In July 2015, Brian Chow, P.Eng, retained Gary McClelland, P.Eng, to provide recommendations to the Ministry of Forests, Lands and Natural Resource Operations as to guidelines for Professional Practitioners pertaining to Bridge Approach Barriers (BAB) for Forest Service Roads.

Presently, the ministry has no specific guidelines or standards in regards to Bridge Approach Barriers as to when they are required, as to their types and configurations and as to their placement.

This report will be directed to the development of a Ministry Philosophy for BABs and seeks to provide a reasonable rationale for developing guidelines for BABs on Forest Service Roads. It is expected that this document will be used as framework on which discussions will be held to develop Ministry direction and then applied to development of standards in subsequent work.

BACKGROUND - PREVIOUS WORK

Associated Engineering (BC) Ltd (AE) provided the Ministry with the following reports:

1. Development of Curb Design Parameters- January 2011
3. Guidelines for Barrier Selection and Design -August 2011

The work investigated how similar jurisdictions are dealing with Bridge Barriers on roads similar to FSRs, investigated the current state of research and suggested decision matrices for Ministry Bridge Barrier design. AE’s work primarily focused on the barriers mounted on the actual bridge decks but did touch on Bridge Approach Barriers. This report is to carry on with BABs where that work left off.

AE’s work present many recommendation but a key one that this report will follow is that it is reasonable for the Ministry to not address the containment of large industrial vehicles but rather to use light traffic as the primary parameter in traffic volumes and vehicle loading for bridge barriers.

Another key recommendation by AE is that the Ministry consider 3 classes of containment with respect to Bridge Barriers:

- Containment Level I
  - Exclusively industrial traffic and minimal public traffic.
  - Relatively low height above water/hazard.
  - Good vertical and horizontal alignment.
  - No pedestrian traffic.
  - Normal operating speeds.
  - Use Standard MFLNRO Bridge Barriers including the top and side mounted timber barriers and the side mounted HSS and W-Beam barriers.
• Containment Level II
  o Increased operating speeds.
  o Limited use by the public and pedestrians – users who may be unfamiliar with the route and associated hazards.
  o Significant height above water and/or near a significant hazard.
  o Adverse geometry and/or visibility.
  o Increased deck width.
  o Develop standard bridge barriers by modifying existing bridge barriers crash-tested to AASHTO MASH Test Level 1 (TL-1).

• Containment Level III
  o High level of public and/or pedestrian use (may provide access to recreation destinations or rural communities), and may see a significant proportion of drivers who are unfamiliar with driving conditions.
  o High operating speeds.
  o Significant height above water.
  o Increased deck width or multi-lane bridge.
  o Adverse geometry and/or visibility.
  o Develop standard bridge barriers by modifying existing bridge barriers crash-tested to AASHTO MASH Test Level 2 (TL-2).

Also, 2 decision matrices were proposed in the Associated Engineering report:

1. To determine the bridge barrier containment level for individual sites based on the risk factors.

2. To determine whether a Bridge Approach Barrier (BAB) is needed and the length of the required barrier based on roadway height above the water course and approach roadway geometry.

(Scans of the above decision matrices are in Appendix II of this report.)
VARIATIONS FROM ASSOCIATED ENGINEERING (BC) LTD’S REPORT

This report will follow the spirit of the AE’s reports but with some variations based on the past performance of Ministry Bridge Barriers.

A. Crash Testing Requirement

The MFLNRO believes that it is reasonable that the level of safety (frequency of serious accidents) recommended by other agencies (including CHBDC) can be met on most of its roads by using systems that have not been crash tested but rather by using its own Standard systems. The Ministry recognizes that forest and resource roads in BC are not analogous in design, geometry or traffic as roads administered by other jurisdictions and agencies. The rate of accidents involving collisions of light traffic into bridge barrier systems on FSRs is very, very low. It is felt that this is due to the relatively low volumes of light traffic using these roads. These volumes fall on the very low end of populations addressed in Low Volume Road Standards developed by other agencies and jurisdictions. The Ministry feels that that this “tail data” can reasonably be treated differently than the higher volume populations.

This report is based on the Bridge Barrier systems the Ministry is presently employing

B. Road Categories

This report categorizes Forest Service Roads by the amount of non-industrial light traffic on them and assumes a different Containment Level for the various categories. They are:

1. Short Term FSRs
2. Low Public Use FSRs
3. Medium Public Use FSRs
4. High Public Use FSRs
5. Very High Public Use FSRs

This report makes assumptions that vary from AE’s containment levels.

- CL-1. This would capture Short Term and Low Public Use FSRs and there is not much variation from AE’s report.
- CL-2. This would broadly capture Medium Public Use FSRs. AE recommends for this Level of Containment the Ministry modify existing barriers meeting AASHTO MASH Test Level 1 (TL-1). This is unlikely to happen in the near future.
- CL-3. This would be used mostly on High Public Use FSRs. Similar to CL-2, AE recommends the Ministry modify existing barriers meeting TL-2. This is unlikely to happen in near future.
- CL-4. This containment level does not formally exist. For the purposes of this report, CL-4 will be considered equivalent to MOTI standards. All bridge barrier systems including the BABs would be crash tested to appropriate AASHTO MASH Test Levels (TL-1 and TL-2).
C. **Specific Traffic Numbers Thresholds**

AE’s report recommended the Ministry develop traffic volume numbers to delineate a road with minimal use by the public (X Vehicles per Day (VPD)) and a road as high public use (Y VPD). Due to the wide variations in user pressures throughout the province these numbers have not been developed and are not expected to be developed soon. At the end of this report there is further discussion and some speculated values on this.

It is recommended that the final road categorization be based the qualitative judgement of Ministry Engineers.

D. **Extra Wide Decks**

This report assumes that wide bridge decks (> 5.6 m) are not double lane crossings and are in place solely to accommodate truck tracking on tight corners. Extra wide bridges (>8 m) are very rare and would have to be addressed as “one offs”.

E. **Varying Levels of Containment on the same road.**

AE’s recommendations imply that the containment level for different structures on the same road might vary due the risks. E.g. a bridge high above the water course may have a higher Containment Level than the same bridge but much lower above the water. This report recommends that there would not be as much variation of Containment Level on the same road. They would tend be “one offs” rather than routine.

**RECOMMENDATIONS**

The purpose of Bridge Approach Barriers is to provide a smooth transition from the approach road onto the bridge and provide for a seamless connection to the Bridge Barrier. The intent is to keep errant light vehicle traffic from sudden impacts and to assist vehicles in maintaining direction of travel onto the bridge deck.

Bridge Approach Barriers are part of the total bridge barrier system and thus, to recommend a Bridge Approach Barrier it should be done in context with the barrier on the bridge itself.

It is recommended that the Ministry’s Philosophy state that BABs be installed on Forest Service Roads (FSRs); the standard of which will be determined by the level of risk to non-truck user traffic. Where the risk is sufficiently high, crash tested barrier systems would be specified; for lower risk, lower standard systems would be specified; and where the risk is below a certain threshold, no BABs are required.

It is recommended that Ministry BAB systems be consistent with BC Ministry Of Transportation and Infrastructure (MOTI) requirements for roads of similar risks.

Risk on the network of Forest Service Road bridges should range on a continuum from high risk to low risk. Risk should be based on:
Number/frequency of non-industrial vehicles
Height of approach
Road geometry
Vehicle speed
Approach road width relative to Bridge roadway width

BRIDGE APPROACH BARRIERS BASED ON ROAD CATEGORY

Although the following implies that the road categories are individual entities, the reality is that FSRs often consist of more than one category. It is very common that the lower section of an FSR could be a Very High Public Use FSR. The middle section could be a Medium Public Use FSR, the upper sections and branches could be Low Public Use FSRs. As well, there could be Short Term roads for harvesting accessing along the entire road length. The type of BAB would vary accordingly depending on road category at the specific location.

LOW PUBLIC USE FSRs

These roads are primarily for industrial access, typically only for harvesting and access little that would be of interest to the general public. In the fall hunters would likely use the road but when translated into the Average Annual Daily Traffic (AADT) the resulting numbers would be quite low. The bridge structures may be permanent or temporary. Design speeds are usually less than 50 kph.

The default bridge barrier is assumed to be CL-1; the default for this type of road is no BAB.

Where there is increased risk due to approach road geometry or roadway height above the water course barriers providing visual guidance would be required. This could consist of guide logs with soil packed in on the back side for extra resistance if struck.

Where there are issues due to roadway geometry a longer barrier may be required.

Given the long term nature of these roads it may be practical from a perspective of minimizing maintenance to install more robust and permanent Concrete Roadside Barriers (CRB) as approach barriers. The BAB system could be the “traditional” MFLNRO system of CRBs consisting of a bullnose, transition barrier and an 890 barrier. CRBs would not need to be attached to bridge barriers.

Rationale: These types of roads are strictly for industrial used and would carry very little public traffic. Of the light vehicles using them they would primarily be people working in the Resource Sector, familiar with the road and driving on resource roads, trained in road protocols and equipped with radios.

WorkSafe BC is the only other Agency involved with Road Safety on these roads and their requirements for Bridge Barriers would be met with what is proposed. In Part 26 of the Occupational Health and Safety (OHS) Guidelines, WorkSafe’s only direction is that bridges “… must be equipped with substantial and well secured continuous timber curbs or bull rails of sufficient height to prevent vehicles from running off the structure, but not less than 25 cm.”
SHORT TERM FSRs

These access only harvesting operations and would access little that would be of interest to the general public. In the fall hunters would use these roads but when translated into AADT the resulting numbers would be quite small. These roads will be deactivated upon completion of harvesting obligations. Traffic speeds are less than 50 kph.

The default bridge barrier is assumed to be CL-1; the default for this type of road is no BAB.

Adverse geometry alone would not necessitate BABs. Where there are risks due to height above the water BABs providing visual guidance would be required. Guide logs with soil packed in on the back side could be used.

Rationale: Traffic on these roads is similar to that of Low Public Use FSRs except that their life is short term so that the total amount of traffic is very small indeed. The total global risk of a light vehicle having an incident with Bridge Barriers or Bridge Approach Barriers would be very, very small as well.

MEDIUM PUBLIC USE FSRs

These are long term roads (often Capital funded) with permanent bridges, often linking up with other networks and used by other resource users. Public use would be limited to moderately popular recreation sites and limited through traffic. Design speeds are less than 80 kph.

The default bridge barrier is assumed to be CL-2.

The default system would be similar to the ‘traditional’ MFLNRO system of Concrete Roadside Barriers (CRB) consisting of a bullnose, transition barrier and an 890 barrier. Additional to the traditional system there should be:

- a mechanism such that when struck by errant light vehicles the face of the BAB will not displace relative to the Bridge Barrier and the vehicle will not strike the end of the Bridge Barrier head on. Rather, the errant vehicle would hopefully “bounce” back into the roadway. In most jurisdictions this is dealt with by directly connecting the BAB to the Bridge Barrier. This detail may be feasible for FSR bridges but concern has been raised that if the BAB is struck by a large vehicle such as a grader there could considerable damage done to the Bridge Barrier and bridge deck. Possibilities to deal with this are to design a connection tying the Bridge Barrier to the BAB that is the “weak link” in the system and would fail first. Alternately the BAB could be restrained with a detail which is independent of the Bridge Barrier
- a smooth inside face in the transition from the BAB to the Bridge Barrier.

This approach could be applied to HSS, W-Beam and timber bridge barrier systems.

For this category of road, crash tested systems would not be mandatory.
Where road speeds are in excess of 80 kph an even more robust BAB may be warranted but it is not expected to be a common case.

Structures of which there is no reduction of roadway width whatsoever when going onto the crossing (e.g. culverts or some MSE structures) may not require BABs or connection of BABs to Bridge Barriers.

The long term intent is that all structures would eventually have BABs.

BABs should be required in order of priority:
1. at all new bridges.
2. where there are identified high risks due to roadway geometry or roadway height above the water course and as budgets allow.
3. on existing structures when major maintenance is being carried out.

Where practical, it is suggested that side mounted timber barriers should be retro-fitted to steel HSS barriers when replaced in the interest of longevity.

If there are sites with enough pedestrian traffic to warrant a pedestrian railing, the bridge barrier system (including the BABs) should include consideration to include a smooth transition from the BAB to the Bridge Barrier hand rail system.

Rationale: There are other jurisdictions in North America that require crash tested systems for bridge barriers for analogous roads. However, two agencies that don’t are the BC MFLNRO and Ontario Ministry of Natural Resources; both are mandated for the efficient extraction of Natural Resources. The US Forest Service (USFS) has a somewhat similar mandate but does require crash tested barriers. It is likely that roads administered by the USFS will typically have higher public use. It is also interesting to note how many of the USFA roads are paved. In low risk sites, the USFS allows barrier systems that meet TL-1. The MFLNRO undertook research to statically test bridge barrier systems. The results indicate that arguably they meet (or almost meet) TL-1 and in some cases TL-2 requirements although they have not been crash tested. As the MFLNRO Bridge Barrier systems have not been specifically crash tested, it would be inconsistent to require the BAB system to be crash tested. Providing a smooth road way face and connecting the Transition Barrier to Bridge Barrier, although not a crash tested detail, would likely be a fairly inexpensive improvement.

HIGH PUBLIC USE FSRs

These roads are heavily used by the public often accessing communities or popular tourist/recreation facilities. Although the inventory of these roads would be considerably less than the Medium Public Use FSRs there still would be significant number in the Province. They are similar to Very High Public Use FSRs (see next bullet) but are more physically and geometrically like an industrial road than a public road. Differences would be:
- lower traffic volumes
- lower speeds < 80 kph
- narrow width
- poor alignment
- poor surfacing

The default bridge barrier is assumed to be a CL-3. The default Bridge Approach Barrier would be the “traditional” MFLNRO system of Concrete Roadside Barriers (CRB) consisting of a bullnose, transition barrier and an 890 barrier. Additional to the traditional system there should be:
  - similar to the Medium Public Use FSR (see above) the BAB would have to be restrained such that when struck by an errant light vehicle it would not displace relative to the Bridge Barrier and the vehicle will not strike the end of the Bridge Barrier head on.
  - a smooth face in the transition from the approach barrier to the bridge barrier.

**Rationale:** The high use by the Public on these roads would necessitate a higher level of containment than CL-2. Similarly to the rationale for Medium Public Use FSRs, seeing that the Bridge Barrier System is not been crash tested it would be inconsistent to require the BAB system to be crash tested.

**VERY HIGH PUBLIC USE FSRs**
The MFLNRO is mandated to be responsible for some roads with very high public use. For all intents and purposes these roads should be administered by MOTI.
The default bridge barrier is assumed to be CL-4. Approach barriers should meet MOTI standards including an engineered and crash tested transition from the BAB to the bridge barrier.

It is expected that most sites will require barriers have been crash tested to TL-1 and, in some cases, TL-2.

**Rationale:** CHBDC and most other jurisdictions in North America, including BC Ministry of Transportation and Infrastructure require Crash Tested Barriers on Low Volume Public Roads. It is suggested that the MFLNRO should target the same level of safety. This type of road is a very low percentage of the network and the extra costs associated with it would not be anticipated to be a major cost driver to the overall MFLNRO (and/or the Forest Sector) budgets.

**DELINEATION OF ROAD CATEGORIES**
Most jurisdictions use Annual Average Daily Traffic (AADT) measured in VPD (vehicles per day) as a major criterion to determine Bridge Barrier and Bridge Approach Barrier Systems. Traffic number data for FSRs is limited but anecdotal evidence would suggest that numbers are very, very small relative to roads administered by MOTI. To categorize roads, BAB systems, and Bridger Barriers on FSRs based on hard traffic numbers would not be practical at this time without more traffic data. However, the Ministry has requested traffic numbers to be included in the report. The AADT numbers that follow are based solely on judgement and are to be used only for discussion purposes.
  - Low Public Use FSR: (proposed non-industrial AADT<5)
Ministry of Forests, Lands and Natural Resource Operations  
Bridge Approach Barriers on Forest Service Roads – January 21, 2016

- Short Term FSR: (proposed non-industrial AADT<5)
- Medium Public Use FSRS: (proposed non-industrial AADT<25)
- High Public Use FSRS: (proposed non-industrial AADT<50. Note this value was selected as it appears to be the threshold below which MOTI’s “Low Volume Road Bridge Design Guidelines” apply)
- Very High Public Use FSRS: (proposed non-industrial AADT>50)

The above numbers do not capture large industrial vehicles. As with current practice with Bridge Barriers, it is recommended that road categories (and subsequent BAB systems) be determined for a particular site based on qualitative judgement of Ministry Engineering Staff.

DISCLAIMER
The advice in this report is to provide a starting point and framework for the MFLNRO to develop a philosophy towards Bridge Approach Barriers. To do this, Bridge Barriers themselves have to be considered and thus, assumptions on Bridge Barriers has been presented.

It is required that the MFLNRO understand, digest and revise this philosophy in regards to Bridge Approach Barriers as it deems to be needed and must take on sole responsibility for its final outcome.

Respectfully Submitted

[Signature]

Gary McClelland, P. Eng.

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### APPENDIX I

#### SUMMARY TABLE

<table>
<thead>
<tr>
<th></th>
<th>Low Public Use AADT&lt;5* V&lt;50 kph</th>
<th>Short term Public Use AADT&lt;5* V&lt;50kph</th>
<th>Medium Public Use AADT&lt;25* V&lt;80kph</th>
<th>High Public Use AADT&lt;50* V&lt;80kph</th>
<th>Very High Public Use AADT&gt;50*</th>
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<tbody>
<tr>
<td>Proposed Containment Level</td>
<td>CL-1</td>
<td>CL-1</td>
<td>CL-2</td>
<td>CL-3</td>
<td>CL-4</td>
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<td>All bridges have BABs?</td>
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<td>Yes</td>
<td>Yes</td>
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<td>BAB and Transition Crash tested to TL-1 and TL-2?</td>
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<td>Bridge Barrier and BAB Arguably meets TL-1?</td>
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<td>Smooth roadway face between BAB Transition and Bridge Barrier?</td>
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<td>Visual Guidance Only</td>
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<td>Yes</td>
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<td>Roadway geometry a risk?</td>
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<td>BAB Length Based on AE’s Bridge Barrier Decision Matrix</td>
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<td>Roadway height above water course a risk?(&gt; 5.0 m)</td>
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<td>Do decks wider than 8 m require extra attention?</td>
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</table>

* AADT above refers to light vehicle numbers; and are only for discussion purposes
APPENDIX II

Associated Engineering (BC) LTD Decision Matrices
(Scanned from “Guidelines for Barrier Selection and design – August 2011”)

Bridge Barrier Decision Matrix

Traffic Mix - Mixture of industrial and public traffic.

Bridge Deck Height - Measured from the top of the bridge deck to the top of the water or ground below.

Design Speed

Bridge Deck Width - Measured between inside of curbs.

Containment Level

Recommended Barrier type for the selected containment level.

Notes: 1.) The Ministry to develop traffic volumes X and Y.
2.) Where pedestrian use is expected, consider installing barrier-top rails to achieve a total height of 1070 mm.
3.) Where vertical grade exceeds the area-specific average (eg. > 4%), apply engineering judgement to determine whether a higher standard barrier is appropriate.

Approach Barrier Decision Matrix

Embankment Height

Approach Radius

Recommended Approach Barrier

No Approach Barrier Required

6.0 m Approach Barrier

12.0 m Approach Barrier