....mm	...	.....mm	...
Special Features:	....								

Figure 6.4 – SBM2, Additional Culvert Information

6.2.8 NUMBER OF RINGS

This field is the number of rings that make up the barrel section of the culvert pipe. A ring is defined as the area between two circumferential seams of the culvert. The length of rings may vary within the same culvert as shown in Figure 6.9.

6.2.9 ARC RADII AND CIRCUMFERENTIAL N COUNTS (TOP, SIDE, BOTTOM & CORNER ARCS)

A culvert that is a perfect circle will have a single value for the radius in all the Radius fields. This value is to be recorded in millimetres. Most flexible culverts however, are elliptical in shape or have an elliptical shape that is flattened in one direction, either in the longitudinal or the vertical. The shapes of these culverts are made from sections of plates that are bent to different radii.

The top, side, bottom, and corner arcs of elliptical shaped culverts can have a variety of plate arrangements and different arc radii within the same culvert. The top and bottom arcs can have up to seven plates per ring and the sides up to four plates per ring. If the inspector needs to number the plates, they are listed in a counterclockwise direction starting from the beginning of the arc.

The plate arrangement is further defined by its circumferential N count. ‘N’ refers to the spacing of the bolts along the circumferential seam as shown in Figure 6.5. Typically, the nominal value for ‘N’ is 244 mm. Individual plate widths in the longitudinal direction are described as 3N, 4N, 5N and so forth.

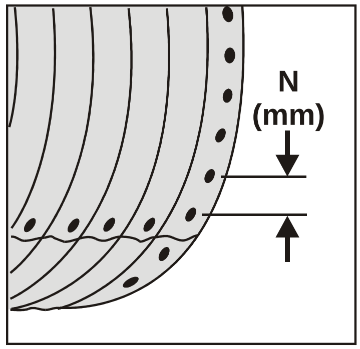


Figure 6.5 – Definition of N

6.2.10 SPECIAL FEATURES

This 'Special Features' item is extracted from the auxiliary module of BIS and is printed on the first dotted line of the Culvert Information section of the form. 'Special Features' refers to unique design features that are used on the barrel section of the culvert for extra strength and/or better soil to structure interaction. These special features include concrete thrust beams, unattached concrete slabs, concrete slab attached with shear connectors at the end sections of the barrel only, metal ribs with or without metal ears, and straw bales.

The second and third solid lines are character fields that can be used for comments, measurements, or any additional details about the culvert barrel shape.

6.3 LEVEL 2 INSPECTION SUMMARY – PAGE 1

After completing the Level 2 inspection, the inspector summarizes some basic information on page one of the SBM2 form. Inspection information is to be summarized for up to three culvert pipes. These will be the same pipes that are listed in the Culvert Inventory section of the form. This Summary Inspection Information section of the form is shown below in Figure 6.6.

SUMMARY INSPECTION INFORMATION:

Total Number of Pipes (or segments) Measured: _____

Pipe No.	Measured (Y/N)	No. of Measurements	No. of Rings Measured
1	_	___	___
2	_	___	___
3	_	___	___

Figure 6.6 – SBM2, Summary Inspection Information

6.3.1 TOTAL NUMBER OF PIPES (OR SEGMENTS) MEASURED

Record the number of culvert pipes or segments that were measured and recorded on the pages following in the SBM2 form. This section only allows the inspector to summarize the information for up to 3 pipes, although the number can be higher if more pipes or segments were actually inspected.

6.3.2 PIPE NUMBER

This is the number assigned to the culvert. The culverts are numbered in the direction of increasing chainage, either from west to east or from south to north. The numbering should be consistent with the pipe numbers in the Culvert Inventory section described in Section 6.2.2 and Figure 6.2.

6.3.3 MEASURED (Y/N)

This is a 'yes' or 'no' field (Y/N) to summarize whether a particular culvert pipe was measured or not during this Level 2 inspection.

6.3.4 NUMBER OF MEASUREMENTS

The inspector totals the number of measurements that were taken in the particular culvert pipe during the Level 2 inspection and records the number in this field.

6.3.5 NUMBER OF RINGS MEASURED

The inspector totals the number of rings that were measured in the particular culvert pipe during the Level 2 inspection and records the value in this field.

6.3.6 COMMENTS

At the bottom of the first page of the SBM2 form, there are four lines provided for the inspector to make any additional comments that relate to the inspection.

6.4 INSPECTION DATA – PAGE 2

The second page of the SBM2 form is where the inspector records detailed barrel measurements for each culvert pipe at a particular site. Inspection data can be entered into the BIM system for up to three culvert pipes. If there are more than three pipes at a particular site and the additional pipes are in poor or suspect condition, the inspector shall perform the Level 2 barrel measurements on the additional pipes and record the results on additional sheets. However, only the first 3 pipes, as defined in the Culvert Inventory section on page one, will be recorded electronically.

A separate data page is to be used for each pipe inspected. More than one data page may be used for a particular pipe if required.

For each pipe, data will be gathered at intervals along the length of the culvert. For structural plate culverts, one set of data will be gathered in each ring with the rise and span measurements taken at the centre of the ring. For other flexible culverts, the data will be gathered at 3 m to 5 m intervals to suit the culvert.

Additional locations may be recorded as necessary if a notable feature would be missed by the established pattern. If measurements are taken in addition to the regular pattern, the inspector should ensure that the measurements are recorded in the proper location on the form. For example, if the inspector is recording data at 5 m intervals, yet there is a noteworthy condition at the 8 m mark, measurements in this area should be recorded between the rows with the 5 m and 10 m measurements on the form.

6.4.1 INSPECTION DATA – HEADER INFORMATION:

The following data shown in Figure 6.7 will appear at the top of each page of inspection data. It serves as a summary for the pipe:

```
INSPECTION DATA: Pipe No.: _    No. of  Measurements: ___   Rings Measured: ___
```

Figure 6.7 – SBM2, Inspection Data Header Information

6.4.1.1 Pipe Number (Pipe No.)

Record the assigned number of the culvert pipe that is being inspected on this page of the SBM2 form. This pipe number is to match the numbering established on page one of the SBM2 form.

6.4.1.2 Number of Measurements (No. of Measurements)

The inspector totals the number of measurements that were taken in the particular culvert pipe during the Level 2 inspection and records the number in this field. This value will be the same as the one recorded in the summary inspection information on the first page of the SBM2 form (Section 6.3.4).

6.4.1.3 Rings Measured

The inspector totals the number of rings that were measured in the particular culvert pipe during the inspection and records the value in this field. This value will be the same as the value recorded in the summary inspection information on the first page of the SBM2 form (Section 6.3.5).

6.4.2 LEVEL 2 MEASUREMENTS

The main section of the SBM2 form, shown in Figure 6.8, is for the measurements taken within the culvert. For each measurement, any previous inspection information from the BIM system will be echoed back for the inspector’s information.

Measurements are taken from the top of the corrugation crest to the top of the corrugation crest on the opposite side of the culvert. Ensure measurements are taken parallel to the cross section of the culvert opening. If measurements are taken at an angle to the culvert, they will be too large, and thus inaccurate. Measurements are generally taken at regular intervals as described in Section 6.4.

It is very important to ensure that the location of measurements are sufficiently marked and labeled to allow future measurements to occur at the same locations.

In general, it is not recommended that an electronic or laser measuring device be used if there is water or uneven debris in the bottom of the culvert. In this case, it is difficult to verify whether accurate vertical measurements are being taken.

The following data will be gathered at each interval:

	Rng No.	Ring Len. (m)	Stn. (m) *	Span (mm)	Def. %	Rise (mm)	Sag %	ICE	Longitudinal Cracks					
									#	Location ***			Min St.	# Blts
Last Now														
Last Now														
Last Now			**THESE ROWS REPEAT DOWN THE PAGE**											
Last Now														
Comments:														

Figure 6.8 – SBM2, Inspection Data

6.4.2.1 Ring Number (Rng No.)

This is the number assigned to the ring. The rings are numbered starting at the upstream end of the barrel, excluding the bevel. If the culvert is not a stream crossing, the upstream end will be taken as the left end when looking in the direction of increasing highway chainage, from west to east or from south to north. See Figure 6.9.

6.4.2.2 Ring Length (Ring Len.)

This is the nominal length of the ring in metres to the nearest 0.01m. See Figure 6.9.

6.4.2.3 Station (Stn.)

This is the station where the rise and span measurements are taken. It is measured in metres to the nearest 0.1m from the upstream (left) end of the barrel. It does not include the bevel. See Figure 6.9.

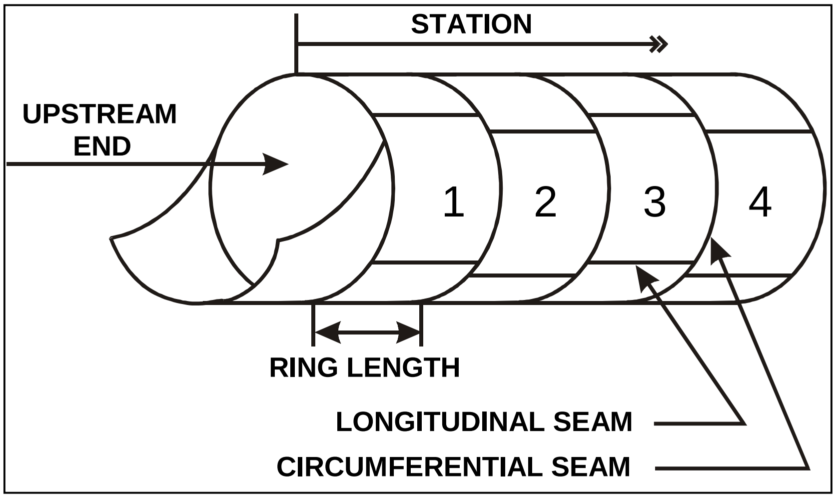


Figure 6.9 – Culvert Barrel Layout

6.4.2.4 Span

This is the measured span of the culvert in millimetres. The span is a horizontal measurement and is measured from the inside crest to the opposite inside crest. See Figure 6.10.

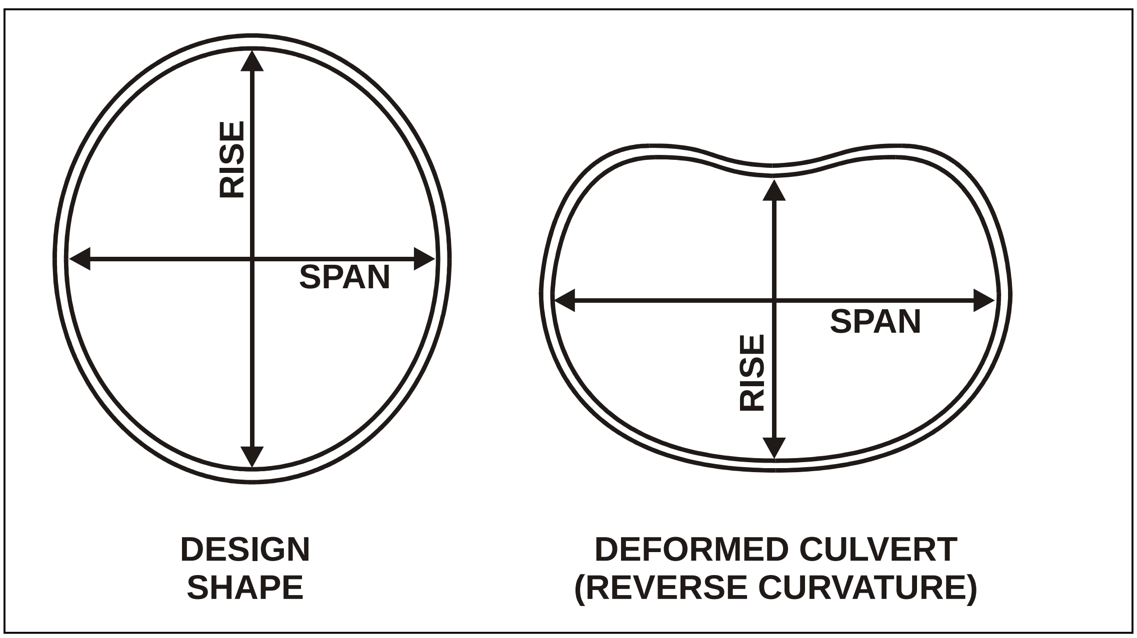


Figure 6.10 – Measurement of Rise and Span

6.4.2.5 Deflection (Def. %)

This is the percent difference between the measured span and the design span. The deflection is positive when the measured span is greater than the design span, such as when the deflection is outwards. Record the percent deflection to one decimal point.

% Deflection = ((Measured Span – Design Span) / Design Span) X 100

6.4.2.6 Rise

This is the measured rise of the culvert in millimetres and it is measured from the inside crest of the crown to the inside crest of the invert. See Figure 6.10.

If ice, silt or other uniform and level obstruction prevents a full crown to invert measurement, the measurement of crown to top of obstruction is to be recorded. If the obstruction is not uniform, the inspector shall undertake reasonable measures to remove the obstruction and enable the measurement of the rise.

6.4.2.7 Sag (Sag %)

This is the percent difference between the measured rise and the design rise. It is positive if the measured rise is less than the design rise such as if the culvert sags downwards. Record the percent sag to one decimal point.

% Sag = ((Design Rise – Measured Rise) / Design Rise) X 100

This calculation is not performed and this field is left blank if there is ice, debris or another obstruction inside the culvert (i.e. the 'ICE' field is 'Y'). See Section 6.4.2.8 below, for further information.

6.4.2.8 ICE

This indicates whether the rise measurement is an accurate and true measurement. If the rise is not measurable due to the presence of ice, debris or other obstruction, if the floor is bulged, or if the obstruction is level and uniform, enter 'Y.' Otherwise, enter 'N.'

If the obstruction is level or uniform, such as smooth ice, the inspector may still measure the Rise as described in Section 6.4.2.6. The top of Figure 6.11 illustrates the measurement of the Rise when there is a level obstruction in the culvert.

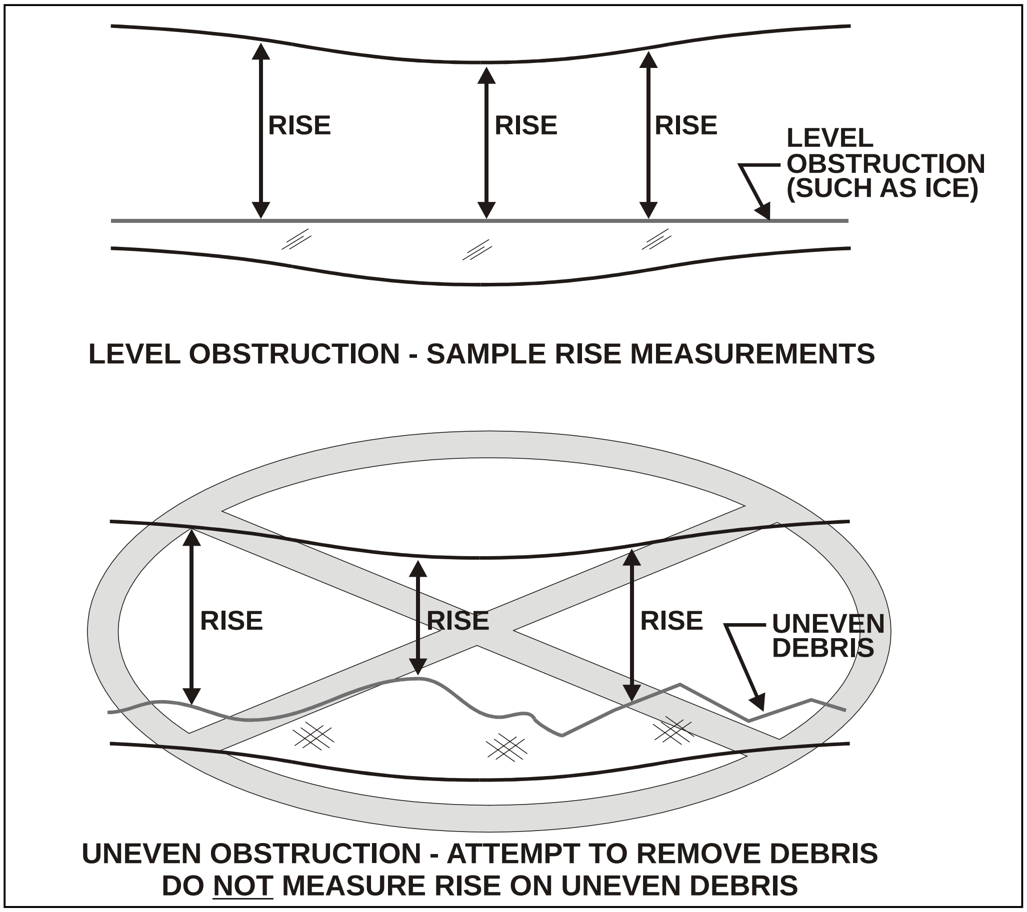


Figure 6.11 – Measurement of Rise with Obstructions

6.4.2.9 Longitudinal Cracks

This section is used for recording information regarding longitudinal cracks in each section of the culvert. The longitudinal seams in SPCSP and riveted CSP culverts are designed to carry the full ring compression in the culvert. They are also required to keep the plates together and aligned, and prevent infiltration of the backfill material.

It is believed that the bending strength of a bolted seam is less than 75% of that of the plates, thus longitudinal cracks may occur along the longitudinal seams in flexible culverts, originating at the bolt holes. Excessive bending strains, improper lapping of plates, and perhaps over-torquing of the bolts can cause longitudinal seams to crack.

A properly lapped seam is one with the bolts in the valley nearer to the visible edge of the plate than the bolts in the crest as in Figure 6.12, 'Correct Lap'. If cracks are found, the ends of the cracks should be marked and dated. The remaining steel between the bolt holes of the largest crack is also measured and recorded as described in Section 6.4.2.9.3.

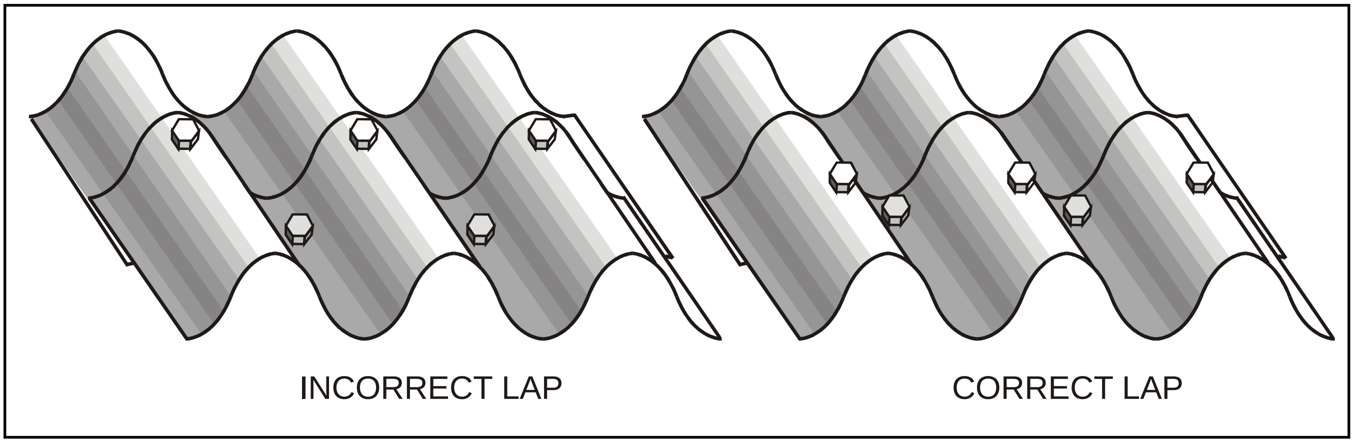


Figure 6.12 – Incorrect and Correct Lapping of Longitudinal Seams in Culverts

6.4.2.9.1 Number of Longitudinal Cracks (Longitudinal Cracks - #)

This is the number of longitudinal seams that are cracked in the ring that is being inspected.

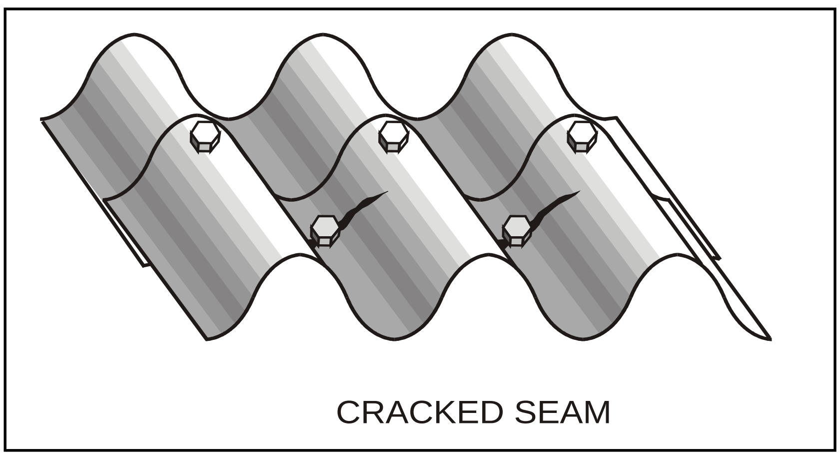


Figure 6.13 – A cracked Longitudinal Seam

6.4.2.9.2 Location of Longitudinal Cracks (Longitudinal Cracks - Location * * *)

This is the location of the cracked longitudinal seams. The face of a clock is used to designate the seam locations when looking downstream. For example, twelve o'clock is straight up, and two o'clock is at the upper right side when facing the downstream end.

This data item also is used to record whether the longitudinal seams are correctly or incorrectly lapped by recording an '**I**' for an incorrect lap, or a '**C**' for a correct lap after the clock number. For example, record '2I' for a cracked seam at 2 o'clock that has an incorrect lap, and '10C' would be recorded for a crack at 10 o'clock with a correct lap. Up to three locations may be entered on the form.

Refer to Section 6.4.2.9 for definitions of incorrectly or correctly lapped seams.

6.4.2.9.3 Minimum Steel Remaining Between Bolts (Longitudinal Cracks - Min St.)

The inspector records the lowest measured steel remaining in millimetres between cracks for all of the cracked longitudinal seams in the ring.

6.4.2.9.4 Number of Cracked Bolts Holes (Longitudinal Cracks - # Blts)

This is the number of bolt holes that have cracks originating from them in a given ring.

6.4.2.10 Comment Lines

There are 4 lines for comments at the bottom of the Inspection Data page. The direction of the ends of the culvert for the first and last rings should be recorded for information and verification. For example, 'Ring 1 = West' and 'Ring 10 = East'. The inspector can also use this area to record any additional comments that relate to the inspection.

6.4.3 BARREL RATING CONDITION SUMMARY (SBM2 RATING SUM.)

This is the General Barrel Condition Rating as determined according to Table 6.1 from the inspection data. The rating for the current inspection will be determined after the inspection data is entered. The ratings from the previous inspection, if entered into the BIM system, will also be displayed.

The inspector shall summarize the Level 2 inspection data for each culvert at the bottom of each Inspection Data Page.

SBM2 Rating Sum.: LAST	%/I	9-7	6/5	4	3	2/1	NOW	%/I	9-7	6/5	4	3	2/1

Figure 6.14 – SBM2, Barrel Rating Condition Summary

6.4.3.1 Percent Inspected (%/I)

Record the percent of the culvert pipe that was inspected during this Level 2 inspection to the nearest 5%.

6.4.3.2 Percent of the Inspected Pipe in Each Rating Category (9-7, 6/5, 4, 3, 2/1)

Record the percent of the pipe that falls within each of the rating categories: 9-7, 6-5, 4, 3, 2/1. The rating assigned to each section, and therefore each row on the SBM2 form, will be the lowest rating for that section. The worst case governs the rating.

Since this section only refers to the area of the pipe that was actually inspected, the total from all the rating categories should total 100%, even if less than 100% of the pipe was inspected. These should be recorded to the nearest 5%. A more isolated area may be recorded as 1%.

The crack or deformation criteria for a Level 2 rating at each station is described as follows in Table 6.1:

Level 2 General Barrel Rating	Cracked Longitudinal Seams		Deformation (% of Span or Rise)
	Number	Remaining Steel (mm)	
9-7	0	N/A	No Deformation
6	0	N/A	5% or less
5	0	N/A	More than 5% and not more than 7%
4	1	50 or more	More than 7% and not more than 10%
3	1	Less than 50	More than 10% and not more than 15%
	2	50 or more	
2	2	Less than 50	More than 15% and not more than 20%
1	2	Less than 30	More than 20%
	3+	Any	

Table 6.1 – Level 2 General Barrel Ratings

6.5 OTHER SBM2 ITEMS – LAST PAGE

Refer to Section 1.5 for instructions on completing the last page of the SBM2 form. The last page shares a common format with the other Level 2 forms.

Culvert File Number: ....
Legal Land Location: ...-..-...-..-.
Latitude/Longitude : ..../.........
Road Auth./Region : .../..
Bridge or Town Name: ....
Stream Name : ....
Highway #:Cntrl Sec: ....:...
Road Classification: ....-...
AADT/Year : .-....../..
Detour Length : ...km

Structure Usage : ..
Year Built : ../..
Clear Roadway/Skew: ....m/...Deg

Prev. Insp. Date : ____/__/__ (YMD)
Insp. Req'd Date : ____/__/__ (YMD)
(based on ____________________)

Current Insp. Date: ____/__/__ (YMD)
Inspector's Code : ____

CULVERT INFORMATION:

Number of Culverts ..

Pipe Num.	Design Span (or Dia.)/Rise	Type	Length	Corrugation Profile	Plate Thickness
1	..... x ..... mm	...	.....m	....x....mm	.../.../...mm
2	..... x ..... mm	...	.....m	....x....mm	.../.../...mm
3	..... x ..... mm	...	.....m	....x....mm	.../.../...mm

Pipe Num.	# of Rings	Top Arc Radius	N	Side Arc Radius	N	Bottom Arc Radius	N	Corner Arc Radius	N
1	...	.....mm	...	.....mm	...	.....mm	...	.....mm	...
2	...	.....mm	...	.....mm	...	.....mm	...	.....mm	...
3	...	.....mm	...	.....mm	...	.....mm	...	.....mm	...

Special Features: ....

SUMMARY INSPECTION INFORMATION:

Total Number of Pipes (or segments) Measured: _____

Pipe No.	Measured (Y/N)	No. of Measurements	No. of Rings Measured
1	_	___	___
2	_	___	___
3	_	___	___

Comments:

Inspection Data Notes:
* Barrel station measured from left end of barrel (not including bevel)
** Crack Location measured clockwise looking in direction of increasing station.
Example - 2I,10C for 2 o'clock incorrect lap & 10 o'clock correct lap

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STEEL CULVERT BARREL MEASUREMENT — Culvert File: .....

INSPECTION DATA: Pipe No.: _ No. of Measurements: ___ Rings Measured: ___

	Rng No.	Ring Len. (m)	Stn. (m) *	Span (mm)	Def. %	Rise (mm)	Sag %	ICE	Longitudinal Cracks					
									#	Location ***			Min St.	# Blts
Last Now														
Last Now														
Last Now														
Last Now														
Last Now														
Last Now														
Last Now														
Last Now														
Last Now														
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Last Now														
Last Now														
Last Now														
Last Now														
Last Now														
Last Now														
Last Now														
Last Now														
Last Now														
Last Now														

Comments:

SBM2 Rating Sum.: LAST	%/I	9-7	6/5	4	3	2/1	NOW	%/I	9-7	6/5	4	3	2/1

LEVEL 1 INSPECTION (INFORMATION ONLY)   Level 1 date: ____/__/__

Structural Condition Rating: __%   Sufficiency Rating: __% Estimated Remaining Life of Structure: __ years Special Comments for Next Inspection:
Next Scheduled Level 1 inspection: ____/__/__   Current Cycle: __months

ITEMS REQUIRING IMMEDIATE ATTENTION:

LEVEL 2 INSPECTION SPECIAL REQUIREMENTS:

Y => Snooper: __   Lift: __   Traffic control: __   Boat: __   Ladder: __ Other: ____

INSPECTOR:

Recommended Cycle __ months OR Next Insp. Date ____/__/__ (blank for default) Recommended Additional Cycles: _ (blank for default, 0 for discontinue)		
Inspector’s Code: ___	Inspector’s Name: __________________________	Class: _
Assistant’s Code: ___ Assistant’s Code: ___	Assistant’s Name: __________________________ Assistant’s Name: __________________________	Class: _ Class: _
Comments: ____ ____		

REVIEWER: Review Date: ____/__/__

Approved Cycle __ months OR Next Insp. Date ____/__/__ (blank for default) Approved Additional Cycle: _ (blank for default, 0 for discontinue)\		
Reviewer’s Code: ___	Reviewer’s Name:____________________________	Class: _
Comments: ____ ____		
Default No. of Inspections: _ Default Cycle: __ months	Number completed to date: __ Next Inspection Required Date ____/__/__	

7.0 CHAPTER 7 – VERTICAL CLEARANCE MEASUREMENTS (VCL2)

7.1 INTRODUCTION

The vertical clearance of a bridge is of concern when vehicles are required to pass under structural components. This is the case with grade separations, where traffic passes under the bridge, or with through trusses where vehicles pass under the portal bracing members. When a vehicle strikes either a portal bracing member or the underside of a bridge, it can damage both the vehicle and the structural components of the bridge. Such damages can put the safety of the travelling public at risk.

The vertical clearance of a bridge is posted on the structure itself. The vertical clearance is also posted in advance of the bridge structure in order to allow vehicles with loads higher than the vertical clearance time to stop or detour before making contact with the overhead members. Large vehicles with high loads are warned of any height restrictions on their permitted routes so they can plan a safe trip.

When a Level 1 inspection notes evidence of a recent reduction in the vertical clearance, such as a new asphalt overlay or gravel buildup, the Bridge Manager is notified. A Level 2 inspection is required to confirm the vertical clearance using the VCL2 Level 2 Inspection form.

7.2 GENERAL VERTICAL CLEARANCE INFORMATION

The current legal vehicle height without permit in the Province of Alberta is 4.15 metres. New grade separation structures are designed to provide a minimum of 5.35 metres of clearance. All bridge structures have their vertical clearance posted on the structure at the midway point over the driving lanes, with one sign for each direction of travel. In situations where there are multiple structures, or a series of structures without access roads between them, the minimum vertical clearance of these structures is posted. The approaching clearance restriction is posted in advance of the structure for both directions of travel.

Vertical clearance information is required for the following structure usage types:

- Grade Separation (GS)
- Pedestrian Grade Separation (PS)
- Through Truss Span (TH)
- Railroad Underpass - roadway goes under railway (RU)

The value that is posted on the vertical clearance sign is the minimum measured height between the lowest point of the structure and the surface of the clear roadway, less 0.1 m tolerance, and rounded down to the nearest 0.1 m.

7.2.1 POSTING REQUIREMENTS

For **undivided highways**, the minimum measured vertical clearance of all the roadway components shall be used in calculating the posted clearance for all directions of travel.

For **divided highways**, the minimum measured vertical clearance for all roadway components over the same direction of travel shall be used in calculating the posted clearance. Thus, westbound highway lanes and westbound collector or distributor lanes would be posted with the same value: the minimum vertical clearance of those roadway components. The eastbound roadway components could have a different minimum vertical clearance posted.

If there are several vertical clearance restrictions on one roadway without any means to enter or exit the roadway between structures, the minimum vertical clearance of all the structures shall be posted in advance of the structures, and the same minimum clearance shall be posted on all the structures. If a particular structure is significantly higher than the minimum vertical clearance, that structure will not be posted.

7.3 MEASURING THE VERTICAL CLEARANCE

Vertical clearance measurements are to be taken on all roadway components that have a vertical clearance restriction.

7.3.1 ROADWAY COMPONENTS

A **roadway component** is considered to be all the roadway elements that are not separated by a concrete, natural or other type of median. Some examples follow to help clarify this definition:

- Undivided highways are considered to be one roadway component
- Divided highways are considered to be two roadway components
- Highway lanes and a merge lane that are not separated by a median are considered to be a single roadway component.
- Highway lanes and a merge lane that are separated by a median, whether concrete, natural or other means, are considered to be two separate roadway components.
- A structure over northbound and southbound highway lanes with a separate northbound or southbound collector/distributor road has three roadway components.

7.3.2 LOCATION OF VERTICAL CLEARANCE MEASUREMENTS

Vertical clearance measurements are taken from the top of the roadway surface to the lowest point on the superstructure. They are generally measured with a digital measuring rod or an electronic measuring device.

The inspector should not disturb the traffic flow when taking the vertical clearance measurements without approved traffic control in place. Main routes may have to be measured at night, non-peak hours or in conjunction with scheduled maintenance activities in order to avoid high traffic volumes.

Vertical clearance measurements shall be taken on roadway components at the following locations:

- The edge of the roadway, pavement or the gutter line if a curb is present
- Shoulder lines
- Lane lines painted on the roadway, including centrelines on undivided highways
- Single lane roadway component shall have an additional measurement taken at the mid-point of the roadway
- Additional measurements can be taken in the centre of lanes, but are not generally necessary for multi-lane roadway components
- If a minimum vertical clearance occurs at any other location other than those listed above, additional measurements are to be taken at those locations

Note that grade separation structures require measurements to be taken on both sides of the structure to ensure that the lowest clearance is recorded. Through truss structures require measurements at portal bracing members, unless a minimum vertical clearance is noted elsewhere.

During the inspection, the inspector shall look for evidence of reduced vertical clearance due to a new asphalt overlay, asphalt patching, gravel build-up, or excessive sagging of bridge elements. Ensure measurements are taken at the areas of lowest clearance if they are different than the measurement locations outlined above. Measurements are in metres and are recorded to three decimal places.

Refer to Figure 7.5 for additional information regarding the location of vertical clearance measurements.

7.4 INVENTORY INFORMATION

The inventory information found at the top of the Level 2 Vertical Clearance Measurement form (VCL2) contains the same inventory data found on the typical Level 1 and other Level 2 bridge and culvert inspection forms. Descriptions of these fields may be found in Section 1.3.2 of the Level 2 Inspection Manual or Section 4 of the Level 1 BIM Inspection Manual.

Ensure the date of the Level 2 inspection is recorded in the header information on the first page. This date will be echoed onto the last page of the VCL2 form.

7.4.1 ADDITIONAL STRUCTURE INVENTORY INFORMATION

In addition to the inventory data in the header of the form, the VCL2 form provides additional information about the bridge structure. This section is located immediately below the header information on page one of the VCL2 form and is shown in Figure 7.1. Refer to Section 1.4 for a complete description of the Structure Information fields.

```
STRUCTURE INFORMATION:

No. of spans: ..    Span Types: .../...  Substructure Types: .../...
Span Lengths: ....-....-....-....-.....m    Total Length: .....m
```

Figure 7.1 – VCL2, Additional Structure Information

The VCL2 form also provides additional information about the current posted vertical clearance signs. It is located immediately below the header information on page one of the VCL2 form. This information is taken from the last Level 1 inspection that was entered into the BIM system.

```
LEVEL 1 VERTICAL CLEARANCE INFORMATION:

Posted Vertical Clearance:Y/N ___  On Bridge __B Lane ___ m; __B Lane ___ m;
Posted : In Advance  __B Lane Y/N ___;  __B Lane Y/N __
Remarks ________________________________________________________________
```

Figure 7.2 – VCL2, Level 1 Vertical Clearance Information

7.4.2 POSTED VERTICAL CLEARANCE (Y/N)

This is a ‘yes’ or ‘no’ field (Y/N) that describes whether there was a posted vertical clearance at the time of the last Level 1 inspection.

7.4.3 DESCRIPTION OF VERTICAL CLEARANCE SIGNS ON BRIDGE

These fields describe the direction of traffic flow for which the bridge-mounted clearance signs are intended. The vertical clearances posted on these signs are also provided. Up to two different signs can be posted on a bridge, one for each direction of traffic. An example of this completed field would be ‘On Bridge NB Lane 4.2 m; SB Lane 4.2 m’.

7.4.4 POSTED SIGNS IN ADVANCE (Y/N)

If vertical clearance signs have been posted in advance of the structure, it will be noted in this ‘Posted:’ line.

7.4.5 REMARKS

Any special remarks that the Level 1 inspector made regarding the vertical clearance will be brought forward on these lines.

7.5 LEVEL 2 VERTICAL CLEARANCE SUMMARY INFORMATION – PAGE 1

After the Level 2 inspection is completed, the inspector summarizes the results of the vertical clearance measurements on page one of the VCL2 form. The results from the previous Level 2 measurements are also provided in this area if they exist in the BIM system.

The following measurements and data are summarized in this section of the form: the vertical clearance measurements, the calculated posting clearance, and the existing postings on the bridge and in advance of the structure. Figure 7.3 shows the Level 2 Vertical Clearance Summary Information section of the form.

LEVEL 2 VERTICAL CLEARANCE SUMMARY INFORMATION:

	_BL O/U _		_ BL O/U _		_ BL O/U _		_ BL O/U _	
	LAST (m)	NOW (m)	LAST (m)	NOW (m)	LAST (m)	NOW (m)	LAST (m)	NOW (m)
Minimum measured clearance								
Calculated posting clearance								
Existing posting on bridge								
Existing posting in advance								
Revise posting	Y/N ___		Y/N ___		Y/N ___		Y/N ___	
Comments:								

Figure 7.3 – VCL2, Vertical Clearance Summary Information

7.5.1 ROADWAY COMPONENTS (___BL)

This field describes the roadway component that will be shown in the column below. The blank field is to be completed by the inspector if it has not already been brought forward from a previous Level 2 inspection. It represents the direction of travel approaching the restricted vertical clearance, and the 'BL' represents '-bound lanes'.

Accepted values for the blank field are N, S, E, W for the directions of the travel; north, south, east, and west. If the roadway component is also a collector or distributor, place a 'C' in front of the direction of travel. An 'X' is entered for undivided highways.

For example:

NBL – indicates northbound highway lanes
CNBL – indicates northbound collector or distributor lanes
XBL – indicates undivided highway lanes

Up to four roadway components can be recorded on the VCL2 form.

7.5.2 CLEARANCE RESTRICTIONS OVER OR UNDER THE BRIDGE STRUCTURE (O/U __)

This field describes whether the vertical clearance restriction is over or under the bridge structure. If the information in this field has not already been brought forward from a previous Level 2 inspection, the inspector should complete this field. The letter 'O' is used for vertical clearance restrictions that are over the deck of the structure, such as a through truss. The letter 'U' is used for vertical clearance restrictions that are under the bridge structure, such as a roadway under a grade separation.

7.5.3 LAST AND NOW COLUMNS

These columns allow the inspector to compare the previous and current data. All of the values that appear in these columns will be given in meters. The 'Last' column is data that has been entered into the BIM system from the previous Level 2 measurements, while the 'Now' column summarizes the current Level 2 inspection data. If no previous Level 2 measurements have been entered into the BIM system, the 'Last' column will appear blank.

7.5.4 MINIMUM MEASURED CLEARANCE

This is the smallest vertical distance between the bottom of the structure and the top surface of the roadway component. The inspector shall enter the minimum vertical clearance measurement for each roadway component in meters to three decimal places.

7.5.5 CALCULATED POSTING CLEARANCE

The calculated posting clearance value is the value that would be posted on the vertical clearance sign for that roadway component. It is calculated as the minimum measured clearance, less a 0.1 metre tolerance, and is then rounded down to the nearest 0.1 metre.

7.5.6 EXISTING POSTING ON BRIDGE

Record in this field the existing posted vertical clearance (in metres) on the bridge structure for each roadway component.

7.5.7 EXISTING POSTING IN ADVANCE

In this field, the inspector is to record the existing posted vertical clearance in metres that is in advance of the bridge structure for each roadway component.

7.5.8 REVISE POSTING (Y/N __)

This is a 'yes' or 'no' field (Y or N) indicating whether a revised vertical clearance posting is required for the roadway element. The inspector shall enter a 'Y if the vertical clearance posting requires revision. An 'N' is entered if the existing vertical clearance posting does not require revision.

7.5.9 COMMENT LINES

Four lines are provided for the inspector to make any additional comments that relate to the inspection.

7.6 INSPECTION DATA WORKSHEET – PAGE 2

The second page of the VCL2 form is the worksheet where the inspector records detailed vertical clearance measurements for each roadway component. This Inspection Data Worksheet is shown in Figure 7.4. There can be a maximum of four roadway components per worksheet. Further, measurements can be recorded for up to 40 different locations for each roadway component per page. Additional pages can be used if required.

INSPECTION DATA:

SPAN ID	_ BL O/U _			_ BL O/U _			_ BL O/U _			_ BL O/U _		
	LOC.	LAST (m)	NOW (m)	LOC.	LAST (m)	NOW (m)	LOC.	LAST (m)	NOW (m)	LOC.	LAST (m)	NOW (m)
				ROWS REPEAT								
MIN.	*****			*****			*****			*****		
Comments:												

Figure 7.4 – VCL2, Inspection Data Worksheet

7.6.1 SPAN IDENTIFICATION (SPAN ID)

This field is for the inspector to identify the span on which the vertical clearance measurements were taken.

For grade separation structures, the span number and the side of the bridge being measured are recorded in this field. The span number is represented by the letter ‘S’ followed by a number. The spans are numbered in the direction of increasing chainage from west to east or from south to north. The span number is then followed by another letter such as ‘N’ for North, or ‘S’ for South to describe the side of the bridge where the measurement was taken. The location could also be described by ‘E’ for East or ‘W’ for West. An example of a span identification number would be ‘S2N’, where the measurement was taken from Span 2 on the north side of the bridge.

For through trusses, the top chord panel points are also identified in this field. These top chord panel points are labeled using the letter ‘U’ followed by a number. The numbering increases from left to right while facing downstream. For example, ‘U1’ would represent the left most top chord panel point when facing downstream.

7.6.2 ROADWAY COMPONENTS (___BL)

This field describes the roadway component on which vertical measurements will be taken.

The B in this field stands for Bound, and may be described by entering a direction such as 'N' for North, 'S' for South, 'E' for East or 'W' for West. For example, 'NB' means the roadway component is Northbound. If the roadway component is also a collector or distributor, place a 'C' in front of the direction of travel. An 'X' is entered for undivided highways.

For example:

N BL – indicates northbound highway lanes
CN BL – indicates northbound collector or distributor lanes
X BL – indicates undivided highway lanes

7.6.3 CLEARANCE RESTRICTIONS OVER OR UNDER THE BRIDGE STRUCTURE (O/U __)

This field describes whether the vertical clearance restriction is over or under the bridge structure. The letter 'O' is for vertical clearance restrictions that are over the deck of the structure, such as for a through truss. The letter 'U' is for vertical clearance restrictions that are under the bridge structure, such as under a grade separation.

7.6.4 LOCATION (LOC.)

This field describes the location of the vertical clearance measurement on the side of the span.

There are two parts to the location code. The first part consists of a 'L' for Left or a 'R' for 'right'. The inspector determines this first part when facing the direction of increasing chainage. The second part of the location code represents the edge of the road, the gutter line, the shoulder, or a lane line.

The following abbreviations are used to describe the measurement location code:

LE - Left edge of road
RE - Right edge of road
LG - Left gutter line
RG - Right gutter line
LS - Left shoulder of road
RS - Right shoulder of road
L# - Lane line, measured from left to right (e.g. L1, L2, etc.)

If a measurement is taken between any of the above locations, it shall be labeled with a letter following the abbreviation. Therefore, a measurement that is taken between L1 and L2 would be represented by the abbreviation L1A.

Refer to Figure 7.5 for additional examples.

The inspector may also use the comment section at the bottom of the page to clarify any measurement locations that are not as described above. For example, a clarifying comment might be ‘L1A located 2.0 m to the right of L1’.

7.6.5 LAST AND NOW COLUMNS

These columns allow the inspector to record the current measurement data and compare it to any previous Level 2 measurements.

The inspector is to record the current inspection measurements in the ‘Now’ column. The ‘Last’ column is data that has been entered into the BIM system from the previous Level 2 measurements. The values in these columns will be in metres and measured and recorded to three decimal places. If there has not been any previous Level 2 measurements entered into the BIM system, the ‘Last’ column will appear blank.

7.6.6 MINIMUM (MIN.)

The minimum vertical clearance measurement for each column (each direction) is recorded in the ‘Min.’ field under the ‘Now’ heading. The previous minimum value will appear in the ‘Last’ column. Minimum vertical clearance measurements are recorded in metres to three decimal places.

7.6.7 COMMENT LINES

Four lines are provided for the inspector to clarify any measurement locations or make any additional comments that relate to the inspection.

7.7 OTHER VCL2 ITEMS – LAST PAGE

Refer to Section 1.5 for instructions on completing the last page of the VCL2 form. The last page shares a common format with the other Level 2 forms.

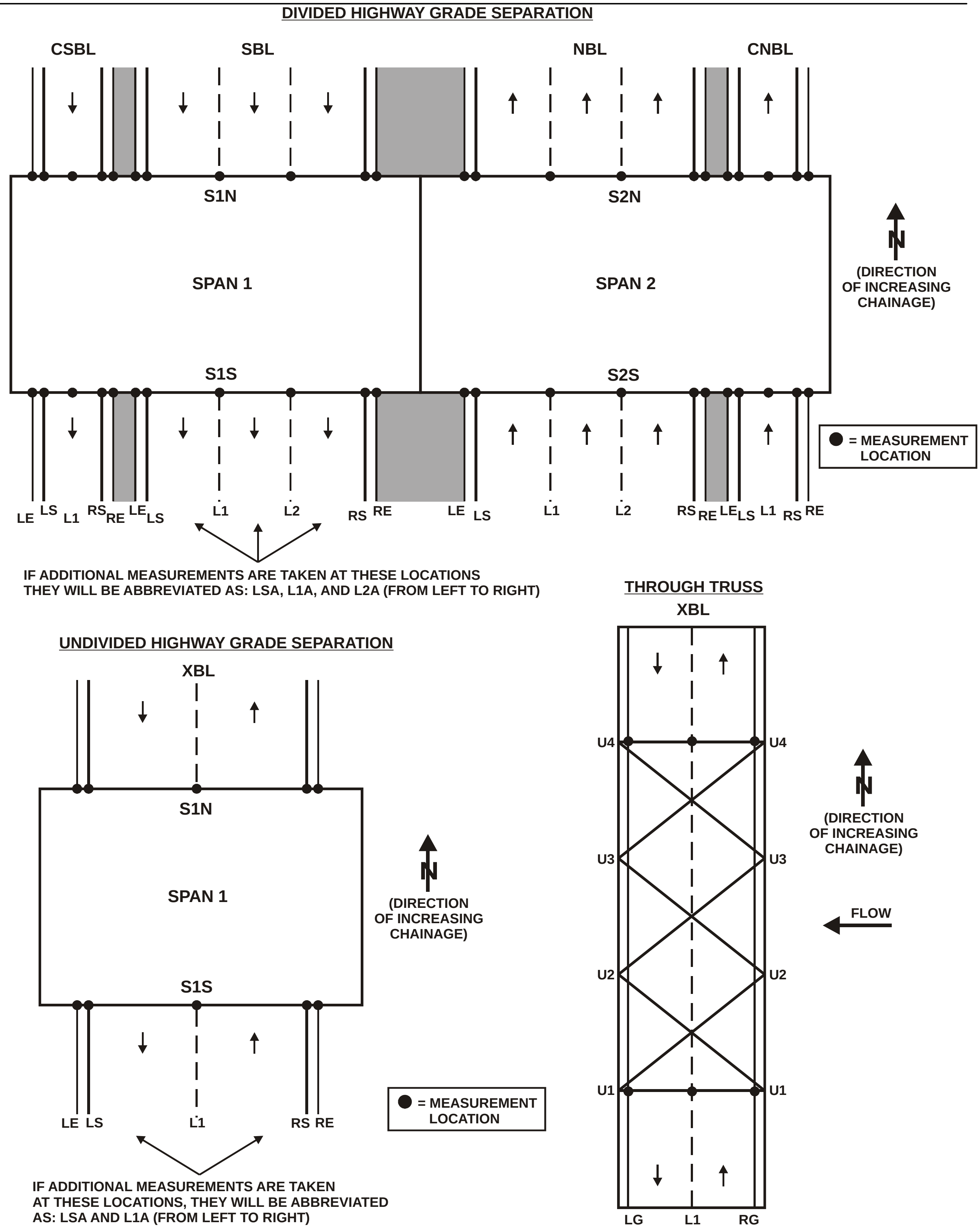


Figure 7.5 – Vertical Clearance Measurement Locations

Bridge File Number : ....
Legal Land Location: ...-..-...-..-.
Latitude/Longitude : ..../.........
Road Auth./Region : .../R.
Bridge or Town Name: ....
Stream Name : ....
Highway #:Cntrl Sec: ....:...
Road Classification: ....-...
AADT/Year : .-....../..
Detour Length : ...km

Structure Usage : ..
Year Built : ../..
Clear Roadway/Skew: ....m/...Deg

Prev. Insp. Date : ____/__/__ (YMD)
Insp. Req'd Date : ____/__/__ (YMD)
(based on ____________________)

Current Insp. Date: ____/__/__ (YMD)
Inspector's Code : ____

STRUCTURE INFORMATION:
No. of Spans: .. Span Types: .../... Substructure Types: .../...
Span Lengths: ....-....-....-....-.....m Total Length: .....m

LEVEL 1 VERTICAL CLEARANCE INFORMATION:

Posted Vertical Clearance: Y/N ___ On Bridge __B Lane ___ m; __B Lane ___ m;
Posted : In Advance __B Lane Y/N ___; __B Lane Y/N __
Remarks ____

LEVEL 2 VERTICAL CLEARANCE SUMMARY INFORMATION:

	_ BL O/U _		_ BL O/U _		_ BL O/U _		_ BL O/U _	
	LAST (m)	NOW (m)	LAST (m)	NOW (m)	LAST (m)	NOW (m)	LAST (m)	NOW (m)
Minimum measured clearance								
Calculated posting clearance								
Existing posting on bridge								
Existing posting in advance								
Revise posting	Y/N ___		Y/N ___		Y/N ___		Y/N ___	
Comments:								

ALBERTA TRANSPORTATION

BIM LEVEL 2 REPORT - 2004
VERTICAL CLEARANCE MEASUREMENT

FORM ID: VCL2
Bridge File: .....
Page: 2

INSPECTION DATA:

SPAN ID	_ BL O/U _			_ BL O/U _			_ BL O/U _			_ BL O/U _		
	LOC.	LAST (m)	NOW (m)	LOC.	LAST (m)	NOW (m)	LOC.	LAST (m)	NOW (m)	LOC.	LAST (m)	NOW (m)
MIN.	*****			*****			*****			*****		

Comments:

LEVEL 1 INSPECTION (INFORMATION ONLY) Level 1 date: ____/__/__

Structural Condition Rating: __% Sufficiency Rating: __% Estimated Remaining Life of Structure: __ years Special Comments for Next Inspection:
Next Scheduled Level 1 inspection: ____/__/__ Current Cycle: __months

ITEMS REQUIRING IMMEDIATE ATTENTION:

LEVEL 2 INSPECTION SPECIAL REQUIREMENTS:

Y => Snooper: __ Lift: __ Traffic control: __ Boat: __ Ladder: __ Other: ____

INSPECTOR:

Recommended Cycle __ months OR Next Insp. Date ____/__/__ (blank for default) Recommended Additional Cycles: _ (blank for default, 0 for discontinue)		
Inspector’s Code: ___	Inspector’s Name: __________________________	Class: _
Assistant’s Code: ___ Assistant’s Code: ___	Assistant’s Name: __________________________ Assistant’s Name: __________________________	Class: _ Class: _
Comments: ____ ____		

REVIEWER: Review Date: ____/__/__

Approved Cycle __ months OR Next Insp. Date ____/__/__ (blank for default) Approved Additional Cycle: _ (blank for default, 0 for discontinue)\		
Reviewer’s Code: ___	Reviewer’s Name:____________________________	Class: _
Comments: ____ ____		

Default No. of Inspections: _ Default Cycle: __ months	Number completed to date: __ Next Inspection Required Date ____/__/__

8.0 CHAPTER 8 - TIMBER CORING

8.1 INTRODUCTION

Coring of timber elements is an effective method of determining the presence of rot. It is also a tool that can be used in forecasting the remaining service life of a bridge, and in helping to determine maintenance and construction requirements.

Generally, coring should be carried out by a minimum of 2 persons, at least one of which should have considerable experience, and be familiar with coring procedures and techniques. This person must also have sufficient experience to assess the core samples, and make the appropriate recommendations based on the findings.

Coring is generally carried out at least once in the service life of bridges with timber substructures. It is recommended that initial coring on timber substructure elements be carried out in year 25, unless visual evidence indicates coring is required sooner. If the initial timber coring finds evidence of only minor rot, additional coring may be required in subsequent years in order to monitor the progression of the rot.

A second coring may be required in year 40 if it is clearly determined that there is a minimum of 10 years life remaining in the bridge structure. If no rot was found in the previous inspection, cores should be taken in between the previous core holes.

Coring is also recommended prior to carrying out major maintenance or rehabilitation (i.e. girder or cap replacements, or concrete overlays).

Timber piles should be cored at times of low water, generally in the late fall, winter, or before or after irrigation seasons.

8.2 SAFETY

As noted above, coring should be carried out by a minimum of 2 people, using the appropriate personal protective equipment.

The inspectors must be aware of the following hazards:

- Use of ladders.
- Use of electrical devices near water.
- Potential for twisting wrists particularly when bit catches a drift pin or lag bolt.
- Working on uneven surfaces.
- Use of restricted chemicals such as creosote.
- Traffic accommodations.
- Thin ice.

8.3 TOOLS AND EQUIPMENT

The following equipment is required for timber coring:

- Drill – cordless or electric
- Generator, cords or extra cordless batteries
- 3/8" dia. bit x 12" long (include extra bits)
- Ladder (if required)
- ½" dia. fluted dowels
- Creosote
- Low pressure back-pack style sprayer
- Timber crayons
- Personal protection – rubber gloves, eye protection, dust mask, etc.
- Clip board, pencils and paper, timber coring forms
- Chain saw and associated protective equipment

8.4 CORING PROCEDURE

- Whenever possible, know the site you are going to core before you travel to it. It may be that the pier piles or caps are inaccessible in the summer due to excessive water depth. Reviewing the latest BIM inspection or photographs of the site can ensure that the coring is completed at the best time of year and that the inspector brings the proper equipment so that all timber members can be cored in a safe, effective manner.
- Begin coring approximately 300 mm from ends of caps, subcaps, and corbels and proceed at 1.5 m intervals.
- Core timber piles approximately 300 mm below top of pile, and again at or just above the visible waterline. For piles that are routinely exposed to water the inspector should try to determine where the pile is exposed to both air and water and take the core in that area. Rot is most likely located where the pile is exposed to water and air in an alternating cycle. If it is not possible to get to this area of the pile, then coring should be deferred.
- If no rot is encountered stop bit approximately 50 mm from backside of cap or pile.
- Stop coring as soon as rot is first encountered. Measure the depth of the hole and record the depth of sound timber. Resume coring through the rotted section, stopping again when it is determined that the rotted section has ended. Measure again and record the depth of the rotted timber. Resume coring again stopping approximately 50 mm from the backside of the cap or pile.
- When rot is found at a particular core hole, coring should continue at 200 mm intervals on either side of the initial core hole until sound timber is encountered. This step can be omitted if the initial core holes, spaced at 1.5 m intervals, all indicate the presence of rot.
- Disinfect the drill bit after each use by dipping in creosote or bleach. This will help to prevent the transfer of rot and fungus to the next core hole. The drill bit should be disinfected even if no rot is encountered in the core.
- Using a low pressure back-pack style sprayer, pump a small amount of creosote into the core hole, then seal the core hole by installing ½" diameter x 1" long fluted dowel plugs that have been soaked in creosote. Again, this step can be deleted if extensive rot is found in all of the core samples.
- Avoid coring in the immediate area where drift pins or lag bolts are likely located. There are small pockets of rot that may form around these locations that may not be indicative of the

condition of the entire cap. As well, it is possible to injure yourself if you hit a drift pin when coring.

When coring bridges in winter remember that heat from friction between the drill bit and the frozen timber can cause the shavings to appear moist. Wet or damp shavings may not indicate rot.

8.5 BIM LEVEL 2 TIMBER CORING FORM

A copy of the Level 2 Timber Coring Form is included at the end of this chapter. One copy of the form is used for each abutment or pier bent that is being cored. The bridge file number, date of timber coring and the name of the inspector and assistant inspector should be recorded on each form.

Each form has a sketch of a timber abutment or pier bent. Also each form has tables for recording the condition of the cores taken in timber caps/corbels and in timber piles. Each table has a number of thumbnails with descriptions into which each core location can be recorded. The form also has another table where other defects of timber piles can be recorded.

8.5.1 FILLING OUT TIMBER CORING FORM

- Record the abutment or pier number and direction on the form. Abutment and piers are numbered from south to north and west to east as shown in Section 1.3.1.
- Record the pile height and spacing as indicated on form.
- Record the timber cap size and indicate whether crowned (Y/N).
- Show the location of all cores on timber bent sketch. Number the core locations consecutively, in the direction South to North or West to East, starting with #1.
- In the tables provided record the identifying number of the timber cores that fit each thumbnail sketch description.
- For timber piles record location of any other defects noted.
- After completing and recording all the timber cores, the inspector must assign a rating number to each piece of timber cap/corbels and each timber pile.
- A general rating must then be assigned to the caps/corbels and the piles of this bent.
- Guidelines on assigning rating numbers are given in Section 8.5.2.

8.5.2 RATING GUIDELINES

- If cap/corbel or piles has no cores showing rot and no other defects affecting condition or functionality, rate 5 or more.
- If cap/corbel has rot only in cores at end of cap/corbel which is outside of any pile or girder, rate 5 or less. .
- If cap/corbel has < 40 mm of rot in two or less cores, rate 4.
- If cap/corbel has between 40 and 80 mm of rot in one core only, rate 4.
- If cap/corbel has between 40 and 80 mm of rot in more than 1 core, rate 3 or less.
- If cap/corbel has > 80 mm of rot in one core only, rate 3.
- If cap/corbel has >80 mm of rot in more than one core, rate 3 or less.
- If cap/corbel has sidewall bulging less than 10 mm at one location only, rate 4 or less.

- If cap/corbel has bulging less than 10 mm at more than one location or more than 10 mm at one location, rate 3 or less.
- If cap or corbel shows signs of crushing, rate 2 or less.
- If pile has the beginning of rot in one core only, rate 4.
- If pile has rot in more than one core or has void in centre less than 0.25 of the diameter of the pile in one core, rate 3 or less.
- If pile has void in centre less than 0.25 of the diameter of the pile in more than one core or has void in centre of more than 0.25 of the diameter of the pile, rate 2 or less.

The general ratings of the caps/corbels and the piles are governed by the lowest rating of an individual cap/corbel or individual pile.

8.6 ADDITIONAL INFORMATION

If rot is found in a timber cap or subcap that is limited to the end of the cap only, and if there is sufficient length of cap overhanging the superstructure, cutting the rotted section of cap off with a chain saw may be an effective means of slowing or stopping the migration of rot further into the cap. A minimum of 6” of cap should remain after cutting. The cut end of the remaining cap should then be treated with 2 field coats of creosote, and ideally sealed with hot pour tar.

After a rotted timber element has been replaced with a new member, considerable experience, knowledge, and insight can be gained by utilizing the rotted timber as a test section before it is properly disposed of. Additional coring and recording can be done, and the core results analyzed. Then the member can be cut through with a saw, to correlate the core results and predictions with the actual condition of the cross section of timber at the core location.

BIM LEVEL II TIMBER CORING SKETCH

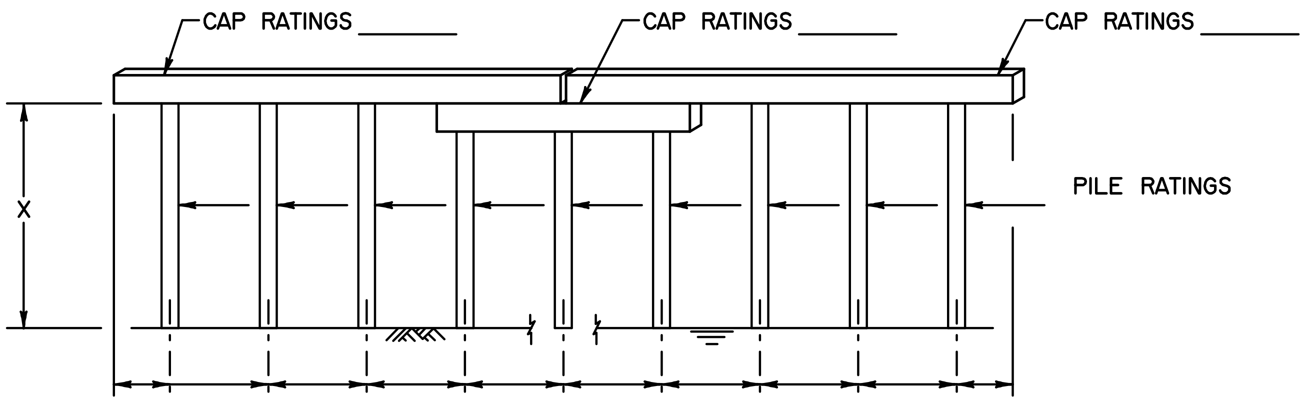
BRIDGE FILE: ____________________

DATE: ____________________

INSPECTOR: ____________________

ASSISTANT INSPECTOR: ____________________

ABUTMENT/PIER: __________ **LOOKING:** __________



CAP SIZE _______ **X** _______ **CROWNED** YES _____ NO _____

GENERAL CAP RATING ____________ GENERAL PILE RATING ____________

CONDITION OF TIMBER CAPS/CORBELS

THUMBNAIL	DESCRIPTIVE CONDITION	APPLICABLE CORE LOCATIONS
N R	NO ROT-SHAVINGS ARE DRY, INTACT AND CURL AROUND BIT	
B R	BEGINNING TO ROT < 40mm - SHAVINGS CRUMBLE	
	ROT AND/OR VOID > 40mm < 80mm - SHAVINGS ARE DUST OR CONSISTENCY OF COFFEE GROUNDS	
	ROT AND/OR VOID > 80mm - SHAVINGS ARE DUST OR CONSISTENCY OF COFFEE GROUNDS	
	SIDEWALL BULGING LESS THAN 10mm	
	SIDEWALL BULGING .... MORE THAN 10mm	
	CRUSHING OF CAP - PILE PUSHING INTO BOTTOM OF CAP	

CONDITION OF TIMBER PILES

THUMBNAIL	DESCRIPTIVE CONDITION	APPLICABLE CORE LOCATIONS
N R	NO ROT-SHAVINGS ARE DRY, INTACT AND CURL AROUND BIT	
B R	BEGINNING TO ROT - SHAVINGS CRUMBLE	
	VOID IN CENTRE LESS THAN 0.25 (DIAMETER) - SHAVINGS ARE DUST OR CONSISTENCY OF COFFEE GROUNDS	
	VOID IN CENTRE MORE THAN 0.25 (DIAMETER) - SHAVINGS ARE DUST OR CONSISTENCY OF COFFEE GROUNDS	

OTHER DEFECTS - TIMBER PILES

	DESCRIPTIVE CONDITION	APPLICABLE CORE LOCATIONS
	PILE SPLIT OR CRACKED > 25mm	
	BROKEN AND/OR MUSHROOMING	
	VERTICAL/HORIZONTAL MISALIGNMENT	

9.0 CHAPTER 9 – PIER SCOUR SURVEY

9.1 INTRODUCTION

Many rivers in Alberta are dynamic in nature, with bank erosion and scour resulting in changes to river geometry over time. Scour, or lowering of the streambed, can occur due to natural processes, such as bedform movement and increased bed load transport under high flow conditions. Additional scour can occur at stream crossings due to constriction of the flow and forces associated with flow interference at structural elements, such as piers and abutments. Some factors that can affect the rate and extent of scour at a pier include:

- Pier geometry – pier width and shape, elevation and extent of footing or pile cap
- Flow alignment – can change due to lateral channel erosion, partial blockage due to drift and/or ice, migration of bedforms etc.
- Subsurface geology – location and depth of bedrock, competency of bedrock, variability across the channel
- Runoff history – magnitude and frequency of large runoff events
- Stream characteristics – flow velocity and depth, bedforms, planform, lateral migration

Due to the wide range of factors and the complex nature of the scour process, the ability to accurately model and predict future changes is limited. It is therefore important to monitor changes at sites that are considered to be vulnerable to scour, such as piers with spread footings or short piles. Monitoring these changes often requires hydrographic surveying, as the stream beds near the piers at many sites are not accessible for visual inspection and/or traditional land-based surveying techniques. Knowledge of changes in streambed in the vicinity of these piers is required to assess the safety of the bridge system and identify required rehabilitation activities. This document describes the current approach to pier scour inspection and survey for Alberta Transportation bridges.

9.2 HISTORY

Alberta Transportation has been undertaking pier scour surveys at many sites across the province since the late 1950's. Much of this work was undertaken by in-house staff until 1996, using various techniques including depth sounders, boats, booms, and sounding rods. Since 1996, this work has mostly been carried out by consultants. The typical set-up for recent surveys has been a low draft boat with a digital depth sounder integrated with a robotic total station to collect xyz data.

Prior to the early 1990's, surveys were obtained on a reactionary basis, such as in response to recent flooding, upcoming construction activities, or sites with known issues. In the early 1990's, a systematic approach was developed. The entire inventory of major bridges was assessed for scour vulnerability, based on theoretical prediction equations. All major river crossings were assigned a pier scour priority rating of 1 to 4, with 1 being assigned to the most critical sites (e.g. shallow spread footings) and 4 assigned to bridges that were deemed to not be of interest to the pier scour program (e.g. piers out of water).

By 1999, baseline surveys had been obtained for most sites in the pier scour inspection program (priority 1 – 3). These surveys consisted of either detailed streamed contour surveys for larger, higher priority sites to profile surveys (cross sections taken just u/s and d/s of the bridge) at the remaining sites. Results from these surveys were used to plan future survey work and to identify rehabilitation needs at problematic sites (e.g. BF00315 - St. Mary River, BF78104 McLeod River). Following the baseline surveys, it was decided to identify further survey needs in the short term based on flood events and infrastructure assessment needs. This resulted in a reduction in the number of surveys between 2000 and 2008. Surveys obtained in this time frame included 9 surveys at high priority sites following the June 2005 flood, and 5 surveys in 2008 to assist with bridge rehabilitation assessments.

For the 2008 surveys, it was observed that the cost of a contour survey had increased significantly. As a result, alternative approaches to data collection were evaluated. In addition, the type of information required was re-assessed, with consideration given to site specific requirements. It was also observed that the pier scour priority system needed to be updated due to bridge rehabilitation, replacement, and new construction activities.

The potential benefits of a more formal inspection schedule were also identified, including economic efficiency of data collection, improved ability to respond quickly to upcoming information needs, and having a more current evaluation of the state of the most scour vulnerable bridges in the system. Based on these factors, the pier scour database was updated in January 2009, with a re-assessment of priorities, the addition of categories of inspection, and the introduction of a formal schedule for survey of larger crossings.

9.3 PIER SCOUR PRIORITY AND SURVEY CATEGORY

As of January 2009, there are 1047 major bridges over rivers in the Alberta Transportation inventory system that are classified as “in service” and not under the jurisdiction of a city. The following number of bridges are considered to not be of interest to the pier scour survey program:

Category	**Number of Structures**
Causeway (crossing a lake or reservoir)	10
Non – AT (not owned by Alberta Transportation)	21
No Piers (single span bridges)	312
Piers not In-stream (piers not within the active waterway at low flow)	292

The 412 remaining structures have been classified as “Criteria” bridges in the screening field of the pier inspection database. Of these, 200 bridges were determined to have foundations deeper than 10m below streambed, and have been assigned a priority of 4, meaning that they also are not of interest to the pier scour survey program.

The remaining 212 bridges have been assigned priorities of 1 to 3 based on the type of foundation and the relative dimension of depth of penetration (P - stream bed to bottom of foundation element) to the pier width (W - measured square to the flow at streambed level). This ratio is used as local scour at piers tends to scale on the width of the obstruction to flow. The required data can be found on the general layout drawings for most sites. In a few cases, sufficient inventory data was not available, and conservative assumptions were made in the calculation of priorities. Priority calculations are based on the most critical pier at a structure. The following criteria have been used:

	Priority = 1	Priority = 2	Priority = 3
Spread Footing	P/W < 1.5	1.5 <= P/W < 3	P/W > = 3
Short Pile (< 6m)	P/W < 3	P/W >= 3	
Long Pile (6 – 10m)		P/W < 3	P/W > = 3

These bridges were also categorized by type of inspection anticipated due to the nature of the stream and the limits of equipment available to collect data. The three categories assigned are as follows :

B – Big stream crossing (T > 50m at low water), likely requiring a manned boat and sounder to collect streambed elevations in the vicinity of the piers
S – Small stream crossing (T <=50m), likely requiring depth sounding, but too difficult to mobilize a manned boat – remote sounding/wading may be appropriate
V – Visual inspection (ground at pier base readily visible from shore, typically T < 20m)

The number of structures in each category (Jan. 2009) are as follows :

	Priority = 1	**Priority = 2**	**Priority = 3**	**Total**
B	28	34	26	88
S	14	27	25	66
V	9	22	27	58
Total	**51**	**83**	**78**	**212**

Of the 88 "B" sites, approximately 10 sites are in the planning/design/construction process and will not require pier scour inspection unless replacement is deferred for an extended period. The pier scour inspection categories, priorities, and supporting inventory data are stored in the "Pier Scour Inspection Management" table in the HIS database ("S:\Bridge Planning\Engg Software\HIS\HIS.mdb"). This database should be updated once per year to account for changes in infrastructure (link to BIS data) and to update survey categories and priorities based on the most recent inspections.

9.4 SURVEY REQUIREMENTS

For sites classified as "V", site confirmation should be made that the streambed in the vicinity of the pier is visible. If so, photographs covering the streambed topography in the vicinity of the pier should be obtained. In addition, if any scour holes are visible or if recent changes in bed topography are apparent, a measurement of the lowest point on the streambed in the vicinity of the pier (within 5m) should be made relative to the bridge deck above the pier. This will facilitate comparison with previous inspections. If the bed topography in the vicinity of the pier can not be readily assessed, the site should be treated as an "S" site and survey information obtained as described below, unless this is due to highwater conditions.

For sites classified as "B" or "S", depth soundings should be obtained in the vicinity of each in-stream pier and along profiles parallel to the bridge. The profiles should be taken close to both the upstream and downstream faces of the bridge. Soundings in the vicinity of the pier should include measurements as close to the pier as possible and cover the streambed for 15m ("B" sites) or 10m ("S" sites) from the pier shaft in all directions, if possible. Data density should be such that there are no gaps in the data that exceed 3m ("B" sites) or 2m ("S" sites). The position of each sounding should be recorded, to enable production of an xyz surface of the streambed. The outline of the pier should be readily visible in the data-set. Profile soundings should extend as close to water's edge as can readily be sounded, with a maximum spacing of 5m ("B" sites) or 3m ("S" sites) between points.

The resulting xyz data-set should be delivered as a CSV text file. The horizontal positioning of the points should be produced in TM grid (parameters provided) or geographic coordinates for use in GIS systems, and with a desirable accuracy of 1m. The streambed elevations will preferably be provided as geodetic, but elevations relative to the reference system used on the most recent general layout drawing are also acceptable, with a desirable accuracy of 0.3m. Where geodetic elevations are provided, deck elevations over the piers must be available to enable comparison with previous data-sets.

The methods and equipment used to collect and prepare this data are not specified. It is anticipated that structures classified as "B" will require the use of manned boats and electronic depth sounders. Positioning can be done by any means as long as it meets the desirable accuracy requirement and can result in conversion to a GIS compatible coordinate system. Structures that are classified as "S" may require more portable techniques, such as wading, sounding from the bridge deck, or using a remote control boat equipped with a sounding system. Consumer grade GPS units may not be sufficient to meet the accuracy expectations, especially due to blockage from satellites due to bridge decks and steep valley walls. Measured offsets from infrastructure elements may be acceptable, if they can be converted to GIS coordinates (e.g. georeferenced photography, accurate GPS measurements) and meet the accuracy requirements.

Surveys are typically done during low flow conditions for safety, accuracy, and scheduling reasons. It is possible that some infilling of scour holes may occur at some sites. Where feasible, visible changes in bed surface material should be noted, and probing of the bed with a bar should be considered. In addition to the xyz data covering the streambed near the piers and along the profiles, the elevation of the water surface and photos of the bridge at the time of survey should be provided.

Drift accumulations at piers can significantly impede the ability to undertake scour surveys. For all "B" sites, contact should be made with regional personnel prior to the annual survey activities to determine if drift accumulations are present at the proposed sites. If possible, arrangements should be made to remove large drift accumulations prior to the survey. A crane with a clamshell bucket has proven to be successful at removing drift from the nose of piers.

Other issues that can impact pier scour surveys include :

- Availability of consultant(s) and/or equipment
- Point of access to river for larger equipment
- Channel and point bars that can impact navigation of larger boats
- Strong currents that can impact navigation of smaller boats
- Weather conditions, such as high winds

9.5 SCHEDULE

For public safety and accountability reasons, it is desirable to inspect all of the pier scour susceptible sites within a somewhat regular cycle, with that cycle being reduced for higher risk sites. The recommended cycle is in the range of every 5 years for priority 1 sites to every 10 years for priority 3 sites. Additional factors to include in determining the pier scour inspection survey schedule include geographic grouping for economy, combining trips with RPW inspection sites, the occurrence of large runoff events, and the availability of survey resources.

This schedule is most important for "B" sites due to the mobilization effort, expense, and limited availability of resources. There are approximately 70 "B" sites that currently require pier scour inspection, not counting structures soon to be removed and some marginal sites that are very remote and can probably be inspected by other means. Based on inspection priorities, inspection cycle criteria, geographic grouping, and recent inspection history, a 10 year program for inspection has been developed. This program results in 10 "B" sites being inspected each year. An annual review of this schedule should be undertaken to account for factors such as recent observations, flooding impacts, and bridge rehabilitation assessment requirements.

To meet the proposed inspection cycle for "S" and "V" sites, approximately 9 "S" inspections and 7 "V" visual inspections will be required annually. A similar methodology can be applied to developing an annual program for these sites. However, as these sites do not require the same amount of equipment and effort as the "B" sites, there is likely to be significant overlap with site inspections for other bridge planning and RPW inspection purposes, so there is less need to develop a formal long range program. Annual review should be undertaken to ensure all sites are meeting the inspection cycle goal and are classified correctly.

These surveys will require ice-free conditions and for safety reasons should generally be done at low flow conditions. As spring runoff generally occurs around April, and most large storm runoff events occur in June and July, May, August and September are the preferable months for surveys. However, monitoring Alberta Environment rainfall and runoff gauges in the vicinity of planned trips can facilitate identification of periods of low flow at any time in the summer.

Tracking of historic surveys and proposed upcoming survey and inspection schedules are maintained in the "Pier Scour Inspection Management" and "Pier Scour Inspection History" tables in the HIS database. The "Management" table has fields for year of last survey and year of next survey, which should be updated after each survey for a given site. The "History" table has fields for survey type, survey by, and survey year, and "Penetration Depth" (minimum height between ground and bottom of foundation). Each new survey will result in appending a record to this table.

9.6 EVALUATION

Collected xyz data for "B" and "S" sites can be processed and developed into contour plots and profiles. Contours can be compared to previous surveys using GIS tools to determine the difference between surfaces. Profiles can be superimposed onto previous profile plots for rapid visual assessment. Bank tracking plots using historic airphotos should also be referenced, where available. Survey actions and updated assessments of pier scour priorities are tracked in the HIS tool. In addition to prepared plots, brief reports should be prepared, summarizing field conditions and observations along with scour assessment and recommendations. Tracking the "Penetration

Depth" field in the "History" table will enable rapid identification of sites with significant changes in bed topography.

The major factors to consider when evaluating scour survey data include :

- Elevation of deepest scour hole relative to base of structural support
- Location and extent of scour hole
- Change in geometry since last survey
- Nature of channel bed
- Changes in flow alignment in the vicinity of the bridge opening

For sites where little change has been observed and there appears to be little risk to the infrastructure, the processed report can be filed and the database updated. However, at sites where significant scour holes are observed and/or there have been significant changes since the last survey, the survey results may trigger action such as rehabilitation or increased rate of inspection. In some cases, the results may identify the need for a bridge replacement assessment. Potential rehabilitation actions include addition of a protection layer near the base of the scour hole, underpinning of the foundation, or realignment of flow using river protection works upstream. Adding a protective layer can lead to additional scour if not done properly.

10.0 CHAPTER 10 – RIVER PROTECTION WORKS INSPECTION

10.1 INTRODUCTION

Many river crossings in Alberta are located over reaches that are prone to lateral instability and changes in flow alignment. As a result, river protection works (RPW) have been designed and constructed at many sites to stabilize and align the stream in the vicinity of bridges and roadway encroachments. These protection works play an important role in maintaining the structural integrity and functionality of bridges and roadways.

RPW can consist of river engineering structures such as guidebanks and spurs, and armouring of channel banks and bridge headslopes. In most cases, these works consist of an earthen fill or slope protected by an armour layer. Although the current preference for armour material is rock riprap (see Best Practice Guideline No. 9), a variety of materials have been used in the past.

These RPW are typically designed to protect the road and bridge infrastructure during a design runoff event, although they may suffer some damage in the process. In addition, it is generally not cost effective or environmentally acceptable to protect for all possible future channel changes during the initial construction. Therefore, it is important to monitor sites that are prone to lateral mobility to assess the condition and functionality of the RPW on an ongoing basis.

The condition of some components of RPW and channels are inspected as part of the Level 1 BIM inspection. However, the condition and functionality of RPW cannot be accurately assessed without an understanding of factors such as:

- the morphological setting of the river, and ongoing river processes
- stream alignment and recent flood history
- interaction of the RPW with the bridge or roadway
- extent and purpose of all RPW structures and armouring

It is therefore beneficial to have the functionality and condition of these works periodically reviewed by personnel with experience in river engineering and familiarity with the characteristics of each site. This document describes the current approach to RPW inspection for Alberta Transportation bridges.

10.2 HISTORY

Prior to 1995, inspection of RPW was done by bridge planning staff with extensive experience in river engineering and familiarity with site characteristics and history. The inspection of sites was triggered by factors such as:

- proximity of nearby projects requiring site investigation
- observations of regional bridge engineers or BIM inspectors
- occurrence of significant floods in the area
- inspection associated with the pier scour inspection program
- results of detailed studies on river processes by the Alberta Research Council.

With changes in the delivery of bridge design services, the need for a formal program for inspection of RPW was identified. In the late 1990's, a systematic review of RPW infrastructure was undertaken to identify all sites with significant river engineering structures, and those that had a high likelihood of lateral instability. Following this review, most of this infrastructure was inspected and reviewed for functionality by personnel with river engineering expertise. In 2009, the system was re-evaluated using more objective criteria and a schedule for functionality review and condition inspection and proposed.

10.3 INSPECTION PRIORITY

As of February 2009, there are 1004 sites with major bridges over rivers or highway encroachments in the Alberta Transportation inventory system that are classified as "in service" and not under the jurisdiction of a city. In addition, there are 23 sites identified as highway encroachments (sites where RPW structures have been built adjacent to highways that are not close to crossings). In order to identify sites of interest for RPW inspection and to establish priorities for inspection, the following parameters have been considered:

- presence of RPW structures that extend beyond the bridge headslopes
- channel morphology – indicator of potential for lateral mobility
- bridge length – indicator of channel size and structure significance

Of the 1027 sites investigated, 164 have RPW structures that extend beyond the bridge headslopes. These structures are indicative of past channel stability and flow alignment issues. These sites will also require channel inspections that exceed the BIM level 1 inspections. All of these sites have been included in the BIM level 2 RPW inspection program.

Each of the 1027 sites were investigated using satellite photography and review of channel profiles to assess the potential for lateral mobility. Each site was assigned to one of the following channel stability rating categories:

Channel Stability Rating	Description	No. Sites
1	• Multiple channels, frequent in-stream bars • Sharp changes in flow alignment • Low water width << bank width • Recent channel shifts	367
2	• Few channel splits, vegetated islands • Active bend erosion - scour, point bars • Some active bank erosion - steep, un-vegetated • Some vegetated oxbows (cutoffs)	293
3	• Few channel features • Vegetated, stable banks • Incised – e.g. rock wall canyons • Lakes, canals	367

The potential for lateral mobility decreases with an increase in the channel stability rating. Sites were assessed on a reach by reach basis to ensure consistency, using the slope derived from the channel profiles in the department's Hydrotechnical Information System (HIS), as an indicator of changes in channel properties. The TIMS Webmap tool, with the satellite photography layer turned on, was used to visually assign the appropriate rating.

As all major bridges are not the same, and those over smaller channels can be more thoroughly examined in a BIM level 1 inspection, bridge length was also used to assist in assigning an inspection priority. The bridge length is used as a rough indicator of stream width and infrastructure significance for the sites that are not stream encroachments. The following criteria were used to group bridges:

Bridge Length	Number of Structures
>= 60m	318
>=40m and <60m	278
<40m	408

These three categorizations were then combined to identify sites of interest to the RPW inspection program, and to assign inspection priorities to them. This was done as follows:

Priority	RPW	Channel	Bridge Length	No. Sites
1	Y	1	All	106
2	Y	2	All	32
2	N	1	>=60m	74
3	Y	3	All	26
3	N	1	>=40m and <60m	66
4	N	2	>=40m	133
5	N	1,2	<40m	242
5	N	3	All	339

The assignment of priority will affect the frequency and extent of inspection at each site. Sites rated '1', '2', or '3' will be in the RPW inspection program. Sites rated '4' will be of marginal interest with periodic review, and sites rated '5' will not be considered as part of the RPW inspection program unless triggered by other factors. The assignment of these ratings and priorities and supporting inventory data are stored in the "RPW Inspection Management" table in the HIS database ("S:\Bridge Planning\Engg Software\HIS\HIS.mdb"). This database should be updated once per year to account for changes in infrastructure (link to BIS data) and to update priorities based on the most recent inspections.

10.4 INSPECTION REQUIREMENTS

There are two aspects to the RPW Inspection program – functionality review and condition inspection. The functionality review will be based on a desktop bank tracking review using temporal airphotos in a GIS tool while the condition inspection will be a visual site inspection.

There are many sources for the airphotos used in the desktop review. Historic hardcopy airphotos dating back as far as 1920 have already been procured and scanned for many sites. Many recent airphotos have been collected by the department in digital format and are available through the TIMS Webmap tool dating back to 1997. The department has also purchased complete coverage of the province in georeferenced satellite imagery, with multiple coverages available between 2005 and 2008, and future purchases planned. Some additional georeferenced block airphotos have been collected for certain areas of the province. Airphotos may also be purchased from the Alberta Environment library as required to provide good temporal coverage for all sites of interest. Sites that are due for a functionality review update can be added to the annual flying list coordinated by AT's GIS Department.

Using Global Mapper, or an equivalent GIS tool, multiple years of airphoto coverage can be georeferenced and river banks can be traced with vectors. Multiple vector layers can then be shown on top of the most recent photography, allowing for observation of historic changes in bank location and flow alignment. The location, magnitude, and rate of change in channel features can be readily identified. This facilitates assessment of the overall functionality provided by existing RPW and the identification of possible future enhancements. It also identifies areas of interest for the next visual condition inspection. It is envisioned that Global Mapper files will be prepared and maintained by TSB staff for all sites rated '1', '2', or '3', with updates based on the approximate schedule shown in the next section.

Prior to undertaking a visual site inspection, output from the latest bank tracking analysis and existing design drawings should be procured and reviewed. All RPW elements should be identified and a plan for the path of inspection developed. These drawings can be used to map and collect inspection observations on site. Specific items of interest during the inspection are as follows:

Category	Description
Typical channel dimensions	• Identify portions of channel that appear typical of the reach • Estimate bed width, top width, and bank height
Hydraulic influences	• Natural - rock ledges, changes in cross section and slope, beaver dams, recent cutoffs • Other structures - weirs, lakes, bridges
Highwater data	• Note type, location, approx. elevation of any highwater/ice marks e.g. drift and grass deposits, siltation, marks on piers and girders, ice scars… • Note any backwater impacts e.g. farmlands, buildings…
Flow alignment	• Sketch channel features on hardcopy map/photo • Note bends, splits, skew, points of attack, zones of high velocity, bars, islands, drift accumulations • Visualize flow alignment at flood stage • Confirm channel stability classification
Bed and banks	• Map and assess bank stability – note slope, height, vegetation, material, erosion, slumps, rock outcrops, springs • Describe bed material – gravel, sand, silt, D_{50}, armour size
RPW	• RPW structures – under direct attack or out of flow, adjacent scour holes, slumps, loss of fill, signs of overtopping or outflanking • Ends of protection tied into bank or exposed • Apron – signs of launching, covered by deposits • Rock armour - lost rock, confirm rock size and angularity, signs of disintegration • Concrete armour – cracks, displacement, missing sections • Other armour – describe, compare to design
Drift potential	• trees in basin, active bank erosion, beaver activity • drift accumulations – at bridge/RPW, on banks, on bars

It is recommended that photos and videos be taken of any condition related issues, as well as general site coverage which should include a pan of the upstream and downstream channel from the bridge deck, and a wide angle or pan of the upstream and downstream faces of the bridge. Some rough vertical measurements may be of assistance to future assessment work, so it is advisable to take some tools along for the inspection, such as a handheld laser rangefinder or level, and a weighted tape. A handheld GPS unit may also be of benefit to mark the position or extent of features of interest.

In addition to the photos and video, a brief report summarizing key observations and measurements should be prepared for each site. This report should also summarize conclusions based on an evaluation of these results, as discussed in section 10.6. These reports should be stored in a directory used by TSB for tracking the BIM Level 2 RPW Inspection program.

10.5 SCHEDULE

For public safety, accountability, and optimal structure management reasons, it is desirable to inspect all sites in the RPW inspection program on a somewhat regular cycle. This cycle should be related to the inspection priority for the site, subject to flood events, observations, and construction activities. A minimum cycle of 5 years and a maximum cycle of 10 years has been selected. Updates to the functionality reviews should be done prior to visual site inspections. Based on the priorities established for the sites in the RPW inspection program, the following inspection cycle for functionality reviews and visual site inspections is proposed:

Priority	No. Sites	Functionality Review Cycle	Visual Site Inspection Cycle
1	106	5	5
2	106	5	10
3	92	10	-
4	133	-	-

Sites rated ‘4’ would receive periodic checks of recent information (satellite photos, BIM level 1 inspection, post-flood observations) to identify any issues that may affect the priorities for these sites.

This schedule will result in approximately 50 functionality review updates and 35 visual site inspections per year. The functionality reviews will mostly be done by TSB staff, and once the base files have been established, preparation of updates should be an efficient process. The visual site inspections may be done by a combination of TSB and regional bridge staff, with appropriate coordination. The site inspections may be bundled with pier scour survey and other bridge engineering trips.

10.6 EVALUATION

The functionality reviews and visual site inspections can be used to modify inspection priorities, identify sites that may require assessment for construction work, provide useful information for future design activities, and provide summary data to assist in reporting the status of the bridge system. The results of the RPW inspection program will also be of use in assessing results from the pier scour survey program, as pier scour is often a function of changes in flow alignment. Assessments that are triggered by the RPW inspection program may consider restoration or enhancement of the works, as well as possible impacts on bridge replacement.