

**5.01 General**

The National Bridge Inspection Standards (NBIS) require a load rating be calculated for each bridge and a scour evaluation be completed for each bridge over water. This chapter defines these requirements as follows: Bridge Load Ratings Definition and Methods, Bridge Posting and Reporting Requirements, and Bridge Scour Evaluation Requirements. Hand calculation forms for load rating a timber bridge and a Phase 1 scour evaluation are provided in each section. These calculations are a permanent part of the bridge file and are to be updated when the condition of the bridge changes. **All load rating calculations shall be stamped, signed, and dated by a registered professional engineer.**

The sufficiency rating (SR) section of this chapter explains what codes affect the calculation of the SR and define how bridges rate as structurally deficient (SD) or functionally obsolete (FO). A hand calculation form is provided at the end of this section and should be used to check the code changes. The SR is calculated by the Washington State Department of Transportation Bridge Preservation Office for all NBIS eligible structures.



## 5.02 Bridge Load Ratings Methods

Bridge load ratings can be calculated by using *working stress*, *load and resistance factor*, and/or *load factor* methods. In the past, load ratings were completed using *working stress* and *load factor* methods. Today, load ratings in Washington State are to be performed as follows:

- In order to evaluate the need for load posting, two methods are used to calculate the maximum allowable load for the three AASHTO legal trucks (Types 3, 3S2, and 3-3) and (optional) overload vehicles:
  - The *load and resistance factor* method is used for steel and concrete bridge spans.
  - The *working stress* method is used for timber bridge spans.
- For reporting to FHWA for the National Bridge Inventory (NBI), the HS load (see the AASHTO Manual for the Condition Evaluation of Bridges) is used for calculating inventory and operating tons (WB 75-52 and 75-55). The following methods will be used to determine these values:
  - The *working stress* method is used for timber bridge spans.
  - The *load factor* method is used for steel and concrete bridge spans.
- AASHTO and FHWA currently permit the use of the *load factor* method to load rate steel or concrete bridges for all loads. However, in Washington State, the Department of Transportation uses the *load and resistance factor* rating method to evaluate the need for load posting. WSDOT recommends that local agency bridge owners use *load and resistance factor* to evaluate the need for load posting for all steel or concrete bridge spans. FHWA intends to move toward requiring load and resistance factor rating in the future.
- Previously performed load ratings using *working stress* for timber bridge spans or *load factor* for steel or concrete bridge spans will continue to be valid as long as conditions have not changed. New load ratings will follow the above stated criteria.
- For administrative load ratings of normal reinforced concrete bridges with no as-built plans, the HS load for NBI reporting of operating and inventory tons will be determined based on sound engineering judgment. The ratings can be approximated at 28 tons for operating, and 17 tons for inventory, providing the following is true\*:
  - The bridge has a history of carrying truck loads;
  - Load carrying members show very little or no sign of distress; and
  - A licensed engineer has provided a written recommendation, stamped and signed, that posting the bridge for legal loads is not required.

*\*To be used as guidance only:* Typically an HS operating level of 28 tons, with a range from 25 to 30 tons for 20 to 110 foot spans, approximates the average of the moments caused by the legal loads. The HS inventory tons can be calculated by using 60 percent of the approximated operating tons.

- Field-testing of bridges can also be performed to determine the proper load carrying capacity of bridges.
  - For concrete bridge spans, the steel reinforcing must be determined prior to testing. After determining reinforcing, calculations should be performed.
  - This method should be reserved for bridges where calculations do not provide reasonable allowable loads. See the AASHTO Manual for Condition Evaluation of Bridges, Section 5, for further information.

For comprehensive details on the process of calculating load rating for bridges, refer to the AASHTO Manual for Condition Evaluation of Bridges and the AASHTO Guide Specifications for Strength Evaluation of Existing Steel and Concrete Bridges.

### **5.03 Purpose of Bridge Load Rating**

A bridge load rating is the measure of a bridge's load carrying capacity. There are two capacity levels that bracket this ability, the Inventory Rating and the Operating Rating. The Inventory Rating is the load that a bridge can carry for an indefinite number of loading cycles without detriment to the bridge. The Operating Rating is the maximum load that can be carried on an infrequent basis without detriment to the bridge.

#### **A. Posting Requirements**

The NBIS require the posting of load limits on a bridge, if a legal load configuration exceeds the Operating Rating for that bridge. Agencies generally post a bridge between the Inventory Rating and the Operating Rating. The minimum posting value is three tons at inventory or operating levels. Bridges not capable of carrying a minimum gross live load of three tons must be closed.

A concrete bridge need not be posted for restricted loading when it has been carrying normal traffic for an appreciable length of time and shows no distress. This general rule may apply to bridges for which details of the reinforcement are not known. However, until such time as the bridge is either strengthened or replaced, it should be inspected at frequent intervals for signs of distress. In lieu of frequent inspections, a bridge may be load tested to determine its capacity.

Washington State uses six trucks to check the capacity levels, but only four are mandated. The first three trucks are AASHTO Type 3, Type 3S2, and Type 3-3 and represent actual legal loads. The fourth truck, AASHTO HS-20, is a national standardized truck. This truck is intended to encompass the majority of loads to which a bridge might be subjected. There are also two overload vehicles used by the state which are optional. The overload vehicles are intended to encompass the typical vehicle which would be allowed to operate under special overload permit in Washington (see Figure 5.03.A-1, Load Rating Vehicles).

The inventory items Operating Rating and Open, Posted or Closed should be revised or verified for any bridge requiring posting. The Washington State Department of Transportation (WSDOT) recommends using the Modified R12-5 sign for posting a load limit (see Figure 5.03.A-2, Modified R12-5).

Bridges shall be posted when the load rating factors for the legal loads is less than 1. The posted tonnage shall be no more than the rating factor for the specific truck times its weight.

Posted Tons      Type 3 =  $RF_{\text{Type 3}} \times 25$  tons  
                          Type 3S2 =  $RF_{\text{Type 3S2}} \times 36$  tons  
                          Type 3-3 =  $RF_{\text{Type 3-3}} \times 40$  tons

**B. Overload Permits**

Overweight loads traveling over state or local agency roads are required to obtain permits/approval from the state, county, or city maintaining those roadways. No permit loads shall be allowed over posted bridges without agency review. The first step in evaluating a permit is to determine the maximum gross weight, load per axle, or axle group for a specific truck per the latest Washington State Commercial Vehicle Guide. The second step is to evaluate the structures on the traveled route. This can be accomplished in two methods.

The first method, which is more precise for a specific structure, is to model the permit load moving on the bridge and calculating its load rating factor. A single lane distribution factor can be used in the model, which means that no other trucks are permitted in the adjacent lanes. A rating factor equal to or above 1 means the permit truck can safely travel over the particular structure.

The second method to calculate the maximum weight per axle allowed over a bridge, is dependent on the load rating factors for the particular structure, as follows:

**Truck Type SA**

Definition      Construction Equipment Tires (a.k.a., Super Single Axle)  
                          (RCW 46.44.091(3))

Range            Up to 45,000 lbs. per axle.

Criteria          Using the Load Rating Factor for the AASHTO2 Truck (a.k.a., Type 3S2), which has dual weighing 31,000 lbs., the equation is **45,000 lbs. \* Rating Factor \* 31/45** rounded to the nearest 500 lbs.

**Collection Truck (RCW 46.44.041) Restriction List**

Truck Type      S/A

Definition      Two axle trucks where the rear drive axle is the item in question on non-interstate routes only.

Range            Up to 26,000 lbs. on rear axle.

Criteria          Using the Load Rating Factor for the AASHTO1 Truck (a.k.a., Type 3), which has dual weighing 34,000 lbs., the equation is **26,000 lbs. \* Rating Factor \* 26/34** rounded to the nearest 500 lbs.

Truck Type      T/D

Definition      Three axle trucks where the rear tandem drive axles are the item in question on non-interstate routes only.

Range            Up to 42,000 lbs. on real dual.

Criteria          Using the Load Rating Factor for the AASHTO1 Truck (a.k.a., Type 3), which has a dual weighing 34,000 lbs., the equation is **42,000 lbs. \* Rating Factor \* 34/42** rounded to the nearest 500 lbs.

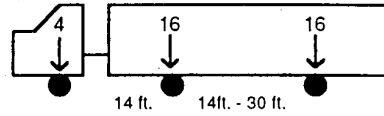
**Tow Truck (RCW 46.44.015) Restriction List**

Truck Type	Tow truck with tandem (dual) drive axles.
Definition	Three axle tow truck with tandem drive axles towing a variety of vehicles.
Range	Up to 48,000 lbs. on drive dual axles.
Criteria	Using the Load Rating Factor for the AASHTO2 Truck (a.k.a., Type 3S2), which has dual weighing 31,000 lbs., the equation is <b>48,000 lbs. * Rating Factor * 31/48</b> rounded to the nearest 500 lbs.
Truck Type	CL8
Definition	Class 8 Short Hitch (RCW 46.44.091) five axle combination (a.k.a., Dual).
Range	Up to 21,500 lbs. per axle in <b>dual</b> group and 20,000 to 22,000 for a <b>single</b> axle.
Criteria	Use the Load Rating Factor for the OL1 Truck and the ratio of the distribution factor for multiple lanes to single lanes per Table 3.23.1 of AASHTO Standard Specifications for Highway Bridges, latest edition. The equation is <b>22,000 lbs. * Rating Factor * (DF<sub>multiple</sub>/DF<sub>single</sub>)</b> rounded to the nearest 500 lbs.
Truck Type	BL
Definition	Big Load (RCW 46.44.091) six plus axle combination and three to four axle single units (a.k.a., Triaxle).
Range	Up to 22,000 lbs. per axle in <b>dual and triaxle</b> groups and up to 22,000 lbs for a <b>single</b> axle.
Criteria	Use the Load Rating Factor for the OL2 Truck and the ratio of the distribution factor for multiple lanes to single lanes per Table 3.23.1 of AASHTO Standard Specifications for Highway Bridges, latest edition. The equation is <b>22,000 lbs. * Rating Factor * (DF<sub>multiple</sub>/DF<sub>single</sub>)</b> rounded to the nearest 500 lbs.  The distribution factors are dependent on the material of the structure as well as the type of deck and the spacing of the griders/stringers. For reinforced concrete slab bridges, a well as in cases where the deck is governing the ratings, the ratio of DF <sub>multiple</sub> /DF <sub>single</sub> equals to 1.

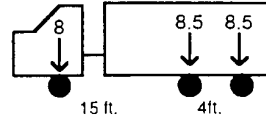
**C. National Bridge Inventory Requirements**

Inventory and Operating Ratings for the NBI must be calculated with the HS live load. These values must be calculated and reported using the LFR method, except for timber bridges which use the WSR method. By having all the states use the same method and loading, the NBI information is in a standard format.

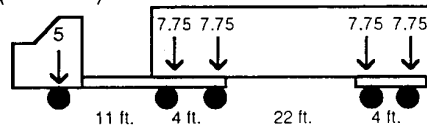
HS-20 (36 Tons)



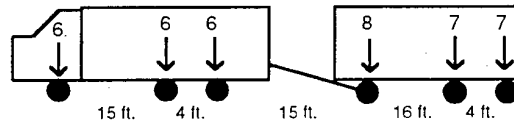
Type 3 (25 Tons)



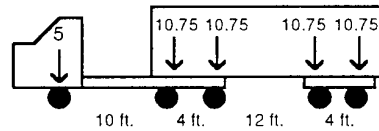
Type 3S2 (36 Tons)



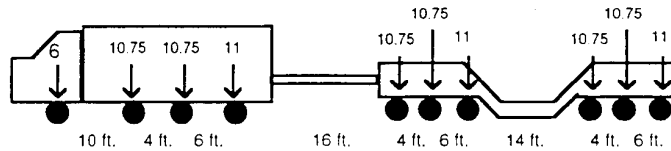
Type 3-3 (40 Tons)



Overload 1 (48 Tons)



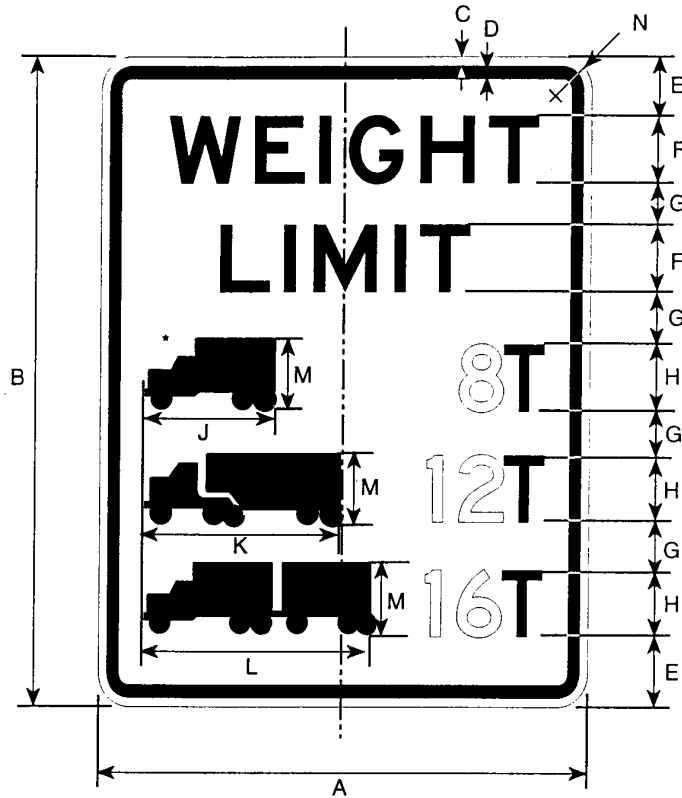
Overload 2 (103.5 Tons)



All weights shown are in tons per axle or kips per wheel line.

**Load Rating Vehicles**

Figure 5.03.A-1



\*See appendix for symbol design.

DIMENSIONS (MILLIMETERS)												
A	B	C	D	E	F	G	H	J	K	L	M	N
600	750	10	16	75	75E	56	75D	150	238	275	75	63
750	900	13	19	88	100E	56	100D	200	300	366	100	72
900	1200	16	22	125	125E	81	125D	250	375	460	125	56
1200	1500	19	31	150	150E	113	150D	300	450	550	150	75

DIMENSIONS (INCHES)												
A	B	C	D	E	F	G	H	J	K	L	M	N
24	30	3/8	5/8	3	3E	2 1/4	3D	6	9 1/2	11	3	1 1/2
30	36	1/2	3/4	3 1/2	4E	2 1/4	4D	8	12	14 5/8	4	1 7/8
36	48	5/8	7/8	5	5E	3 1/4	5D	10	15	18 3/8	5	2 1/4
48	60	3/4	1 1/4	6	6E	4 1/2	6D	12	18	22	6	3

COLORS

LEGEND — BLACK (NON-REFL)  
 BACKGROUND — WHITE (REFL)

Modified R12-5

Figure 5.03.A-2

## 5.04 Load Capacity Calculation for Timber Girders, Example

### A. Procedures

#### 1. Measurements of Various Bridge Elements

During any routine inspection of the bridge, the following bridge measurements should be taken (to the nearest 1/4") for use in determining the load ratings of the bridge:

- Base width and height of each rectangular timber stringer.
- Type of timber material (i.e., cedar, or fir).
- Grade of the timber material.
- Number of lines of stringers.
- Typical (or average) spacing between stringers.
- Maximum span length(s) from center of bearing to center of bearing.
- Deck type and thickness.
- Surfacing type and thickness.
- Extent of any deterioration.

As these measurements are being taken, the inspector should also note the extent and location of any surface or internal rot on individual timber stringers.

#### 2. Individual Stringer Capacity Available for Live Loading

Calculations are required only for the timber stringer with the least load-carrying capacity. The weakest member determines the bridge's ability to carry a load. The basic formula is:

$$\text{Moment available for live load} = (\text{Section Modulus}) \times (\text{Allowable Stress}) \times 0.083\text{-Dead Load Moment}$$

Calculations are made for both the inventory and operating rating values. To do this, first determine the dead load moment for the selected stringer. The formula is:

$$\text{Dead Load Moment} = (\text{Total Dead Load Weight}) \times (\text{Span Length})^2 \times 0.000125$$

Next, determine the section modulus by using one of three possible formulas, which are dependent upon the stringer shape and the amount of surface or internal rot present. Then, determine the allowable stress which is based upon the type and grade of timber in the stringer.

Finally, by using the basic formula above, the moment available for live load is determined.

3. Inventory and Operating Ratings for the Bridge as a Unit

Once the available capacity for an individual stringer is known, the Inventory and Operating Ratings are determined for the following types of loading: HS-20, Type 3, Type 3S2, and Type 3-3. (See Figure 5.03.A-1 for illustrations of these truck configurations.)

Determine the distribution factors. Distribution factors are dependent upon the number of traffic lanes the bridge is designed to carry, the type of floor system on the bridge, and the stringer spacing. (Use the tables provided in the worksheet.)

Next, find the allowable moment per line of girder by dividing the value previously calculated for live load capacity available, by the distribution factor just determined.

When allowable moment per line of wheels is known, the bridge's safe load rating can be calculated. The safe load capacity is the allowable moment per line of wheels, divided by the live load moment per wheel line, multiplied by the appropriate truck loading. The figure to use for live load moment per wheel line is derived from tables (see the worksheet) and will vary for the various types of loads carried on the bridge.

4. WSBIS Inventory Coding Form.

Once the Inventory and Operating Ratings for the HS live load are calculated, they need to be entered in the appropriate fields on the Inventory Coding Form. In addition, the particular rating method used to make these calculations should be indicated.

If the Operating Rating is less than the values shown below for the three AASHTO truck loadings, the bridge must be posted in accordance with Section 4 of the AASHTO Manual for Condition Evaluation.

<b>Truck</b>	<b>Weight (tons)</b>
Type 3	25
Type 3-S2	36
Type 3-3	40

**B. Example and Form**



Washington State  
Department of Transportation

**Load Capacity Calculation  
for Timber Stringers**

Agency <u>W.S.D.O.T.</u>	Calculated By <u>JLS</u>
Bridge Number <u>302/3</u>	Checked By <u>TJN</u>
Bridge Name <u>Couther Creek</u>	Date <u>1/10/94</u>

**Necessary Information**

Stringers:  Base (Inches) 6.0" Height (Inches) 17.5"  
 Butt (Inches) \_\_\_\_\_ Tip (Inches) \_\_\_\_\_

Material: Douglas Fir  Cedar \_\_\_\_\_ Hem Fir \_\_\_\_\_  
 Grade: Select Struct. \_\_\_\_\_ No. 1

No. of Lines of Stringers 16 Typical Spacing Ctr. to Ctr. (Feet) 1.75'  
 Max Span Length Ctr. to Ctr. of Bearings (Feet) 19.0'

Deck: Type Timber Lam. Thickness (Inches) 4" Roadway Width (Feet) 26.50'  
 Surfacing: Type ACP Thickness (Inches) 7"

Describe Stringer Section Loss: None

**Calculations Per Individual Stringer**

Dead Load:

Stringers:  H (Inches) 17.5 x B (Inches) 6.0 x 0.35 = 36.75 lb./ft.  
 Ave. D (Inches) ( \_\_\_\_\_ )<sup>2</sup> x 0.27

Deck: Timber Thickness 4 (inches) x 4.17  
 Concrete Thickness \_\_\_\_\_ (inches) x 12.50  
 Corrugated Steel: Gage Thickness Factor  
 (Factor includes wt. of asphalt to top of corrugations)  
 7 .179 21.2  
 10 .135 18.5  
 12 .105 16.7

Surfacing: (Bituminous) Thickness 7 (inches) x 11.67  
 (Gravel) Thickness \_\_\_\_\_ (inches) x 9.17

Stringer Spacing (ft.) 1.75 = 29.19 lb./ft.  
 Stringer Spacing (ft.) 1.75 = 142.96 lb./ft.

Total Dead Load 208.90 lb./ft.  
 Dead Load Moment: ( 208.90 ) x ( 19.0 )<sup>2</sup> x 0.00125 = 9.43 K-ft.  
 Total D.L. (lb./ft.) Span Length (ft.)

Stringer Capacity: Section Modulus (6(17.5)<sup>2</sup>)/6 = 306.25 in.<sup>3</sup>  
 Choose Formula From Below (All dimensions in inches)

Solid Rectangular;  $\frac{BH^2}{6}$   
 Solid Circular; Approx.  $\frac{D^3}{10}$   
 Top rot above Neutral Axis (N.A.); Approx.  $\frac{B(H - \frac{H_1}{3})^2}{6}$   
 Center rot symmetrical about N.A.;  $\frac{BH^2 - B_2H_2^2}{6H}$   
 Center rot symmetrical about N.A.; Approx.  $\frac{D^3 - D_1^3}{10D}$

DOT Form 148-086 EF  
Revised 2/98

**Calculations Per Individual Stringer - Continued**

Allowable Stress:  
(Choose value from  
table below)

For Inventory Rating = 1.35  
For Operating Rating = 1.80

	Douglas Fir		Cedar		Hem Fir	
	Select Structure	No. 1	Select Structure	No. 1	Select Structure	No. 1
Inventory	1.60 ksi	1.35 ksi	1.10 ksi	0.95 ksi	1.30 ksi	1.05 ksi
Operating	2.13 ksi	1.80 ksi	1.46 ksi	1.25 ksi	1.73 ksi	1.40 ksi

Available for Live Load:  
(Calculate as shown below)

For Inventory Rating = 24.89  
For Operating Rating = 36.32

Inventory Calculation	Operating Calculation
$1.35 \times 306.25 \times 0.083 = 34.32$ (Inv. Stress) (Sec. Mod.)	$1.80 \times 306.25 \times 0.083 = 45.75$ (Oper. Stress) (Sec. Mod.)
Subtract Dead Load Moment - <u>9.43</u>	Subtract Dead Load Moment - <u>9.43</u>
Available for Live Load = <u>24.89</u>	Available for Live Load = <u>36.32</u>

**Calculations for Bridge as a Unit:**

Distribution Factor:  
(Calculate from table  
below)

For Inventory Rating  
And Operating Rating = S/4.0 = 0.44

Kind of Floor	For Bridge Roadway ≤ 18 ft.	For Bridge Roadway > 18 ft.
Timber: Plank <sup>1</sup>	S/4.0	S/3.75
Timber: Strip 4 in. (101.6 mm) thick or multiple layer floors over 5 in. (127 mm) thick	S/4.5	S/4.0
Timber: Strip 6 in. (152.4 mm) or more thick	S/5.0 If S exceeds 5 ft. use footnote <sup>2</sup>	S/4.25 If S exceeds 5 ft. use footnote <sup>2</sup>
Concrete: On Timber Stringers	S/6.0 If S exceeds 5 ft. use footnote <sup>2</sup>	S/5.0 If S exceeds 5 ft. use footnote <sup>2</sup>
Corrugated Steel: 7 gage 10 gage 12 gage	S/4.0 S/3.85 S/3.75	S/3.75 S/3.65 S/3.55

S = Average stringer spacing in feet.

1 = Splined and dowelled timber flooring shall have the same distribution as strip floors of equivalent thickness.

2 = In this case, the load on each stringer shall be the reaction of the wheel loads, assuming the flooring between the stringers to act as a simple beam.

DOT Form 148-086 EF  
Revised 2/98

**Calculations for Bridge as a Unit - Continued**

Allowable Moment per Line of Wheels (Calculate as shown below) For Inventory Rating = 56.57  
 For Operating Rating = 82.55

Inventory Calculation			Operating Calculation		
<u>24.89</u>	/	<u>0.44</u> = <u>56.57</u>	<u>36.32</u>	/	<u>0.44</u> = <u>82.55</u>
(Available for Live Load for Inventory)		(Dist. Fac.) (Allowable Moment)	(Available for Live Load for Operating)		(Dist. Fac.) (Allowable Moment)

**Load Ratings**

**Safe Load Capacity:** (Calculate for each truck as shown at right)  
 For Inventory Rating =  $\frac{\text{Calculated allowable moment per line of wheels for inventory}}{\text{Live load moment per line of wheels (from table on following page)}}$   
 For Operating Rating =  $\frac{\text{Calculated allowable moment per line of wheels for operating}}{\text{Live load moment per line of wheels (from table on following page)}}$



Purpose	Truck	Inventory Calculation	Operating Calculation
Inventory Coding Data	HS-20	$\frac{56.57}{76.0} \times 36 = 26$ (Tons)	$\frac{82.55}{76.0} \times 36 = 39$ (Tons)
Safe Load Carrying Capacity (Bridge Posting)	Type 3	$\frac{56.57}{63.9} \times 25 = 22$ (Tons)	$\frac{82.55}{63.9} \times 25 = 32$ (Tons)
	Type 3S2	$\frac{56.57}{58.3} \times 36 = 34$ (Tons)	$\frac{82.55}{58.3} \times 36 = 50$ (Tons)
	Type 3-3	$\frac{56.57}{52.6} \times 40 = 43$ (Tons)	$\frac{82.55}{52.6} \times 40 = 62$ (Tons)
Special Permits	Overload 1	$\frac{56.57}{80.1} \times 48 = 33$ (Tons)	$\frac{82.55}{80.1} \times 48 = 49$ (Tons)
	Overload 2	$\frac{56.57}{100.1} \times 103.5 = 58$ (Tons)	$\frac{82.55}{100.1} \times 103.5 = 85$ (Tons)





Agency	Calculated By
Bridge Number	Checked By
Bridge Name	Date

## Necessary Information

Stringers:  Base (Inches) \_\_\_\_\_ Height (Inches) \_\_\_\_\_  
 Butt (Inches) \_\_\_\_\_ Tip (Inches) \_\_\_\_\_

Material: Douglas Fir \_\_\_\_\_ Cedar \_\_\_\_\_ Hem Fir \_\_\_\_\_

Grade: Select Struct. \_\_\_\_\_ No. 1 \_\_\_\_\_

No. of Lines of Stringers \_\_\_\_\_ Typical Spacing Ctr. to Ctr. (Feet) \_\_\_\_\_

Max Span Length Ctr. to Ctr. of Bearings (Feet) \_\_\_\_\_



Deck: Type \_\_\_\_\_ Thickness (Inches) \_\_\_\_\_, Roadway Width (Feet) \_\_\_\_\_

Surfacing: Type \_\_\_\_\_ Thickness (Inches) \_\_\_\_\_

Describe Stringer Section Loss: \_\_\_\_\_

## Calculations Per Individual Stringer

Dead Load:

Stringers:  H (Inches) \_\_\_\_\_ x B (Inches) \_\_\_\_\_ x 0.35 \_\_\_\_\_ = \_\_\_\_\_ lb./ft.  
 Ave. D (Inches) ( \_\_\_\_\_ )<sup>2</sup> x 0.27 \_\_\_\_\_

Deck: Timber Thickness \_\_\_\_\_ (inches) x 4.17 \_\_\_\_\_  
Concrete Thickness \_\_\_\_\_ (inches) x 12.50 \_\_\_\_\_

Corrugated Steel:	Gage	Thickness	Factor	} x _____ = _____ lb./ft.
(Factor includes wt. of asphalt to top of corrugations)	7	.179	21.2	
	10	.135	18.5	
	12	.105	16.7	



Surfacing: (Bituminous) Thickness \_\_\_\_\_ (inches) x 11.67 \_\_\_\_\_  
(Gravel) Thickness \_\_\_\_\_ (inches) x 9.17 \_\_\_\_\_


Total DeadLoad \_\_\_\_\_ lb./ft.


Dead Load Moment: ( \_\_\_\_\_ )<sup>2</sup> x ( \_\_\_\_\_ ) x 0.000125 = \_\_\_\_\_ K-ft.


Stringer Capacity: Section Modulus \_\_\_\_\_ = \_\_\_\_\_ in.<sup>3</sup>


Choose Formula From Below  
(All dimensions in inches)


 B  
 H Solid Rectangular;  $\frac{BH^2}{6}$

 H<sub>1</sub> Top rot above Neutral Axis (N.A.); Approx.  $\frac{B(H - \frac{H_1}{3})^2}{6}$

 H<sub>2</sub> Center rot symmetrical about N.A.;  $\frac{BH^3 - B_2H_2^3}{6H}$

 D Solid Circular; Approx.  $\frac{D^3}{10}$

 D<sub>1</sub> Center rot symmetrical about N.A.; Approx.  $\frac{D^4 - D_1^4}{10D}$

 B<sub>2</sub>

## Calculations Per Individual Stringer - Continued

**Allowable Stress:**  
(Choose value from table below)

For Inventory Rating = \_\_\_\_\_

For Operating Rating = \_\_\_\_\_

	Douglas Fir		Cedar		Hem Fir	
	Select Structure	No. 1	Select Structure	No. 1	Select Structure	No. 1
Inventory	1.60 ksi	1.35 ksi	1.10 ksi	0.95 ksi	1.30 ksi	1.05 ksi
Operating	2.13 ksi	1.80 ksi	1.46 ksi	1.25 ksi	1.73 ksi	1.40 ksi

**Available for Live Load:**  
(Calculate as shown below)

For Inventory Rating = \_\_\_\_\_

For Operating Rating = \_\_\_\_\_

Inventory Calculation	Operating Calculation
_____ x _____ x 0.083 = _____ (Inv. Stress) (Sec. Mod.)	_____ x _____ x 0.083 = _____ (Oper. Stress) (Sec. Mod.)
Subtract Dead Load Moment - _____	Subtract Dead Load Moment - _____
Available for Live Load = _____	Available for Live Load = _____

## Calculations for Bridge as a Unit:

**Distribution Factor:**  
(Calculate from table below)

For Inventory Rating  
And Operating Rating = \_\_\_\_\_

Kind of Floor	For Bridge Roadway ≤ 18 ft.	For Bridge Roadway > 18 ft.
Timber: Plank <sup>1</sup>	S/4.0	S/3.75
Timber: Strip 4 in. (101.6 mm) thick or multiple layer floors over 5 in. (127 mm) thick	S/4.5	S/4.0
Timber: Strip 6 in. (152.4 mm) or more thick	S/5.0 If S exceeds 5 ft. use footnote <sup>2</sup>	S/4.25 If S exceeds 5 ft. use footnote <sup>2</sup>
Concrete: On Timber Stringers	S/6.0 If S exceeds 5 ft. use footnote <sup>2</sup>	S/5.0 If S exceeds 5 ft. use footnote <sup>2</sup>
Corrugated Steel: 7 gage 10 gage 12 gage	S/4.0 S/3.85 S/3.75	S/3.75 S/3.65 S/3.55

S = Average stringer spacing in feet.

<sup>1</sup> = Splined and doweled timber flooring shall have the same distribution as strip floors of equivalent thickness.

<sup>2</sup> = In this case, the load on each stringer shall be the reaction of the wheel loads, assuming the flooring between the stringers to act as a simple beam.

## Calculations for Bridge as a Unit - Continued

**Allowable Moment per Line of Wheels** For Inventory Rating = \_\_\_\_\_  
 (Calculate as shown below) For Operating Rating = \_\_\_\_\_

Inventory Calculation	Operating Calculation
$\frac{\text{_____}}{\text{_____}} = \text{_____}$ (Available for Live Load for Inventory) (Dist. Fac.) (Allowable Moment)	$\frac{\text{_____}}{\text{_____}} = \text{_____}$ (Available for Live Load for Operating) (Dist. Fac.) (Allowable Moment)

## Load Ratings

**Safe Load Capacity:** For Inventory Rating =  $\frac{\text{Calculated allowable moment per line of wheels for inventory}}{\text{Live load moment per line of wheels (from table on following page)}}$   
 (Calculate for each truck as shown at right) For Operating Rating =  $\frac{\text{Calculated allowable moment per line of wheels for operating}}{\text{Live load moment per line of wheels (from table on following page)}}$

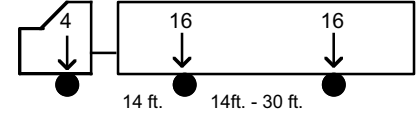
Purpose	Truck	Inventory Calculation	Operating Calculation
<b>Inventory Coding Data</b>	HS-20	$\frac{\text{_____}}{\text{_____}} \times 36 = \text{_____}$ (Tons)	$\frac{\text{_____}}{\text{_____}} \times 36 = \text{_____}$ (Tons)
<b>Safe Load Carrying Capacity (Bridge Posting)</b>	Type 3	$\frac{\text{_____}}{\text{_____}} \times 25 = \text{_____}$ (Tons)	$\frac{\text{_____}}{\text{_____}} \times 25 = \text{_____}$ (Tons)
	Type 3S2	$\frac{\text{_____}}{\text{_____}} \times 36 = \text{_____}$ (Tons)	$\frac{\text{_____}}{\text{_____}} \times 36 = \text{_____}$ (Tons)
	Type 3-3	$\frac{\text{_____}}{\text{_____}} \times 40 = \text{_____}$ (Tons)	$\frac{\text{_____}}{\text{_____}} \times 40 = \text{_____}$ (Tons)
<b>Special Permits</b>	Overload 1	$\frac{\text{_____}}{\text{_____}} \times 48 = \text{_____}$ (Tons)	$\frac{\text{_____}}{\text{_____}} \times 48 = \text{_____}$ (Tons)
	Overload 2	$\frac{\text{_____}}{\text{_____}} \times 103.5 = \text{_____}$ (Tons)	$\frac{\text{_____}}{\text{_____}} \times 103.5 = \text{_____}$ (Tons)

### Live Load Moment Per Line of Wheels

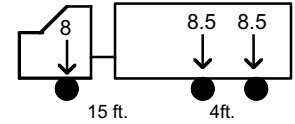
(Values shown are in kip-feet without impact)

Type of Loading						Span (In ft. from center to center of bearing)
HS-20	Type 3	Type 3S2	Type 3-3	OL1	OL2	
40.0	27.2	24.8	22.4	32.3	27.2	10
44.0	31.3	28.5	25.8	37.7	35.3	11
48.0	35.4	32.2	29.1	43.0	43.4	12
52.0	39.4	36.0	32.5	48.4	51.5	13
56.0	43.5	39.7	35.8	53.8	59.6	14
60.0	47.6	43.4	39.2	59.2	67.6	15
64.0	51.7	47.1	42.6	64.5	75.8	16
68.0	55.8	50.8	45.9	69.9	83.9	17
72.0	59.8	54.6	49.3	75.3	92.0	18
76.0	63.9	58.3	52.6	80.1	100.1	19
80.0	68.0	62.0	56.0	86.0	108.2	20
88.0	76.5	69.8	63.0	99.3	124.5	22
96.4	85.0	80.0	70.0	112.5	140.7	24
111.1	93.5	90.2	77.0	125.8	156.9	26
126.0	102.0	100.5	84.0	142.3	173.9	28
141.1	111.6	110.7	91.0	162.9	193.1	30
156.3	123.6	121.0	101.0	183.6	212.3	32
171.8	135.6	131.2	111.5	206.4	231.5	34
189.5	148.0	141.5	122.1	230.1	250.7	36
207.2	160.5	151.7	132.6	253.9	269.9	38
224.9	173.0	162.0	143.2	277.6	290.0	40
269.4	204.3	190.8	170.1	337.1	369.9	45
314.0	235.5	219.6	197.0	396.7	449.4	50
358.6	266.8	262.8	239.5	456.4	529.2	55
403.3	298.0	306.0	282.0	516.1	609.2	60
448.0	329.3	349.2	326.0	575.9	717.4	65
492.8	360.5	392.4	370.0	635.7	839.3	70
537.6	391.8	436.7	420.0	695.5	961.2	75
582.5	423.0	481.0	470.0	755.3	1083.0	80
627.4	454.3	526.0	520.0	815.2	1209.1	85
672.2	485.5	571.0	570.0	875.1	1388.7	90
717.1	516.8	616.0	620.0	935.0	1468.2	95
762.0	548.0	661.0	670.0	995.0	1597.5	100
851.8	610.5	751.3	770.0	1114.5	1856.5	110
941.7	673.0	841.6	870.0	1234.5	2115.5	120
1031.6	735.5	931.3	970.0	1354.5	2374.5	130
1121.4	798.0	1021.0	1070.0	1474.5	2633.5	140
1237.6	860.5	1111.0	1170.0	1594.0	2892.5	150
1384.0	923.0	1201.0	1270.0	1714.0	3151.5	160
1538.6	985.5	1291.0	1370.0	1834.0	3410.0	170

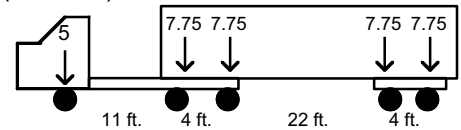
HS-20 (36 Tons)



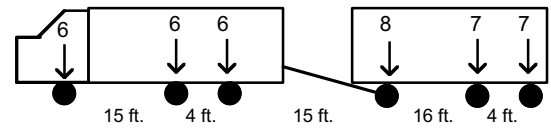
Type 3 (25 Tons)



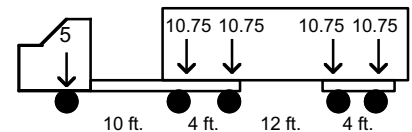
Type 3S2 (36 Tons)



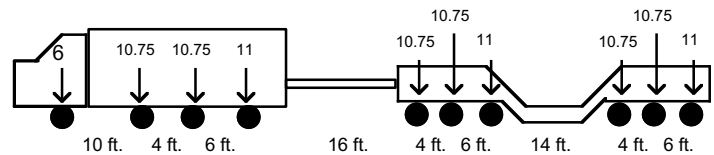
Type 3-3 (40 Tons)



Overload 1 (48 Tons)



Overload 2 (103.5 Tons)



All weights shown are in tons per axle or kips per wheel line.

## 5.05 Scour Evaluation

All bridges crossing waterways are required by the NBIS to have a scour evaluation. A scour evaluation is done to identify the susceptibility of erosion of streambed material and the degree of foundation element stability. The evaluation should include as-built foundation details, current condition of the foundation, stream bed cross section profile, and stream flow rates. Scour evaluations are site specific and additional information may be required to do an accurate analysis.

As the bridge foundation condition changes and/or the stream bed characteristics change, the scour criticality will have to be reanalyzed. Upon determining a bridge is scour critical, the agency needs to develop a plan of action to monitor, mitigate, or close the bridge. In particular, monitoring the performance enclosing of the bridge, if necessary, during and after flood events. For additional information, contact the WSDOT Bridge Scour Engineer or the Bridge Engineer for Local Agencies.

The following is an explanation for the process of evaluating bridges over water. Scour evaluations are divided into two parts.

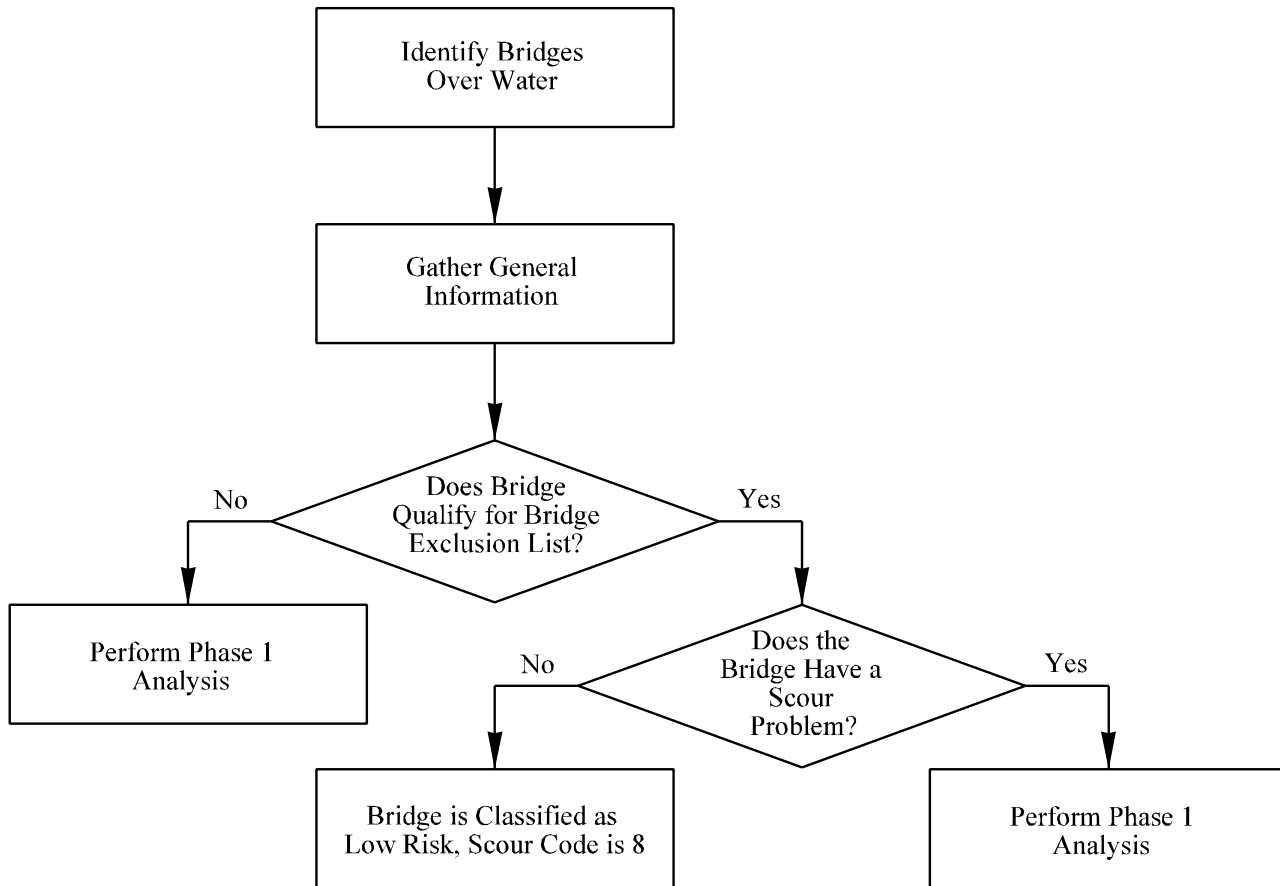
### A. Assessment and Phase 1 Analysis

This is an initial screening of all bridges over water to determine if they are scour critical or not. The first step in this part is determining the number of bridges over water (see Figure 5.05.A-1, Assessment). If the Bridge Exclusion List applies and there is no history of scour, the bridge is classified as Low Risk. No further evaluation is required. A low risk bridge would receive a scour code of 8 in field WB76 - 80 of the WSBIS form.

#### Bridge Exclusion List

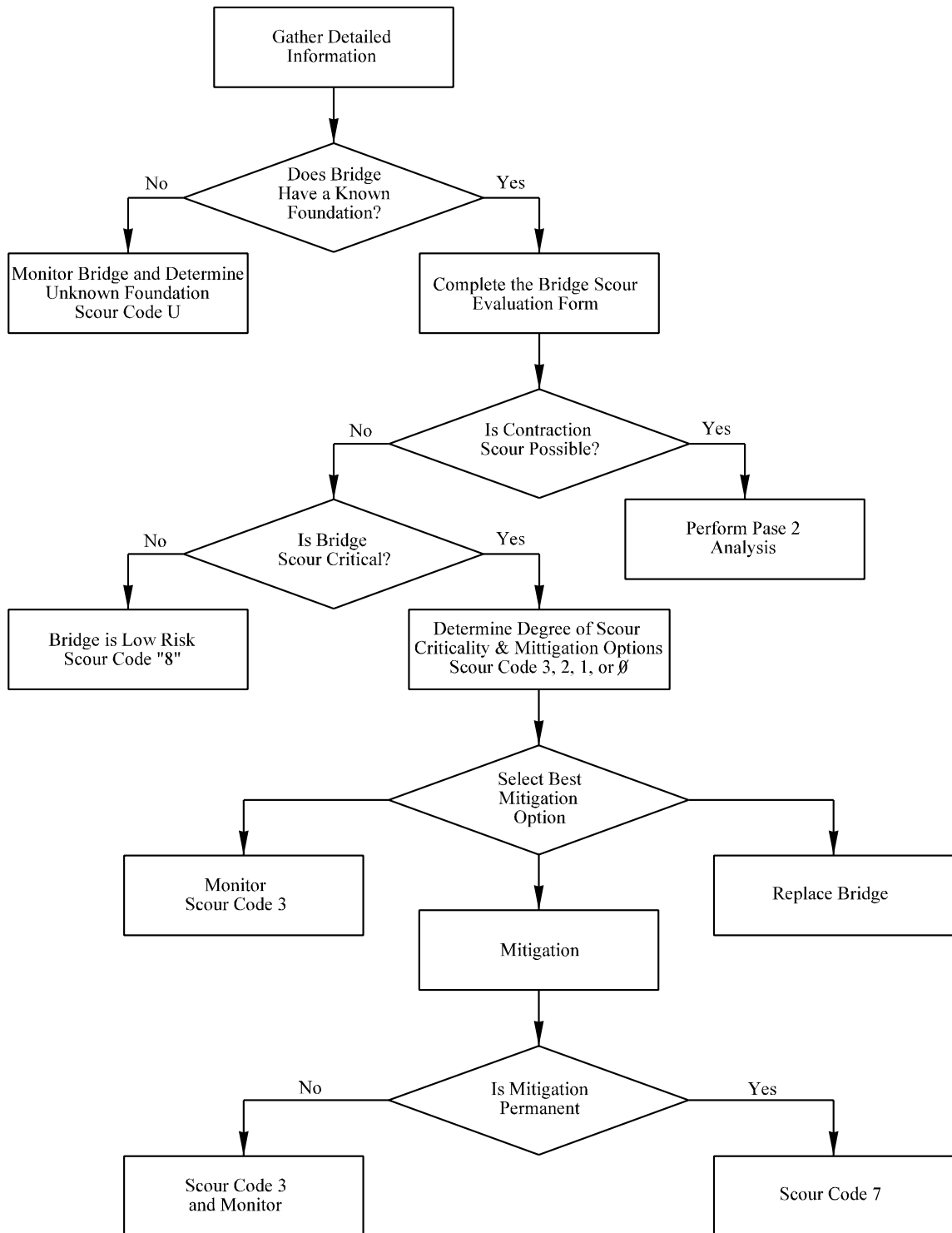
1. Single span bridges with good abutment riprap and no history of scour.
2. Bridges with foundations well above the flood plain.
3. Bridges over lakes, pools, swamps, ponds, or slow moving reservoirs.
4. Bridges over irrigation canals.
5. Bridges over concrete or timber lined channels.
6. Bridges with spread footings on bedrock.
7. Culverts with bottoms.

If the bridge does not meet any of the conditions in the Bridge Exclusion List, it requires a Phase 1 analysis (see Figure 5.05.A-2, Phase 1 Analysis). The simple local scour calculations referred to on the flow chart are the Bridge Scour Evaluation work sheets contained in this section. If the bridge qualifies as Low Risk or Scour Critical based on the Phase 1 Analysis, no further calculations are required.



In the Assessment stage of the Scour Evaluation Program, bridges over water are identified based on a review of plans and WSBIS data. Bridges are screened from further analysis if they qualify for a Bridge Exclusion List and have shown no previous signs of scour.

**Assessment**  
*Figure 5.05.A-1*



The Phase 1 Analysis stage of the Scour Evaluation Program examines the scour susceptible bridges. Simple conservative formulas and on-site evaluations are used to determine whether the bridge is scour critical or if an in-depth Phase 2 Analysis is required. If the bridge is determined to be scour critical, this information is used to select the appropriate mitigation.

**Phase 1 Analysis**  
*Figure 5.05.A-2*

## **B. Phase 2 Analysis**

If the bridge does not qualify as Low Risk or Scour Critical based on Phase 1 Analysis, it will require a Phase 2 Scour Analysis (see Figure 5.05.B-1). Bridges that are determined to have possible contraction scour from the Phase 1 analysis will require further analysis using FHWA publication HEC-18, revised April 1993 and November 1995. Complex analysis requires the involvement of structural, hydraulic, and geotechnical specialists.

## **C. Determining Susceptibility to Scour**

Each bridge's susceptibility to scour damage must be determined to be either:

1. Stable for calculated scour conditions (scour code 8, 7, 5, 4).
2. Scour critical (scour code 3, 2, 1, 0).
3. Scour risk cannot be determined due to unknown foundations (scour code U).
4. Tidal water that has not been evaluated for scour, but considered low risk (scour code T).

The results of the scour analysis is to be recorded in scour (WB76 - 80) on the WSBS Inventory Coding Form. Upon completion of all scour evaluation, there should not be any bridges with a code "6." The completed scour evaluations, information required to do the evaluation, and the best mitigation option for this bridge are to be incorporated into the permanent bridge file for the bridge.

## **D. Action Plans for Scour Critical Bridges**

For each bridge that has been determined to be scour critical, a written plan of action shall be developed to identify the appropriate measures necessary to make the bridge less vulnerable to damage or failure due to scour. A plan of action has three primary components:

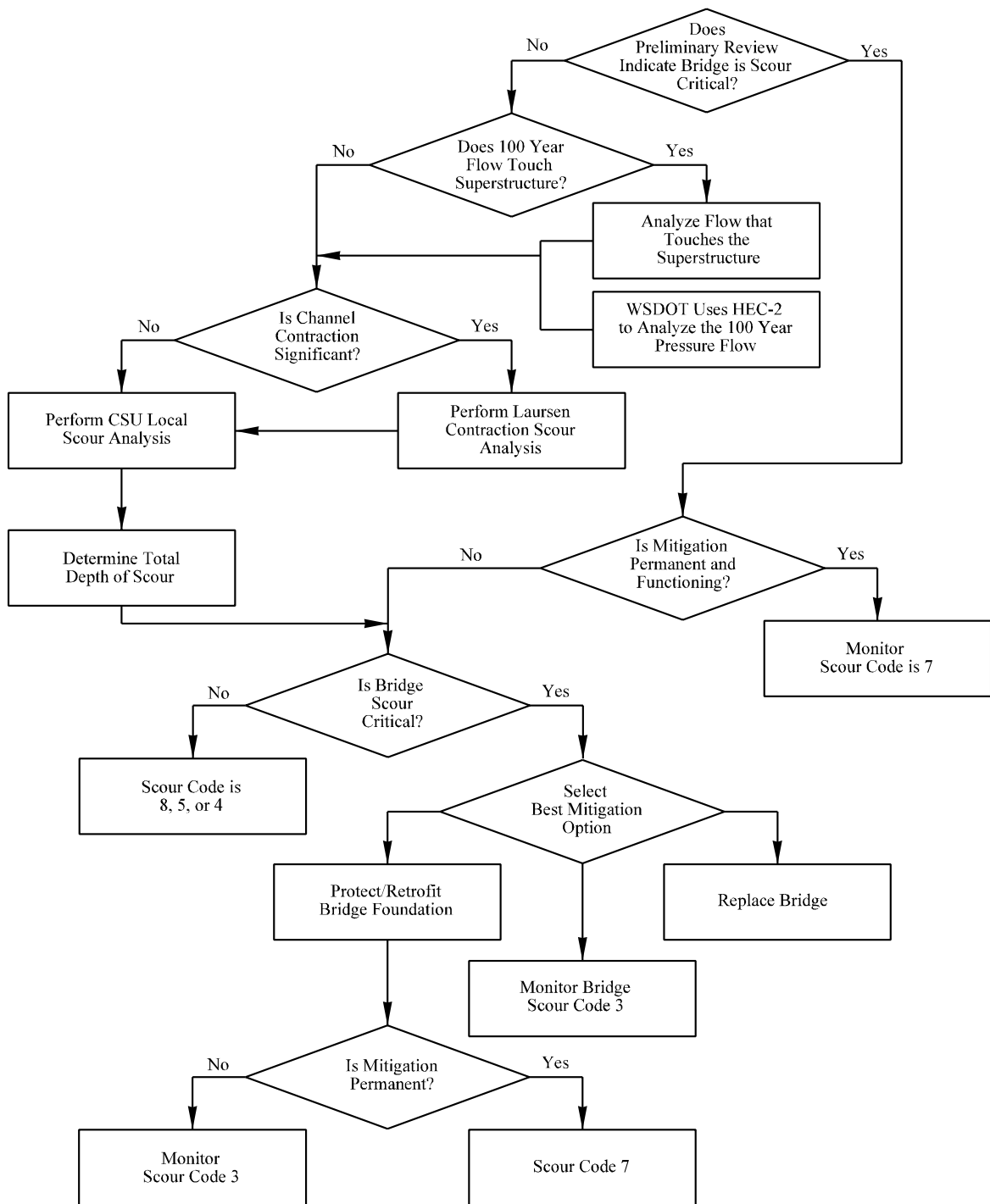
1. Development and implementation of a monitoring program.
2. Timely installation of temporary scour countermeasures (e.g., riprap).
3. Schedule construction of appropriate permanent scour countermeasure.

Each action plan should address each of these components and explain why the preferred actions were chosen.

### Monitoring

It is very important that all scour critical bridges be monitored during and after flood events. The action plan should include specific instructions to bridge inspectors or maintenance workers on what to look for, at what locations, and methods of inspection to use. Guidance should also be included as to when a bridge should be closed to traffic. Agencies should also develop and inform appropriate personnel of bridge closure procedures. The intensity of the monitoring effort is related to the risk of scour hazard, as determined from the scour evaluation. Some of the items to consider when developing the monitoring plan include:

- Amount of existing rotational movement or settlement of substructure units
- Degree of streambed degradation, aggradation, or lateral movement



The Phase 2 Analysis stage of the Scour Evaluation Program closely examines scour potential bridge site. Complex formulas and computer programs are used to more accurately estimate the depth of scour including contraction scour.

A maximum value of 5 feet shall be used for contraction scour. The maximum value is an average depth across the stream bed, if the structure is on a bend and it can be shown that contraction is greater for a portion of the stream bed, the maximum may be exceeded. If the bridge is determined to be scour critical, then appropriate mitigation is selected.

### Phase 2 Scour Analysis

Figure 5.05.B-1

- Recommended procedures and equipment for taking measurements of streambed elevations (rods, probes, weights, portable sonic equipment, etc.)
- Instructions for inspecting existing countermeasures such as riprap, dikes, barbs, mats, etc.
- Guidance on maximum permissible scour depths, flood flows, water surface elevations, etc. beyond which the bridge should be closed to traffic
- Instructions for checking the operation of fixed scour monitoring devices
- Reporting procedures for conditions that warrant bridge closure. Establish the chain of command with authority to close bridges.
- Forms and procedures for documenting inspection results and instructions regarding follow-up actions when necessary

#### Temporary Countermeasures

Temporary countermeasures provide a degree of protection for scour critical bridges. They may prevent damage for most flows, but are sacrificial, low-cost treatments that help insure the safety of a bridge during flood events. Use of such measures may postpone the need to close a bridge during high flows. Temporary countermeasures, such as riprap, should not be viewed as an alternative to monitoring, but rather as a supplement.

#### Permanent Countermeasures

Permanent countermeasures are engineered to make a bridge safe from damage due to scour. A variety of methods exist including channel improvements, structural strengthening or underpinning, drop structures, relief bridges or constructing additional spans. These types of fixes would eliminate the bridge from being “scour critical,” but are more costly. Agencies prioritize permanent countermeasures to address the most critical needs as funds permit.

### **E. Recording Bridge Scour Information**

**The completed bridge scour evaluation shall include the resulting WB76 - 80 scour code, the information required to do the evaluations, and the written action plan to mitigate scour risk. The evaluation is to be incorporated into the permanent bridge file for the bridge.** Any changes to bridge inventory data should be accomplished promptly after the evaluation, or field review, are complete. Monitoring information or schedule should be communicated to all affected parties.

WSBIS data fields that relate to bridge hydraulics and/or scour are:

- WB76-62 Waterway Adequacy Appraisal
- WB76-77 Channel Protection
- WB76-80 Scour
- WB78-32 Water Type
- WB78-33 Flood Plain Intrusion
- WB78-34 Flood Control
- WB78-35 Scour History
- WB78-36 Streambed Material Type
- WB78-37 Substructure Stability
- WB78-38 Waterway Obstruction
- WB78-39 Streambed Stability
- WB78-40 Streambed Anabranch
- WB78-41 Piers in Water





Date	Agency		
Bridge Number	Bridge Name		
Evaluated By			
Superstructure Type	Superstructure Continuity?	Any Spread Footings?	
	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	

## Evaluation

- Yes  No     **Evaluation:** Are foundation elevations known? If not, consider the bridge scour critical (using engineering judgment and any other information available).
- Yes  No     **Evaluation:** Does the thalweg (the deepest portion of the stream; the main channel) meander back and forth across the floodplain? If so, the potential for a scour critical condition is increased.
- Yes  No     **Evaluation:** For a spread footing, is the bottom of the seal (or footing, if the seal is not used) above the thalweg? If so, the bridge is scour critical; no need to proceed further.
- Yes  No     **Evaluation:** For a pile supported footing, is the pile tip elevation 10 feet or less below the thalweg? If so the bridge is scour critical; no need to proceed further.

**Bridge Is Scour Critical**    Yes    No

## Evaluation Criteria

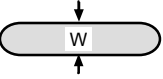
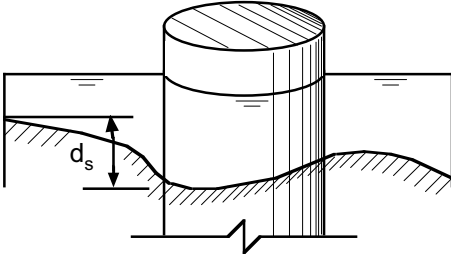
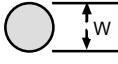
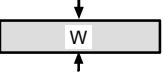
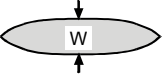
- Foundation elevations are (or are not) known and available.
- The thalweg meanders back and forth across the floodplain.
- Pier scour is always measured from the thalweg, even if the pier is in the overbank.
- For a spread footing, if the calculated depth of scour is below the footing, the bridge is scour critical.
- For a pile supported footing, if calculated depth of scour is 10' or less above pile tip elevation, the bridge is scour critical.
- Scour should be calculated for 100 year flood. If not shown on bridge plan layout, check FEMA map. If not mapped by FEMA, use high water shown on layout or the USGS Regression equations found in the WSDOT Hydraulics Manual (M23-03).

## Evaluate Interior Piers for Scour

(For bridges with no interior piers, proceed to Page 4)

If the column only protrudes above the thalweg, use the following method to calculate pier scour,  $d_s$ .

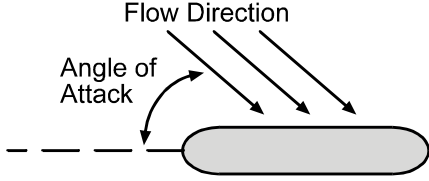
**Local Scour Allowances for Piers Aligned Parallel to Flow**

Pier Shape in Plan	Pier Shape in Profile	Suggested Allowance for Local Scour*
		$d_{s \text{ aligned}} = 2w$
		$d_{s \text{ aligned}} = 2w$
		$d_{s \text{ aligned}} = 2w$
		$d_{s \text{ aligned}} = 2w$

**Note:** If the depth of flow exceeds  $5w$ ,  $d_{s \text{ aligned}} = 3w$

**$K_2$  - Alignment Factors**  
(Interpolate Between Values)

Angle of Attack	Length-To-Width Ratio of Pier in Plan		
	4	8	12
$0^\circ$	1.0	1.0	1.0
$15^\circ$	1.5	2.0	2.5
$30^\circ$	2.0	2.5	3.5
$45^\circ$	2.5	3.5	4.5



Flow Direction  
Angle of Attack

$w =$  \_\_\_\_\_  $d_s = d_{s \text{ aligned}} \times K_2$

$d_{s \text{ aligned}} =$  \_\_\_\_\_

$K_2 =$  \_\_\_\_\_  $d_s =$  \_\_\_\_\_  $\times$  \_\_\_\_\_  $=$  \_\_\_\_\_

Does pedestal, if used, and/or footing protrude above the thalweg?  
If yes, continue with **Step A**; if no, skip to **Step B**.

**Step A** Use the larger of  $d_s$  as determined for the column only as calculated above, or from the following equation:







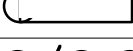
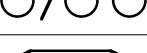
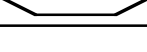
$$d_s = 1.5K_sK_2(w)^{0.7}(y)^{0.3} \text{ where: } d_s = \text{depth of scour.}$$

$K_s$  = Shape factor, as indicated below. Use only if the pier is aligned with the flow; otherwise, use 1.0.

$K_2$  = Alignment factor, see page 2.

$w$  = Width of the pedestal if only the pedestal protrudes above the thalweg, or;  
Width of footing if the footing or footing and pedestal protrude above the thalweg.

$y$  = Height that the pedestal, footing or footing and pedestal protrude above the thalweg.

<b><math>K_s</math> - Shape Factors</b>			
Nose Form	Length : Width	Shape	$K_s$
Rectangular or Square			1.00
Semicircular			0.90
Elliptic	2:1		0.80
	3:1		0.75
Lenticular	2:1		0.80
	3:1		0.70
Round			0.90
Cylinder / Group of Cylinders (i.e. piles, columns)			0.90
Sharp			0.80

$$K_s = \underline{\hspace{2cm}}, K_2 = \underline{\hspace{2cm}}, w = \underline{\hspace{2cm}}, y = \underline{\hspace{2cm}}$$

$$d_s = 1.5 ( \underline{\hspace{2cm}} ) ( \underline{\hspace{2cm}} ) ( \underline{\hspace{2cm}} )^{0.7} ( \underline{\hspace{2cm}} )^{0.3} = \underline{\hspace{2cm}}$$

**Step B**

Thalweg Elevation                     

Bottom of foundation (footing or seal elevation, or pile tip for pile columns)                     

Scour elevation = Thalweg Elevation -  $d_s$  =                      -                      =                     

**If Scour Elevation is lower than the bottom of the foundation elevation or within 10 feet of the pile tip, the bridge is Scour Critical.**

**Bridge Is Scour Critical**  Yes  No

**Scour Code WB76-80**

## Evaluate End Abutment and Contraction Scour

- Adequate and practical formulae for determining anticipated local scour due to an end abutment exist but are very conservative; each bridge must be evaluated individually.
- Check condition or existing riprap and embankments.
- If there is no riprap in place, **or** if existing riprap appears to be in place, and **can be bypassed** by migration of the stream at the upstream end of the riprap, run abutment or contraction scour equations.
- If existing riprap is in place, **cannot be bypassed** by migration of the stream at the upstream end of the riprap, and the system has experienced a 100 yr. event, the bridge **is not** scour critical.

Bridge Is Scour Critical  Yes  No      Scour Code WB76-80 \_\_\_\_\_

If Scour Critical, Action Plan for High Water Event:

## 5.06 Bridge Sufficiency Rating

The sufficiency rating (SR) is the basis for establishing eligibility and priority for replacement or rehabilitation of bridges with Federal Highway Bridge Replacement and Rehabilitation Program (HBRRP) funds. The sufficiency rating is a numeric value which indicates a bridge's relative ability to serve its intended purpose. The value ranges from 100 (a bridge in new condition) to 0 (a bridge incapable of carrying traffic). The sufficiency rating is the summation of four calculated values: Structural Adequacy and Safety, Serviceability and Functional Obsolescence, Essentiality for Public Use, and Special Reductions. The sufficiency rating is generated automatically in WSBIS, other bridge management software, or hand calculated using the Sufficiency Rating Worksheet in this section. The WSBIS field names are bolded and italic for clarity.

There are two types of deficient bridges — structurally deficient (SD) and functionally obsolete (FO) (see Figure 5.07-A). A structurally deficient bridge, as defined by the FHWA, is one whose condition or design has impacted its ability to adequately carry its intended traffic loads. A functionally obsolete bridge is one in which the deck geometry, load carrying capacity, clearance, or approach roadway alignment has reduced its ability to adequately meet the traffic needs below accepted design standards. Those bridges meeting the criteria for both SD and FO are only considered SD, the structural deficiency overrides the functional obsolescence and the bridge will be considered in the SD classification.

In general, the lower the sufficiency rating, the higher the priority. To qualify for replacement, a bridge must have a sufficiency rating of less than 50.0 and be structurally deficient or functionally obsolete. To be eligible for rehabilitation, a bridge must have a SR of 80.0 or less and be structurally deficient or functionally obsolete. The bridges must be greater than ten years old.

Structurally Deficient (SD) — A determination that a structure's condition or design is reducing its ability to adequately carry its intended load. The bridge is Structurally Deficient if:

1. It has a condition rating of four or less for any ONE of the following fields:

WB76 - 63	<b>DECK OVERALL</b>
WB76 - 71	<b>SUPERSTRUCTURE OVERALL</b>
WB76 - 76	<b>SUBSTRUCTURE OVERALL</b>
WB76 - 78	<b>CULVERTS *</b>

- or -

2. It has an appraisal rating of two or less for any ONE of the following fields:

WB76 - 57	<b>STRUCTURAL ADEQUACY</b>
WB76 - 62	<b>WATERWAY ADEQUACY **</b>

Functionally Obsolete (FO) — A determination that a structure's condition or geometry is reducing its ability to adequately carry its intended traffic. The bridge is Functionally Obsolete if:

1. It has an appraisal rating of three or less for any ONE of the following:

WB76 - 58	<b>DECK GEOMETRY</b>
WB76 - 59	<b>UNDERCLEARANCE ADEQUACY ***</b>
WB76 - 61	<b>ALIGNMENT ADEQUACY</b>

- or -

2. It has an appraisal rating of three for any ONE of the following:

WB76 - 57	<b>STRUCTURAL ADEQUACY</b>
WB76 - 62	<b>WATERWAY ADEQUACY **</b>

*\*Applies only if the last two digits of WB75 - 33 MAIN SPAN DESIGN is coded 07 or 19.*

*\*\*Applies only if the last digit of WB75 - 45 SERVICE UNDER is coded 0,5,6,7,8, or 9.*

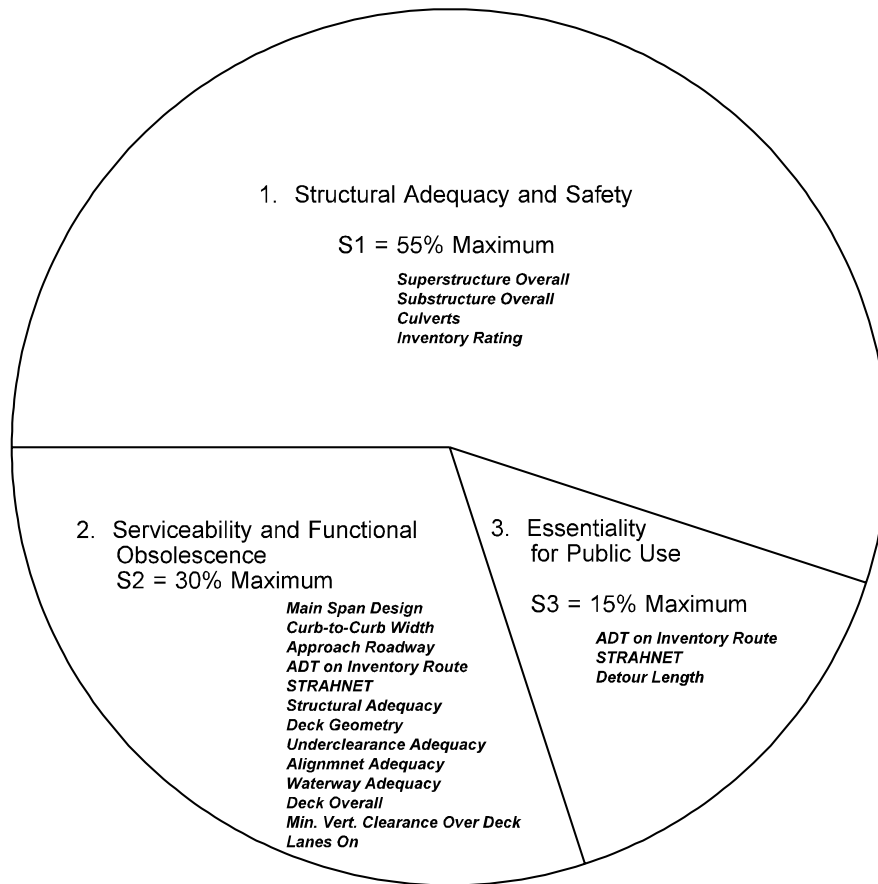
*\*\*\*Applies only if the last digit of WB75 - 45 SERVICE UNDER is coded 0,1,2,4,6,7, or 8.*

### **Bridge Deficiency Definitions**

*Figure 5.07-A*

# Sufficiency Rating Worksheet

## An Illustration of Sufficiency Rating (SR) Factors



**4. Special Reductions**  
 S4 = 13% Maximum  
*Detour Length*  
*Main Span Design*  
*Bridge Rail*  
*Transition*  
*Guardrail*  
*Terminal*

Sufficiency Rating = S1 + S2 + S3 - S4  
 Sufficiency Rating shall not be < 0 nor > 100  
 If S1 + S2 + S3 ≥ 50, then subtract S4,  
 otherwise SR = S1 + S2 + S3

Note: WSBIS Field Names are Italicized and Bold

<b>Agency:</b>	_____
<b>Structure Identifier:</b>	_____
<b>Bridge Number:</b>	_____
<b>Bridge Name:</b>	_____
<b>Sufficiency Rating = S1 + S2 + S3 - S4 (Range: 0 to 100)</b>	
	<b>= ( ) + ( ) + ( ) - ( )</b>
	<b>= _____</b>
<b>Deficiency = _____ (See Figure 5.07-A)</b>	
<b>Calculated By:</b>	_____
<b>Date:</b>	_____

*Note:*

This form uses English units for calculating the sufficiency rating. The calculated value may differ from that calculated by WSDOT Bridge as they perform the calculations using Metric values.

**STRUCTURAL ADEQUACY & SAFETY (S1)**

**1. Determine the value of A:**

(a) Enter the condition codes for:

<i>WB76 - 71</i>	<i>SUPERSTRUCTURE OVERALL</i>	_____
<i>WB76 - 76</i>	<i>SUBSTRUCTURE OVERALL</i>	_____
<i>WB76 - 78</i>	<i>CULVERT</i>	_____

(b) Find A:

- A = 55 : If the lowest code above is less than or equal to 2
- A = 40 : If the lowest code is equal to 3
- A = 25: If the lowest code is equal to 4
- A = 10 : If the lowest code is equal to 5
- A = 0 : If the lowest code is greater than 5

*A* = \_\_\_\_\_

**2. Determine the value of B:**

(a) Enter the Inventory Rating (IR):

<i>WB75 - 55</i>	<i>INVENTORY RATING (IR)</i>	_____ TONS
------------------	------------------------------	------------

(b) Find the value of B:

$$B = (36 - IR)^{1.5} \times 0.2778$$

*B* = \_\_\_\_\_

**3. Determine S1:**

$$S1 = 55 - (A + B)$$

*S1* = \_\_\_\_\_ (points range from 0 to 55)

**SERVICEABILITY & FUNCTIONAL OBSOLESCENCE (S2)**

**1. Determine the value of C:**

- (a) Enter the adequacy or condition codes for the fields listed.
- (b) Determine corresponding values for these codes from Table 1.

TABLE 1

	<u>Code</u>	<u>Value</u>
If <b>STRUCTURAL ADEQUACY</b> is: WB76 - 57	≤ 3	= 4
	= 4	= 2
	= 5	= 1
If <b>DECK GEOMETRY</b> is: WB76 - 58	≤ 3	= 4
	= 4	= 2
	= 5	= 1
If <b>UNDERCLEARANCE ADEQUACY</b> is: WB76 - 59	≤ 3	= 4
	= 4	= 2
	= 5	= 1
If <b>ALIGNMENT ADEQUACY</b> is: WB76 - 61	≤ 3	= 4
	= 4	= 2
	= 5	= 1
If <b>WATERWAY ADEQUACY</b> is: WB76 - 62	≤ 3	= 4
	= 4	= 2
	= 5	= 1
If <b>DECK OVERALL</b> is: WB76 - 63	≤ 3	= 5
	= 4	= 3
	= 5	= 1

- (c) Add the values to determine C.

	<u>Code</u>	<u>Value</u>
<b>WB76 - 57</b> <b>STRUCTURAL ADEQUACY</b>	_____	_____
<b>WB76 - 58</b> <b>DECK GEOMETRY</b>	_____	_____
<b>WB76 - 59</b> <b>UNDERCLEARANCE ADEQUACY</b>	_____	_____
<b>WB76 - 61</b> <b>ALIGNMENT ADEQUACY</b>	_____	_____
<b>WB76 - 62</b> <b>WATERWAY ADEQUACY</b>	_____	_____
<b>WB76 - 63</b> <b>DECK OVERALL</b>	_____	_____
<b>TOTAL C =</b>		_____ (13 maximum)

**2. Determine the value of D:**

(a) Enter measurements for the following fields:

**WB73 - 97      APPROACH ROADWAY WIDTH      \_\_\_\_\_**  
**WB73 - 56      CURB-TO-CURB WIDTH                      \_\_\_\_\_**

(b) Find the value of D: (For bridges that are not culverts (i.e., Main Span Design not equal to 19))

**APPROACH ROADWAY WIDTH > (CURB-TO-CURB WIDTH + 2.0'), D = 5**  
**APPROACH ROADWAY WIDTH ≤ (CURB-TO-CURB WIDTH + 2.0'), D = 0**

**D = \_\_\_\_\_**

**3. Determine the value of E:**

(a) Enter or determine the following values:

**WB73 - 52      LANES ON                                      \_\_\_\_\_**  
**WB73 - 56      CURB-TO-CURB WIDTH                              \_\_\_\_\_**  
**WB75 - 45      ADT ON INVENTORY ROUTE                              \_\_\_\_\_**  
 Lane Width: **CURB-TO-CURB** \_\_\_\_\_  
**WIDTH/LANES ON** \_\_\_\_\_  
 ADT/Lane: **ADT ON INVENTORY** \_\_\_\_\_  
**ROUTE/LANES ON** \_\_\_\_\_

(b) Find the value of E: (where the following conditions apply)

For One-Lane Bridges:

- Lane Width < 14, E = 15
- $14 \leq \text{Lane Width} < 18$ ,  $E = 15 ((18 - \text{Lane Width})/4) = \underline{\hspace{2cm}}$
- Lane Width  $\geq 18$ , E = 0

For Two or More Lane Bridges:

- **LANES ON** = 02 and Lane Width  $\geq 16$ , E = 0
- **LANES ON** = 03 and Lane Width  $\geq 15$ , E = 0
- **LANES ON** = 04 and Lane Width  $\geq 14$ , E = 0
- **LANES ON** > 05 and Lane Width  $\geq 12$ , E = 0

***If the above calculations apply, do not continue.***

- ADT/Lane > 50 and Lane Width < 9, E = 15
- ADT/Lane  $\leq 50$  and Lane Width < 9, E = 7.5
- ADT/Lane  $\leq 50$  and Lane Width  $\geq 9$ , E = 0
  
- $50 < \text{ADT/Lane} \leq 125$  and Lane Width < 10, E = 15
- $50 < \text{ADT/Lane} \leq 125$  and  $10 \leq \text{Lane Width} < 13$ ,  
 $E = 15 (13 - \text{Lane Width})/3 = \underline{\hspace{2cm}}$
- $50 < \text{ADT/Lane} \leq 125$  and Lane Width  $\geq 13$ , E = 0
  
- $125 < \text{ADT/Lane} \leq 375$  and Lane Width < 11, E = 15
- $125 < \text{ADT/Lane} \leq 375$  and  $11 \leq \text{Lane Width} < 14$ ,  
 $E = 15 (14 - \text{Lane Width})/3 = \underline{\hspace{2cm}}$
- $125 < \text{ADT/Lane} \leq 375$  and Lane Width  $\geq 14$ , E = 0

**Bridge Analysis**

- $375 < \text{ADT/Lane} \leq 1350$  and Lane Width  $< 12$ ,  $E = 15$
- $375 < \text{ADT/Lane} \leq 1350$  and  $12 \leq \text{Lane Width} < 16$ ,  
 $E = 15 (16 - \text{Lane Width})/4 = \underline{\hspace{2cm}}$
- $375 < \text{ADT/Lane} \leq 1350$  and Lane Width  $\geq 16$ ,  $E = 0$
  
- $\text{ADT/Lane} > 1350$  and Lane Width  $< 15$ ,  $E = 15$
- $\text{ADT/Lane} > 1350$  and  $15 \leq \text{Lane Width} < 16$ ,  
 $E = 15 (16 - \text{Lane Width}) = \underline{\hspace{2cm}}$
- $\text{ADT/Lane} > 1350$  and Lane Width  $\geq 16$ ,  $E = 0$

$E = \underline{\hspace{2cm}}$

**4. Determine the value of F:**

(a) Enter the following values:

**WB73 - 70**      **MIN. VERT. CLEARANCE OVER DECK**                            
**WB74 - 85**      **STRAHNET**                          

(b) Find the value of F: (using the following conditions)

- **STRAHNET**  $> 0$  and **MIN. VERT. CLEARANCE OVER DECK**  $\geq 16\ 00$ ,  $F = 0$
- **STRAHNET**  $> 0$  and **MIN. VERT. CLEARANCE OVER DECK**  $< 16\ 00$ ,  $F = 2$
  
- **STRAHNET**  $= 0$  and **MIN. VERT. CLEARANCE OVER DECK**  $\geq 14\ 00$ ,  $F = 0$
- **STRAHNET**  $= 0$  and **MIN. VERT. CLEARANCE OVER DECK**  $< 14\ 00$ ,  $F = 2$

$F = \underline{\hspace{2cm}}$

**5. Determine S2:**

$S2 = 30 - (C + (D + E) + F)$       ( $(D + E)$  cannot be more than 15)

$S2 = \underline{\hspace{2cm}}$  (points range from 0 to 30)

**ESSENTIALITY FOR PUBLIC USE (S3)**

**1. Determine the value of G:**

(a) Enter the following values:

**WB74 - 45**      **ADT ON INVENTORY ROUTE**                            
**WB74 - 103**      **DETOUR LENGTH**                            
                                  **S1 POINTS**                            
                                  **S2 POINTS**                          

(b) Calculate the value of G:

$G = \frac{(\underline{\hspace{2cm}})(\underline{\hspace{2cm}})(7.5)}{[(S1 + S2)/85](100,000)}$

$G = \frac{(\underline{\hspace{2cm}})(\underline{\hspace{2cm}})(7.5)}{[(\underline{\hspace{2cm}} + \underline{\hspace{2cm}})/85](100,000)}$

$G = \underline{\hspace{2cm}}$  (15 maximum)



**Bridge Analysis**

(b) Find the value of K:

- If 2 of the above values are 0, then  $K = 1$
- If 3 of the above values are 0, then  $K = 2$
- If 4 of the above values are 0, then  $K = 3$

$K =$  \_\_\_\_\_

**4. Determine S4:**

$$S4 = I + J + K$$

$S4 =$  \_\_\_\_\_ (points range from 0 to 13)