TECHNICAL PAPER 04

Hydrology and flooding impact assessment

Appendix D Blockage assessment for cross-drainage structures

NARRABRI TO NORTH STAR—PHASE 2 ENVIRONMENTAL IMPACT STATEMENT

APPENDIX D – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

1. BLOCKAGE OF HYDRAULIC STRUCTURES

For the N2NS Phase 2 project, blockage of cross drainage structures is a risk that needs to be understood and managed or minimised through the design. Blockage is a random event but for the purposes of design it needs to be quantified.

ARR 2019 – Book 6, Chapter 6 includes advice and an approach for estimating blockage of bridges and culverts. This chapter concentrates specifically on blockage of cross drainage structures, in particular culverts and small bridges. The procedure has been developed to quantify the most likely blockage level and mechanism for a small bridge or culvert when impacted by sediment or debris laden floodwater.

The approach is both qualitative and quantitative and relies upon site and catchment specific information and engineering judgement. The intent of the approach is to estimate a numerical blockage factor that can be included in a hydraulic model.

2. ADOPTED APPROACH

The approach to the estimation of blockage has been adopted as per ARR2019. In applying this approach for N2NS there are assumptions and interpretations of the guidance required and these are set out in the following sections.

2.1 FACTORS INFLUENCING BLOCKAGE

ARR2019 documents that the main factors influencing blockage include:

- Debris Type and Dimensions - Whether floating, non-floating or urban debris present in the source area and its size;
- Debris Availability - The volume of debris available in the source area;
- Debris Mobility - The ease with which available debris can be moved into the stream;
- Debris Transportability - The ease with which the mobilised debris is transported once it enters the stream;
- Structure Interaction - The resulting interaction between the transported debris and the bridge or culvert structure; and
- Random Chance - An unquantifiable but significant factor.

These various factors which impact debris movement and interaction with the structure are discussed further in the following sections.

2.2 PROJECT SPECIFIC FACTORS

2.2.1 DEBRIS TYPE AND DIMENSIONS

Experience has shown that there are three different types of debris typically that accumulated upstream of or within a blocked structure. This debris may be classified as:

- Floating (e.g. trees);
- Non-floating or depositional (e.g. sediment); and
- Urban (e.g. cars and other urban debris).

For the project it has been determined that floating and sediment/depositional types of debris are the most appropriate. There is a small potential for urban type debris where there are urban areas or farm houses and sheds upstream of the structure. These have been considered on a case by case basis.

FLOATING DEBRIS

Floating debris of various sizes can cause blockage of structures. A desktop review for the main river channels of the Mehi and Gwydir Rivers indicates that the rivers generally maintain a constant baseflow at the project crossings. For these two major rivers, there are large sections of tree lined reiver banks upstream local to the project that could provide floating debris load. Many of the minor creeks and drainage lines upstream of the project area remain dry most of the time and are generally cleared of trees or denser vegetation. For these minor channels and floodplain areas, large floating debris such as tree branches would generally only be available from upper catchment areas with the majority of this debris expected to be confined to the two main river channels. Based on site visit observations and a review of site photographs and maintenance records, the dominant floating debris for smaller bridges and culverts within the floodplain will be dense grasses and smaller branches, i.e small to medium size debris. It is noted that small floating debris tends to pass through structures due to their size compared to the structure.

NON FLOATING/DEPOSITIONAL DEBRIS

Non floating debris is generally related to sediment size. A desktop review of regional soil maps was undertaken on the NSW online soil and land information resource eSPADE (refer to Figure 2.1 below for an extract showing the upstream catchment area). The soils can generally be classified as grey, brown and red clays in good condition (dark grey legend colour) with pockets of red brown and red earths upstream of the project. Figure 2.1 also includes point markers that provide localised erosion hazard profiles. The profiles give a ranking of the soils susceptibility to the prevailing agents of erosion and demonstrates the majority of the catchment is ranked at the lowest level of “slight” or no appreciable erosion damage is likely to take place (indicated by the green points in the image).

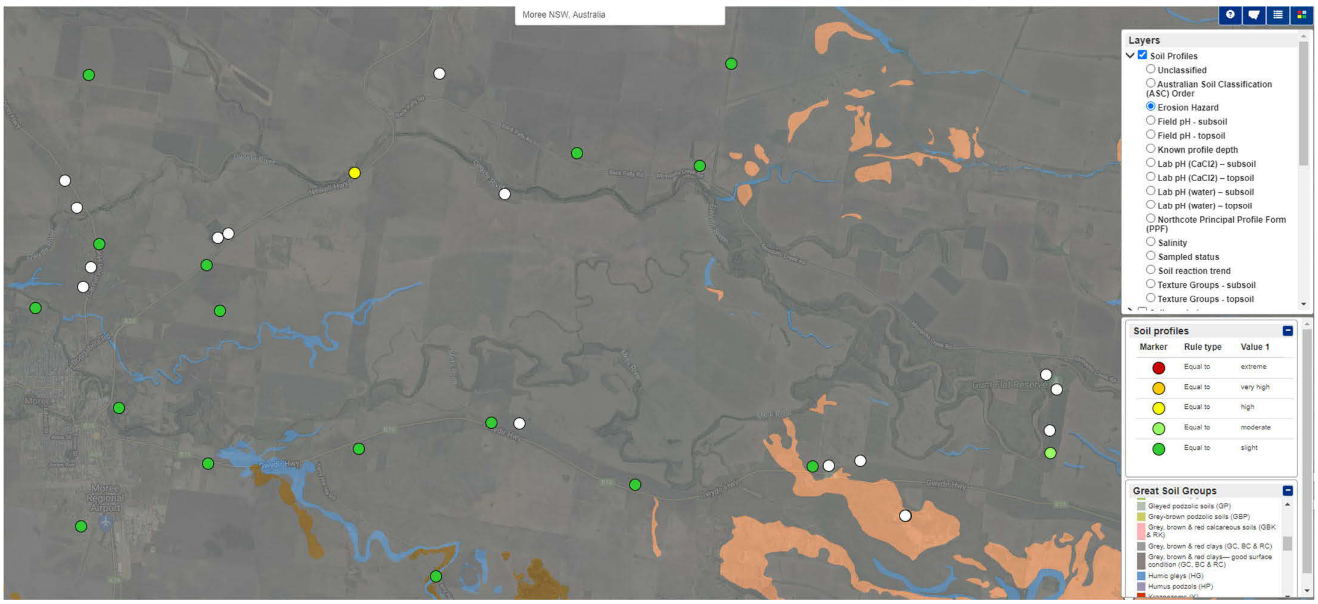

Figure 2.1 Soil Information (eSPADE v2.1), Accessed 16/11/2020

For the project corridor, the results of a series of adjacent boreholes have been assessed and d50 sediment size estimated at locations along the corridor. The results of the assessment indicate soil type of clays, sands and gravels are present along the corridor. Sediment size for the blockage assessment has been chosen based on the nearest borehole information. A review of existing structure photographs and maintenance records does not indicate the presence of depositional debris issues for the existing rail corridor at this location.

2.2.2 DEBRIS AVAILABILITY

The availability of debris is determined by the area (source) that is upstream of the point of interest from which debris can come from. ARR2019 indicates that the availability is also dependent on the event, such that a small event is likely to only collect debris from a small area, and a larger event is likely to generate debris from a larger area simply by extent of inundation or volume of runoff.

The ARR2019 procedure is used to initially establish debris potential in a 1% Annual Exceedance Probability (AEP) event.

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SOURCE AREA

The source area for the majority of the project can be described as gently undulating cleared agricultural land. The catchment immediately upstream of the project is predominantly used for dryland and irrigated cropping with some pockets of grazing land use. The cropping is seasonal and therefore this may have some impact on debris availability but only if immediately adjacent to the project alignment. A review of the aerial photographs of the catchment to the east (upstream) of the project alignment has been completed to help describe the source area. There are some patches of remnant native vegetation at local high points and there are some paddocks with contour banking that is assumed to control and reduce erosion during rainfall events.

Site photographs have also been reviewed to help establish an understanding of the source area. A selection of these photos illustrating the range of typical conditions at existing structures are included below:

Chainage 667.027

APPENDIX D – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

Chainage 667.671

Chainage 672 .375

APPENDIX D – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

Chainage 680.610

Debris availability for each culvert and bridge crossing has been classified on a case by case basis but in general the classification is low. ARR2019 describes the low classification as:

- Well maintained rural agricultural lands and paddocks with minimal outbuildings or stored materials in the source area.
- Streams with moderate to flat slopes and stable bed and banks.

3. IMPLEMENTATION OF THE PROCESS

In order to estimate a blockage factor for use in the hydraulic assessment a process has been developed that considers the qualitative factors above and site specific hydraulic factors that influence blockage. The inputs and process are described in detail below.

3.1 INPUTS

Fourteen parameters are used to assess the blockage risk on culvert structures. These include;

- **Approach Bed Slope**, this is extracted from the bed slope implemented in hydrological modelling of the catchment and provides an indicative upstream slope approaching the structure under investigation;
- **Stream Velocity**, this parameter is extracted from the maximum velocity result grid file from the latest iteration of the hydraulic models. Point sampling of hydraulic model results provides an indicative upstream maximum stream velocity across all modelled storm patterns and durations;
- **Peak Velocity**, obtained from hydraulic model results tabulated outputs of the storm pattern and duration deemed to be most representative of the project area. Specifically, the 1 dimensional tabulated structure output file is opened and the absolute maximum value of velocity through each structure is adopted in the process;
- **Stream Depth**, similar to Stream Velocity, this parameter is extracted by point sampling of maximum depth result grid results. Both Stream Velocity and Stream Depth are sampled at the same upstream location and are assumed to provide an indicative value. Again, the maximum depth value at the specified location across all modelled storm patterns and durations of the hydraulic model results is extracted and implemented;
- **Inlet Clear Width**, extracted from the hydraulic model input 1d Network layer, this parameter is the value of internal width of a single cell within a structure;
- **Inlet Clear Height**, extracted from the hydraulic model input 1d Network layer, this parameter is the value of internal height of a single cell within a structure;
- **Number of Cells**, provides the number of cells a structure is made up of;
- **Effective Stream Width**, defined as the effective material transporting width of an active stream at some distance upstream of a structure;
- **Temporal Variability in Max Stream Flows**, a parameter ranked High/Medium/Low. For a higher temporal variability, a High rating is applied;
- **L_{10}**, a parameter representing the average length of the longest 10% of the debris that could arrive at the site;
- **Debris Availability**, a parameter ranked High/Medium/Low.
- **Debris Mobility**, a parameter ranked High/Medium/Low.
- **AEP**, the Annual Exceedance Probability determined by the event under assessment;
- **Mean Sediment Present**, determined from geotechnical investigations close to a structures location.

3.2 PROCESS

The process implemented is based on guidance provided in Book 6, Chapter 6 of ARR2019 with key assumptions displayed clearly.

3.2.1 DEBRIS TRANSPORTABILITY

The site rating for each of the categories in Table 3.1 is a number, 3, 2 or 1 based on where each parameter falls in relation to the assessment conditions.

Table 3.1 Debris Transportability Assessment Table (modified from ARR2019, Book 6, Chapter 6, Table 6.6.3)

FACTOR	HIGH (3)	MEDIUM (2)	LOW (1)	SITE RATING
Slope (S) (%)	S ≥ 3	1 ≤ S < 3	S < 1	
Stream Velocity (Vs) (m/s)	Vs ≥ 2.5	1 ≤ Vs < 2.5	Vs < 1	
Stream Depth (ds) (m) relative to L10 (m)	ds > 0.5×L10	ds = 0.5×L10	ds < 0.5×L10	
Effective Stream Width (Ws) (m)	Ws > L10	Ws = L10	Ws < L10	
Temporal Variability in Maximum Stream Flows	Determined by assessor (3,2 or 1)			
			Debris Transportability Rating	

Key Assumption

The overall Debris Transportability, as assessed in Table 3.1, receives either a High, Medium or Low rating. Each of the five assessment categories receives a score of 3, 2 or 1. The summation of these site ratings is used to determine the final Debris Transportability rating, High, Medium or Low. An approach based on the guidance for Debris Potential, Table 6.6.4 for Book 6, Chapter 6, of ARR2019, is adopted. Table 3.2 shows the process for determining the summation bounds that yield an end Debris Transportability rating of High, Medium or Low.

Table 3.2 Debris Transportability Assessment Final Rating Factors Table

FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	SUM	AVERAGE	H/M/L
3	3	3	3	3	15	3	H
3	3	3	3	2	14	2.8	H
3	3	3	2	2	13	2.6	H
3	3	3	3	1	13	2.6	H
3	3	2	2	2	12	2.4	M
3	2	2	2	2	11	2.2	M
3	3	3	1	1	11	2.2	M
2	2	2	2	2	10	2	M
3	3	1	1	1	9	1.8	M
2	2	2	2	1	9	1.8	M
2	2	2	1	1	8	1.6	M
3	1	1	1	1	7	1.4	L
2	2	1	1	1	7	1.4	L
2	1	1	1	1	6	1.2	L
1	1	1	1	1	5	1	L

The options 1 to 5 presented in Table 3.2 represent all possible final summation scenarios that impact the final site ranking. It is noted that the scenarios do not account for a specific category scoring a H (3), M (2) or L (1). By taking a simple average of the individual factor scores, and sorting from highest to lowest average value, a single number between 0 and 3 is achieved. Based on the factors average and the observed severity of each scenario, the following bounds for final Debris Transportability rating were established;

$5 \leq SUM < 8$ = LOW $8 \leq SUM < 13$ = MEDIUM $SUM \geq 13$ = HIGH

3.2.2 DEBRIS POTENTIAL

Apart from Debris Transportability, the factors influencing the Debris Potential are directly drawn from the user inputs. Criteria used to determine Debris Mobility are detailed in Table 6.6.2 of ARR2019, Book 6, Chapter 6. Similarly, for Debris Availability, Table 6.6.1 of ARR2019, Book 6, Chapter 6. The site rating for each of the categories in Table 3.3 is a number, 3, 2 or 1 based on the score of the previously assessed factors.

Table 3.3 Debris Potential Assessment Table

FACTOR	HIGH (3)	MEDIUM (2)	LOW (1)	SITE RATING
Debris Availability	3	2	1	
Debris Mobility	3	2	1	
Debris Transportability	3	2	1	
			Debris Potential Rating	

Table 3.4 Debris Potential Assessment Final Rating Table (modified from ARR2019, Book 6, Chapter 6, Table 6.6.4)

DEBRIS POTENTIAL RATING	COMBINATIONS
High	HHH (9), HHM (8)
Medium	MMM (6), HML (6), HMM (7), HLL (5)
Low	LLL (3), MML (5), MLL (4)

Where a score of 5 is determined, from the combinations in Table 3.4, the process will apply a condition such that if a score of 5 is achieved, and one of the values contributing to the score is, High (3), then the Debris Potential is Medium, otherwise it is Low.

The Debris Potential is then adjusted based on the Annual Exceedance Probability of the assessment. The adjustment conditions are shown in Table 3.5. Where the AEP does not satisfy an Event AEP condition, a site rating of zero if given. Therefore, the final site rating will be either 3, 2 or 1 corresponding directly to a High, Medium or Low site rating.

Table 3.5 Adjustment for Annual Exceedance Probability (modified from ARR2019, Book 6, Chapter 6, Table 6.6.5)

EVENT AEP	DEBRIS POTENTIAL AT STRUCTURE			
	HIGH (3)	MEDIUM (2)	LOW (1)	SITE RATING
AEP ≥ 5%	2	1	1	
0.5% ≤ AEP < 5%	3	2	1	
AEP < 0.5%	3	3	2	
			Adjustment of Annual Exceedance Probability	

3.2.3 DESIGN BLOCKAGE LEVEL

The design blockage level for a structure is determined from Table 3.6. The table is used as a lookup with the two inputs; the condition relating Inlet Clear Width and L_{10} and the Adjusted Debris Potential detailed in section 3.2.1.

Table 3.6 Most likely Inlet Blockage Levels (modified from ARR2019, Book 6, Chapter 6, Table 6.6.6)

CONTROL DIMENSIONS INLET CLEAR WIDTH (W_i) (m)	**AEP ADJUSTED DEBRIS POTENTIAL AT STRUCTURE**			**SITE RATING**
	HIGH	MEDIUM	LOW	
$W_i < L_{10}$	100%	50%	25%	
$L_{10} \leq W_i \leq 3\times L_{10}$	20%	10%	0%	
$W_i > 3\times L_{10}$	10%	0%	0%	
			Inlet Blockage Level (%)	

3.2.4 SEDIMENT DEPOSITING IN BARREL/WATERWAY

By comparing the Peak Velocity through the structure with the Mean Sediment Size, Table 3.7 is utilised to determine the likelihood of sediment deposition in the barrel/waterway.

Table 3.7 Likelihood of Sediment Being Deposited in Barrel/Waterway (modified from ARR2019, Book 6, Chapter 6, Table 6.6.7)

PEAK VELOCITY THROUGH STRUCTURE (V_P) (m/s)	**MEAN SEDIMENT SIZE PRESENT (mm)**					**SITE RATING**
	Clay/Slit 0.001 – 0.04	Sand 0.04 - 2	Gravel 2 - 63	Cobbles 63 - 200	Boulders > 200	
$V_P \geq 3$	LOW	LOW	LOW	LOW	MEDIUM	
$1.0 \leq V_P < 3.0$	LOW	LOW	LOW	MEDIUM	MEDIUM	
$0.5 \leq V_P < 1.0$	LOW	LOW	LOW	MEDIUM	HIGH	
$0.1 \leq V_P < 0.5$	LOW	LOW	MEDIUM	HIGH	HIGH	
$V_P < 0.1$	LOW	MEDIUM	HIGH	HIGH	HIGH	
					Likelihood of Sediment Being Deposited in Barrel/Waterway	

Table 3.7 is used as a lookup table. The user defines the Mean Sediment Size and together with the Peak Velocity the Likelihood of Sediment Deposition is determined.

The most likely depositional blockage level is then determined using the lookup Table 3.8 with the Likelihood of Sediment Deposition and the Adjusted AEP Debris Potential from Table 3.5.

Table 3.8 Most likely Depositional Blockage Levels (modified from ARR2019, Book 6, Chapter 6, Table 6.6.8)

LIKELIHOOD OF SEDIMENT DEPOSITION	**AEP ADJUSTED NON FLOATING DEBRIS POTENTIAL (SEDIMENT) AT STRUCTURE**			**SITE RATING**
	HIGH	MEDIUM	LOW	
HIGH	100%	60%	25%	
MEDIUM	60%	40%	15%	
LOW	25%	15%	0%	
			Depositional Blockage Level (%)	

3.2.5 CELL HEIGHT AND L_{10} CONSIDERATIONS

Key Assumption

The implemented value of Inlet Clear Width, to the process described in previous sections, is defined based on the number of cells in the structure, the structure type, the Inlet Clear Height and the originally inputted value of Inlet Clear Width itself. The conditions are;

- If the number of cells is greater than one, the Inlet Clear Width is implemented as W_i;
- If the number of cells is equal to one, and the Inlet Clear Height is zero, a pipe culvert, the Inlet Clear Width is implemented as W_i;
- If the number of cells is equal to one, and the Inlet Clear Height is greater than zero, a box culvert, and the Inlet Clear Height is less than or equal to one third of the Inlet Clear Width, the Inlet Clear Height is implemented as W_i, otherwise the Inlet Clear Width is implemented as W_i.

Where the Inlet Clear Height is implemented as W_i, the value of L_{10} input is divided by two and takes the place of the original L_{10} value in the assessment.

3.2.6 FINAL DESIGN BLOCKAGE APPLIED

Key Assumption

The Final Design Blockage is the maximum of Shared Inlet Blockage Level and Shared Depositional Blockage Level. In line with ARR2019, Book 6, Chapter 6, Section 6.4.4.9, inlet and depositional shared blockage levels are assessed based on the structures width and the Effective Stream Width. The following conditions are applied;

- If the Active Stream Width is greater than or equal to the structure width, calculated as the product of Inlet Clear Width and Number of Cells, all cells are applied with a blockage equal to the Inlet/Depositional Blockage Level.
- If the Active Stream Width is less than the structure width the following conditions are applied;
  - Cells that are exposed to any flow from the active stream are applied with a blockage equal to the Inlet/Depositional Blockage Level.
  - Cells that are not exposed to any flow from the active stream are applied with a blockage equal to half of the Inlet/Depositional Blockage Level.
  - The shared blockage value is then derived by dividing the summation of each cell blockage level by the Number of Cells.

The Final Design Blockage Level is then adopted as the larger of the derived shared inlet and depositional blockage levels.

4. APPLICATION OF THE METHOD: WORKED EXAMPLE

Table 4.1 details the inputs used in this worked example.

Table 4.1 Worked Example Input Values

PARAMETER	UNIT	VALUE
Approach Bed Slope (S)	%	0.132
Stream Velocity (Vs)	m/s	4.03
Peak Velocity (Vp)	m/s	2.319
Stream Depth (ds)	m	0.324
Inlet Clear Width (Wi)	m	3
Inlet Clear Height (Hi)	m	2.4
Number of Cells (Ncells)		40
Active Stream Width (Ws)	m	20
Temporal Variability in Max Stream Flows	L/M/H (1,2,3)	2
L10	m	5
Debris Availability	L/M/H (1,2,3)	2
Debris Mobility	L/M/H (1,2,3)	1
AEP	%	1
Mean Sediment Present	mm	200

Intermediate Steps

L10 and Wi Implemented

- The structure contains more than one cell, therefore the Wi implemented is equal to the Inlet Clear Width (3m);
- The structure contains more than one cell, therefore the L10 implemented is equal to L10 (5m).

Debris Transportability

- Slope (0.132%) <1% therefore the site rating equals 1;
- Stream Velocity (4.03m/s) >2.5m/s therefore the site rating equals 3;
- Stream Depth (0.324m) < 0.5 × L10 (5m) therefore the site rating equals 1;
- Active Stream Width (20m) > L10 (5m) therefore the site rating equals 3;
- Temporal Variability in Max Stream Flows is 2 therefore the site rating is 2;
- Final summation of the above site ratings is 10, 8≤10<13 therefore the Debris Transportability is **Medium**.

Debris Potential

- Debris Availability is 2 therefore the site rating equals 2;

- Debris Mobility is 1 therefore the site rating equals 1;
- Debris Transportability was determined as Medium therefore the site rating is 2;
- Final summation of the above site ratings is 5, as none of the site ratings are High (3) the Debris Potential is **Low**.

AEP Adjusted Debris Potential

- AEP (1%) is between 5% and 0.5% and previously determined Debris Potential is Low, therefore site rating is 1;
- Summation is also equal to 1 and therefore the Adjusted Debris Potential is **Low**.

Design Inlet Blockage Level

- L10 (5m) ≤ Wi (3m) ≤ 3 × L10 (5m) and the Adjusted Debris Potential is Low therefore the Design Inlet Blockage Level is **0%**.

Likelihood of Sediment Being Deposited in Barrel/Waterway

- Peak Velocity (2.319m/s) is between 1.0 and 3.0 and the Mean Sediment Present is 200mm, therefore the site rating is 2;
- Summation is also equal to 2 therefore the Likelihood of Sediment Begin Deposited in Barrel/Waterway is **Medium**.

Design Depositional Blockage Level

- The Likelihood of Sediment Begin Deposited in Barrel/Waterway is Medium and the Adjusted Debris Potential is Low therefore the Design Depositional Blockage Level is **15%**.

Final Output

- Debris Potential was determined as Low;
- AEP Adjusted Debris Potential was determined as Low;
- Design Inlet Blockage Level was determined as 0%;
- Likelihood of Sediment Begin Deposited in Barrel/Waterway was determined as Medium;
- Design Depositional Blockage Level was determined as 15%;
- The Effective Stream Width (20m) < Number of Cell (40) × Inlet Clear Width (3m) therefore the number of cells to apply full blockage values to is equal to the division of Effective Stream Width and Inlet Clear Width;

$$\frac{W_s}{W_i} = \frac{20}{3} \approx 7$$

- This value is rounded up to the nearest integer value. 7 cells are applied with full blockage values and 33 are applied with half blockage values;
- The maximum of the shared blockage values is taken;

$$Shared\ Inlet\ Blockage = \frac{7 \times 0\% + 33 \times 0.5 \times 0\%}{40} = 0\%$$

$$Shared\ Depositional\ Blockage = \frac{7 \times 15\% + 33 \times 0.5 \times 15\%}{40} = 8.8125\%$$

- Final Blockage Applied to the structure is **8.81%**.

5. RESULTS AND CONCLUSION

The results of the blockage assessment at each structure for the design case are presented in the results sheets below. The assessment indicates that the blockage factor at the crossing locations within the study project is between 0 to 25% with an average estimated blockage value of 15%. Subsequently, a 15% blockage factor was applied to all culverts within the hydraulic model.

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Structure ID	Pipe Description	Approach Bed Slope (S)	Stream Velocity (Vs)	Peak Velocity (Vp)	Stream Depth (ds)	Inlet Clear Width (Wi)	Inlet Clear Height (Hi)	Number of Cells (Ncell)	Active Stream Width (Ws)	Temporal Variability in Max Stream Flows	L10	Debris Availability	Debris Mobility	AEP	Mean Sediment Present	Debris Potential	Adjustment for Annual Exceedance Probability	Design Inlet Blockage Level	Likelihood of Sediment Being Deposited in Barrel/Waterway (HML)	Depositional Blockage Level	Cells Applied with B_{DES}	Cells Applied with 0.5 x B_{DES}	Shared Inlet Blockage	Shared Depositional Blockage	Final Design Blockage
		(%)	m/s	m/s	m	m	m		m	L/M/H (1,2,3)	m	L/M/H (1,2,3)	L/M/H (1,2,3)	%	mm			B_{DES}%		B_{DES}%			%	%	%
668.200	RCBC IR N2NS NEW	0.178	0.507	1.41	1.027	3.0	1.2	30	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 30	30 of 30	12.50%	0.00%	12.50%
668.700	RCBC IR N2NS NEW	0.273	0.309	3.48	2.021	1.8	0.6	60	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 60	60 of 60	12.50%	0.00%	12.50%
668.830	RCBC IR N2NS R EX BRIDGE	0.225	0.237	2.85	2.188	2.4	2.4	2	5	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	2 of 2	0 of 2	25.00%	0.00%	25.00%
669.000	RCBC IR N2NS NEW	0.144	0.350	3.42	1.794	1.8	0.6	60	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 60	60 of 60	12.50%	0.00%	12.50%
669.200	RCBC IR N2NS NEW	0.102	0.373	3.33	1.746	1.8	0.6	60	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 60	60 of 60	12.50%	0.00%	12.50%
669.305	RCBC IR N2NS	0.113	0.280	2.80	1.873	1.8	1.8	1	5	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	1 of 1	0 of 1	25.00%	0.00%	25.00%
669.450	RCBC IR N2NS NEW	0.139	0.360	1.93	1.845	1.8	0.6	60	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 60	60 of 60	12.50%	0.00%	12.50%
669.650	RCBC IR N2NS NEW	0.217	0.397	3.19	1.670	1.8	0.6	60	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 60	60 of 60	12.50%	0.00%	12.50%
669.850	RCBC IR N2NS NEW	0.165	0.427	3.22	1.791	1.8	0.6	60	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 60	60 of 60	12.50%	0.00%	12.50%
671.200	RCBC IR N2NS NEW	0.168	0.459	1.18	1.312	1.8	0.6	50	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 50	50 of 50	12.50%	0.00%	12.50%
671.400	RCBC IR N2NS NEW	0.496	0.474	1.63	1.695	1.8	0.6	50	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 50	50 of 50	12.50%	0.00%	12.50%
671.520	RCBC IR N2NS	0.232	0.432	1.43	2.327	3.0	2.1	7	5	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	2 of 7	5 of 7	16.07%	0.00%	16.07%
672.700	RCBC IR N2NS NEW	0.262	0.529	1.11	1.418	3.0	1.2	20	45	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	15 of 20	5 of 20	21.88%	0.00%	21.88%
673.050	RCBC IR N2NS NEW	0.181	0.465	1.46	1.367	3.0	1.1	15	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 15	15 of 15	12.50%	0.00%	12.50%
673.270	RCBC IR N2NS NEW	0.170	0.470	1.47	1.332	3.0	1.1	15	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 15	15 of 15	12.50%	0.00%	12.50%
675.380	RCBC IR N2NS	0.132	0.233	1.28	2.046	3.0	1.1	2	5	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	2 of 2	0 of 2	25.00%	0.00%	25.00%
675.720	RCBC IR N2NS	1.210	0.199	1.40	1.825	3.0	1.1	2	5	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	2 of 2	0 of 2	25.00%	0.00%	25.00%
676.730	RCBC IR N2NS NEW	0.298	0.241	1.21	1.185	2.4	0.8	20	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 20	20 of 20	12.50%	0.00%	12.50%
676.850	RCBC IR N2NS NEW	0.171	0.475	1.77	1.282	2.4	0.8	13	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 13	13 of 13	12.50%	0.00%	12.50%
677.350	RCBC IR N2NS NEW	0.118	0.194	4.83	1.792	3.0	1.2	5	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 5	5 of 5	12.50%	0.00%	12.50%
677.600	RCBC IR N2NS NEW	0.064	0.200	4.60	1.649	3.0	1.2	5	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 5	5 of 5	12.50%	0.00%	12.50%
677.770	RCBC IR N2NS NEW	1.809	0.339	2.74	2.625	3.0	1.8	3	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 3	3 of 3	12.50%	0.00%	12.50%
677.875	RCBC IR N2NS NEW	0.208	0.234	2.60	1.433	3.0	1.2	5	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 5	5 of 5	12.50%	0.00%	12.50%
670.100A	RCBC IR N2NS NEW	0.155	0.374	1.95	1.760	1.8	0.6	60	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 60	60 of 60	12.50%	0.00%	12.50%
670.100B	RCBC IR N2NS NEW	0.090	0.420	2.12	1.787	1.8	0.6	60	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 60	60 of 60	12.50%	0.00%	12.50%
670.500A	RCBC IR N2NS NEW	0.113	0.389	1.88	1.808	1.8	0.6	50	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 50	50 of 50	12.50%	0.00%	12.50%
670.500B	RCBC IR N2NS NEW	0.146	0.421	2.03	1.898	1.8	0.6	50	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 50	50 of 50	12.50%	0.00%	12.50%
670.500C	RCBC IR N2NS NEW	0.048	0.419	2.00	1.817	1.8	0.6	50	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 50	50 of 50	12.50%	0.00%	12.50%
670.500D	RCBC IR N2NS NEW	0.381	0.420	1.75	1.658	1.8	0.6	40	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 40	40 of 40	12.50%	0.00%	12.50%
670.790A	RCBC IR N2NS NEW	0.286	0.441	1.92	1.710	1.8	0.6	30	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 30	30 of 30	12.50%	0.00%	12.50%
670.790B	RCBC IR N2NS	0.321	0.404	2.15	1.640	3.0	1.2	1	5	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	1 of 1	0 of 1	25.00%	0.00%	25.00%
671.000A	RCBC IR N2NS NEW	0.141	0.372	1.39	1.524	1.8	0.6	50	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 50	50 of 50	12.50%	0.00%	12.50%
671.000B	RCBC IR N2NS NEW	0.153	0.422	1.13	1.433	1.8	0.6	50	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 50	50 of 50	12.50%	0.00%	12.50%
672.000A	RCBC IR N2NS NEW	0.180	0.366	1.63	1.512	1.8	0.6	50	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 50	50 of 50	12.50%	0.00%	12.50%
672.000B	RCBC IR N2NS NEW	0.189	0.426	1.66	1.839	1.8	0.6	70	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 70	70 of 70	12.50%	0.00%	12.50%
672.000C	RCBC IR N2NS NEW	0.377	0.518	1.73	1.836	1.8	0.6	70	30	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	17 of 70	53 of 70	15.54%	0.00%	15.54%
672.000D	RCBC IR N2NS NEW	0.561	0.476	1.88	2.228	1.8	0.6	70	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 70	70 of 70	12.50%	0.00%	12.50%
672.450A	RCBC IR N2NS NEW	0.299	0.398	2.07	2.707	1.8	0.6	60	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 60	60 of 60	12.50%	0.00%	12.50%
672.450B	RCBC 3.6h	3.499	0.689	1.14	3.578	3.6	3.6	20	45	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	13 of 20	7 of 20	20.63%	0.00%	20.63%
678.615A	RCBC IR N2NS	1.533	0.290	1.63	1.882	2.4	0.8	20	5	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	3 of 20	17 of 20	14.38%	0.00%	14.38%
678.615B	RCBC IR N2NS	0.410	0.296	1.63	1.873	3.0	1.8	4	5	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	2 of 4	2 of 4	18.75%	0.00%	18.75%
680.500A	RCBC IR N2NS NEW	0.751	0.376	1.26	1.506	2.4	0.8	50	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 50	50 of 50	12.50%	0.00%	12.50%
680.500B	RCBC IR N2NS	0.392	0.335	1.30	1.991	3.0	2.1	5	5	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	2 of 5	3 of 5	17.50%	0.00%	17.50%
CM677.300	RCBC IR N2NS NEW	1.539	0.304	1.59	1.801	3.0	1.8	3	0	2	5	1	2	1	15.000	LOW	LOW	25%	LOW	0%	0 of 3	3 of 3	12.50%	0.00%	12.50%
																								Average	14.77%