



Ministry of Transportation and Infrastructure
Malahat Highway No. 1 Safety Review
Proposed Highway Improvements

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1.0 EXECUTIVE SUMMARY

The Trans Canada Highway No. 1 on Vancouver Island is a north-south rural arterial highway that begins in Nanaimo and ends in Victoria. It is the main highway corridor on Vancouver Island that connects the communities of southern Vancouver Island with the communities of central Vancouver Island. The Annual Average Daily Traffic along the corridor is 22,300 vehicles per day thus making this one of the most important transportation corridors on the island.

The Malahat section of Highway No. 1 is approximately 20 km long beginning at West Shore Parkway and ending at the Bamberton Overpass. The Malahat has been the subject of several studies in recent years with the focus being to improve safety and reliability.

The objective of this report is to conduct a thorough review to assess corridor safety performance and identify improvements that could be considered in both the short and longer term. The short term recommendations are improvements without major constraints that could be implemented within the one to two year time horizon, whereas the long term improvements identified for consideration are more challenging, may need to address environmental or other constraints, and are larger scale improvements that would require more detailed analysis.

Collision data along the corridor and on a segment by segment basis were analyzed and compared to Provincial safety averages or benchmarks to determine how the corridor is performing. These safety measures were then used to identify safety improvements along the corridor. Factors affecting reliability were also considered in the review in order to minimize the frequency of closures.

The short term improvements that the Ministry may want to consider include the following:

- Installation of concrete median barrier in areas of relatively less challenging construction constraints;
- Safety improvements at key intersections such as Finlayson Arm Road and Shawnigan Lake Road and the Malahat Village area, Summit Lookout, Arbutus Rest Area and Rock Cut View Point ;
- Installation of enforcement pullouts;
- Enhanced signing and delineation along the corridor.

In the long term it is recommended that the Ministry consider:

- Further barrier installation at priority locations from a safety and reliability perspective;
- Further intersection improvements at Finlayson Arm and other priority intersections along the corridor; and further access management strategies, particularly on the section between Summit Lookout and the Rock Cut Viewpoint.

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2.0 REVIEW OBJECTIVE AND BACKGROUND

The Trans Canada Highway No. 1 on Vancouver Island is a north-south rural arterial highway that begins in Nanaimo and ends in Victoria. It is the main highway corridor on Vancouver Island that connects the communities of southern Vancouver Island with the communities of central Vancouver Island. The Annual Average Daily Traffic along the corridor is 22,300 vehicles per day thus making this one of the most important transportation corridors on the island.

The Malahat section of Highway No. 1 is approximately 20 km long beginning at West Shore Parkway and ending at the Bamberton Overpass. The Malahat has been the subject of several studies in recent years with the focus being to improve safety and reliability.

The alignment of the Malahat is curvilinear and perched on a plateau above the Saanich Inlet. The corridor is generally constrained by high rock bluffs on the west and high fill slopes on the east. There are also several environmentally sensitive areas and streams along the corridor. Due to these features, any construction along the Malahat will be challenging.

The Malahat is primarily a three lane rural arterial undivided highway alternating between two northbound / one southbound and one northbound / two southbound lanes. There are three sections of the Malahat that have a two lane cross section (i.e. one lane per direction) and one section which has been upgraded to a four lane facility. The posted speed along the Malahat segment is 80 km/h although advisory curve warning signs are located at some horizontal curves. There are several small accesses and unsignalized intersections along the corridor.

The Goldstream Provincial Park, located at the southern end of the Malahat, is a popular recreational destination. This is also one of the most challenging locations along the corridor to provide any improvements due to a high rock bluff and the proximity of an environmentally sensitive creek providing spawning habitat for salmon. This is also one of only three segments along the corridor with only a two-lane cross section.

Although not considered part of the Malahat, the section of Highway No.1 from Spencer Road to West Shore Parkway has also been included as part of this review. The reason for this inclusion is that this is the only remaining undivided section of Highway No. 1 between Victoria and the start of the Malahat at West Shore Parkway.

The objective of this report is to conduct a thorough review to assess corridor safety performance and identify improvements that could be considered in both the short and longer term. The short term recommendations are improvements without major construction constraints that could be implemented within the one to two year time horizon, whereas the long term improvements identified for consideration are more costly, may need to address environmental or other constraints, and are larger scale improvements that would require more detailed analysis. The limits of the safety review corridor are shown in **Figure 1**.

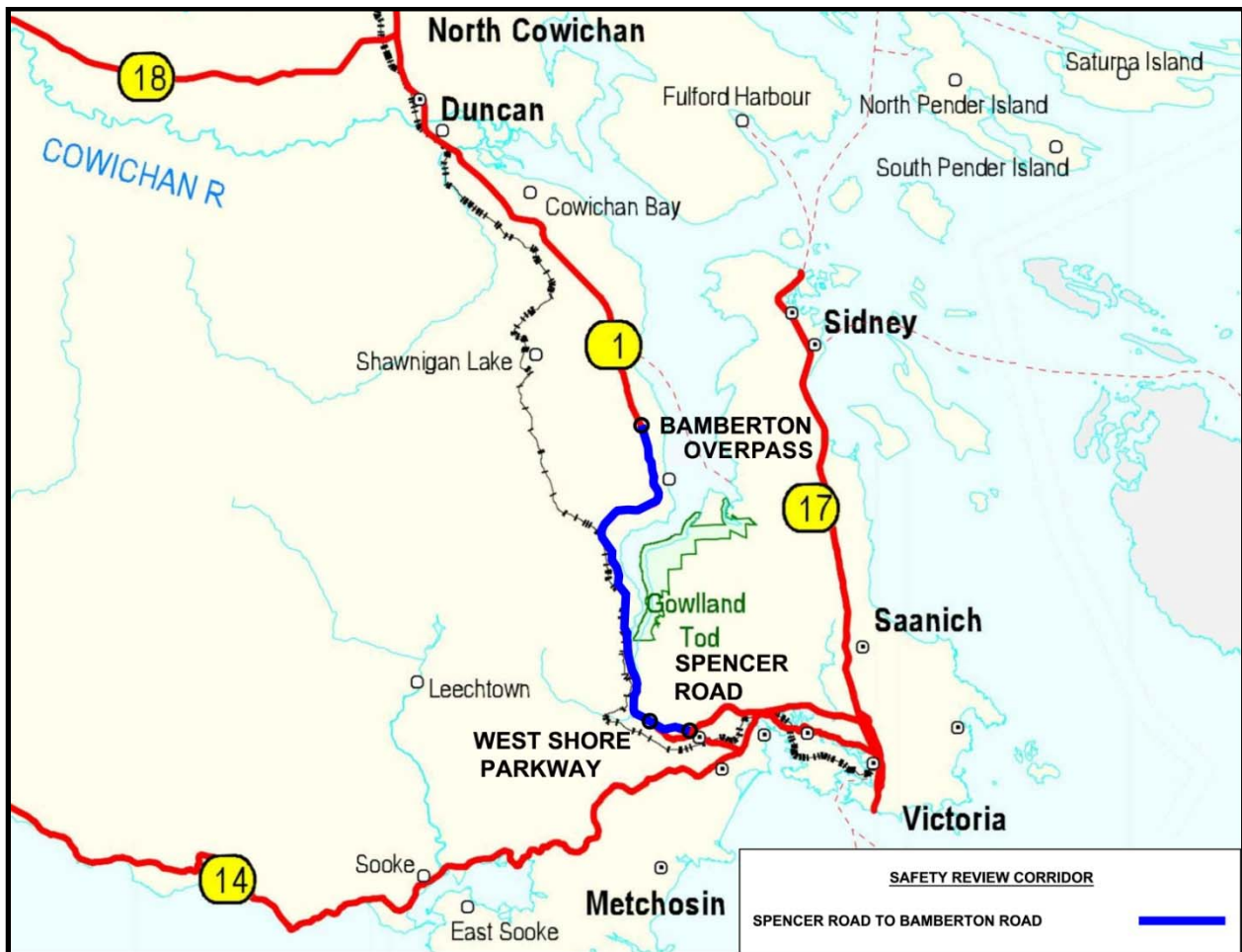


Figure 1: Limits of Safety Review Corridor

3.0 HISTORICAL SAFETY PERFORMANCE FOR ENTIRE CORRIDOR

Collision data for a 10 year time period between January 1, 2002 and December 31, 2011 were analyzed along the corridor and safety performance measures determined. The corridor safety performance measures were then compared to provincial safety averages or benchmarks to determine how the corridor is performing. The safety performance measures and benchmarks used in the analysis along with a brief description of each are included below and further detailed in **Appendix A**.

Safety Performance Measures

The safety performance measures used in this review study include the Collision Frequency, Collision Rate and Collision Severity Index. These safety measures were determined using historical collision records and are commonly used when assessing the safety performance of a corridor or segment and are defined below.

- *Collision Frequency*: The collision frequency is defined as the number of collisions per location during a specific time period.
- *Collision Rate*: The collision rate is defined as collisions per million-vehicle-kilometers (MVKm) for highway sections and collisions per million entering vehicles for intersections.

Collision Severity Index: The collision severity index is used as a measure of collision severity levels, which is defined as the weighted sum of fatal, injury, and property-damage-only (PDO) collisions. A fatal collision is given a weighting of 100, an injury collision is given a weighting of 10 and a PDO collision is given a weighting of 1. A higher severity index indicates a higher proportion of high severity collisions.

Provincial Safety Benchmarks

Critical for the assessment of the safety performance is the comparison to reliable benchmarks of normal or expected safety performance. The following safety performance benchmarks, based on provincial rates, are the most commonly used to determine the performance of a corridor and have been used as part of this review.

- *Provincial Average Collision Rate*: An average collision rate is simply an average of the calculated collision rates for a large group of similar locations that can be used as the basis for comparison. The average collision rates are often generated by road classification and traffic volume levels.

- *Critical Collision Rate*: The critical collision rate, which is based on statistical quality control procedures, has been the most widely used statistical technique among highway agencies to identify collision prone locations. The technique defines a location as collision prone if the observed collision rate exceeds a critical collision rate, which is based on the average collision rate.
- *Provincial Average Collision Severity Index (CSI)*: An average collision severity index is simply an average of the calculated collision severity indices for a large group of similar locations that can be used as the basis for comparison. Similar to average collision rates, the average CSI are often generated by road classification.

3.1 4-LANE SECTION BETWEEN SPENCER ROAD AND WEST SHORE PARKWAY

As previously mentioned, this section is not considered part of the Malahat but has been included as part of this review because it is the only remaining undivided section of Highway No. 1 between Victoria and the start of the Malahat at West Shore Parkway.

In the 10 year time period between January 1, 2002 and December 31, 2011, there were a total of 130 collisions on the study corridor between Spencer Road and West Shore Parkway. This included 1 fatal collision, 51 injury collisions and 78 property damage only collisions. This translates into a collision frequency of approximately 13 collisions per year. The following are the safety performance statistics for the corridor between Spencer Road and West Shore Parkway and provincial safety benchmarks to indicate how the corridor is performing.

Safety Performance Measures

- Collision Frequency on this segment = 13.0 collisions per year
- Collision Rate on this section = 0.53 collisions per MVKm
- Collision Severity index (CSI) = 5.29

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.54 collisions per MVKm
- Critical Collision Rate = 0.62 collisions per MVKm
- Provincial Average CSI = 6.65

The collision rate within this section is slightly below both the Provincial Average and Critical Collision Rates which indicates that this section of highway is operating at a slightly better level of safety when compared to other highway segments of similar class and traffic volumes. The Collision Severity Index is also below the provincial average CSI which indicates that the collisions that are occurring within the corridor are of lower severity than the provincial average. A histogram of the collisions that have occurred on the corridor from 2002 to 2011 can be found in **Appendix B**.

3.2 MALAHAT SECTION BETWEEN WEST SHORE PARKWAY AND BAMBERTON OVERPASS

In a 10 year time period between January 1, 2002 and December 31, 2011, there were a total of 515 collisions on the study corridor, north of the West Shore Parkway. This included 12 fatal collisions, 225 injury collisions and 278 property damage only collisions. This translates into a collision frequency of approximately 52 collisions per year, which has been fairly stable over the last 10 years. The following are the safety performance statistics for the Malahat corridor (north of the West Shore Parkway) and some provincial safety benchmark values to indicate how the corridor is performing.

Safety Performance Measures

- Collision Frequency on the Malahat = 51.5 collisions per year
- Collision Rate on Malahat = 0.31 collisions per MVKm
- Collision Severity index (CSI) = 7.24

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.32 collisions per MVKm
- Critical Collision Rate = 0.34 collisions per MVKm
- Provincial Average CSI = 7.17

The collision rate within the Malahat corridor is slightly below both the Provincial Average and Critical Collision Rates which indicates that this section of highway is operating at a slightly better level of safety when compared to other highway segments of similar class and traffic volumes. The Collision Severity Index however is slightly above provincial average CSI which indicates that the collisions that are occurring within the corridor are of marginally higher severity than the provincial average.

There are individual segments along the Malahat that have higher collision rates and collision severity indexes than provincial averages or benchmarks and these individual segments will be discussed separately in **Section 5** of this report.

A histogram of the collisions that have occurred on the Malahat corridor from 2002 to 2011 can be found in **Appendix B**.

4.0 RELIABILITY ALONG THE CORRIDOR

Based on a review of six years (2006 to 2011) of Malahat closure documentation from the Provincial Highways Control Center, there have been a total of 63 closures along the Malahat for an average of 10.5 closures per year. These closures were the result of collisions and non-collision related incidents such as hydro lines on road, rock slides, fallen trees and vehicle breakdowns.

Currently if a collision occurs within a two or three lane section of highway, the highway can be closed for several hours stranding motorists and severing the primary connection between southern and central Vancouver Island.

Closures ranged in duration from less than one hour to over 20 hours with the average closure duration being just over an hour. **Table 1** below provides a summary of the duration and frequency of the closures from 2006 to 2011.

Table 1: Summary of duration and frequency of closures on Malahat from 2006 to 2011

Closure Duration	Frequency
< 1 hour	37
1 to 2 hours	12
2 to 3 hours	8
3 to 4 hours	3
4 to 5 hours	1
5 to 6 hours	0
6 to 7 hours	1
20 to 21 hours	1
Total	63

Highway closures are a greater concern on the Malahat section between the West Shore Parkway and Shawnigan Lake Road where no alternate detour routes are available should a collision close the highway. The Shawnigan Lake Road can be used as a temporary detour route if a collision closes the highway between Shawnigan Lake Road and the Bamberton overpass. An intrinsic benefit to improving safety along the corridor is that the reliability will also improve as a result of fewer crash-related closures.

5.0 PROJECT REVIEW SEGMENTS AND SAFETY IMPROVEMENTS

For the purpose of this safety review report, the Highway No. 1 corridor was divided into 13 segments as listed below and shown in **Figure 2**. Segment 1 (Spencer Road to West Shore Parkway) is not considered part of the Malahat however it was still included as part of this review because it is the only remaining undivided section of Highway No. 1 south of the West Shore Parkway. Segment's 2 to 13 contain the Malahat section of Highway No. 1 which begins at the West Shore Parkway intersection in the south and ends at the Bamberton Overpass in the north.

The collision statistics for each segment were determined and short and long term improvements were considered for each segment.

- Segment 1: Spencer Road to West Shore Parkway (2.35 km)
- Segment 2: West Shore Parkway to Median Barrier (Offset 0.00 km to 1.45 km)
- Segment 3: Median Barrier to Finlayson Arm Road (Offset 1.45 km to 2.93 km)
- Segment 4: Finlayson Arm Road to Median Barrier (Offset 2.93 km to 4.26 km)
- Segment 5: Median Barrier to End of Median Barrier (Offset 4.26 km to 6.27 km)
- Segment 6: End of Median Barrier to Aspen Road (Offset 6.27 km to 8.33 km)
- Segment 7: Aspen Road to Petro Canada (Offset 8.33 km to 10.52 km)
- Segment 8: Petro Canada to Shawnigan Lake Road (Offset 10.52 km to 12.77 km)
- Segment 9: Shawnigan Lake Road to Whittaker Road (Offset 12.77 km to 13.62 km)
- Segment 10: Whittaker Road to Summit Lookout (Offset 13.62 km to 14.76 km)
- Segment 11: Summit Lookout to Arbutus Rest Area (Offset 14.76 km to 17.00 km)
- Segment 12: Arbutus Rest Area to Rock Cut Viewpoint (Offset 17.00 km to 17.76 km)
- Segment 13: Rock Cut View Point to Median Barrier (Offset 17.76 km to 19.59 km)

The primary goal of the improvements is to increase the overall safety of the corridor with particular attention given to preventing cross over collisions with the installation of concrete median barrier. Other improvements such as the construction of acceleration and deceleration lanes at key intersections, access management, and enhanced delineation and signing will also be considered.

Widening of the highway median would be required in many locations to accommodate barrier placement and this widening may require rock excavation or the construction of retaining walls which can add significant costs to the installation of the median barrier. The end of the concrete median barrier is also a hazard and motorists will need to be protected from striking the barrier with impact attenuators. It is therefore desirable to limit the number of exposed barrier ends by limiting the amount of short barrier segments, and if possible provide longer barrier segments. Therefore priority will be given to extending existing median barrier sections south of Shawnigan Lake Road.

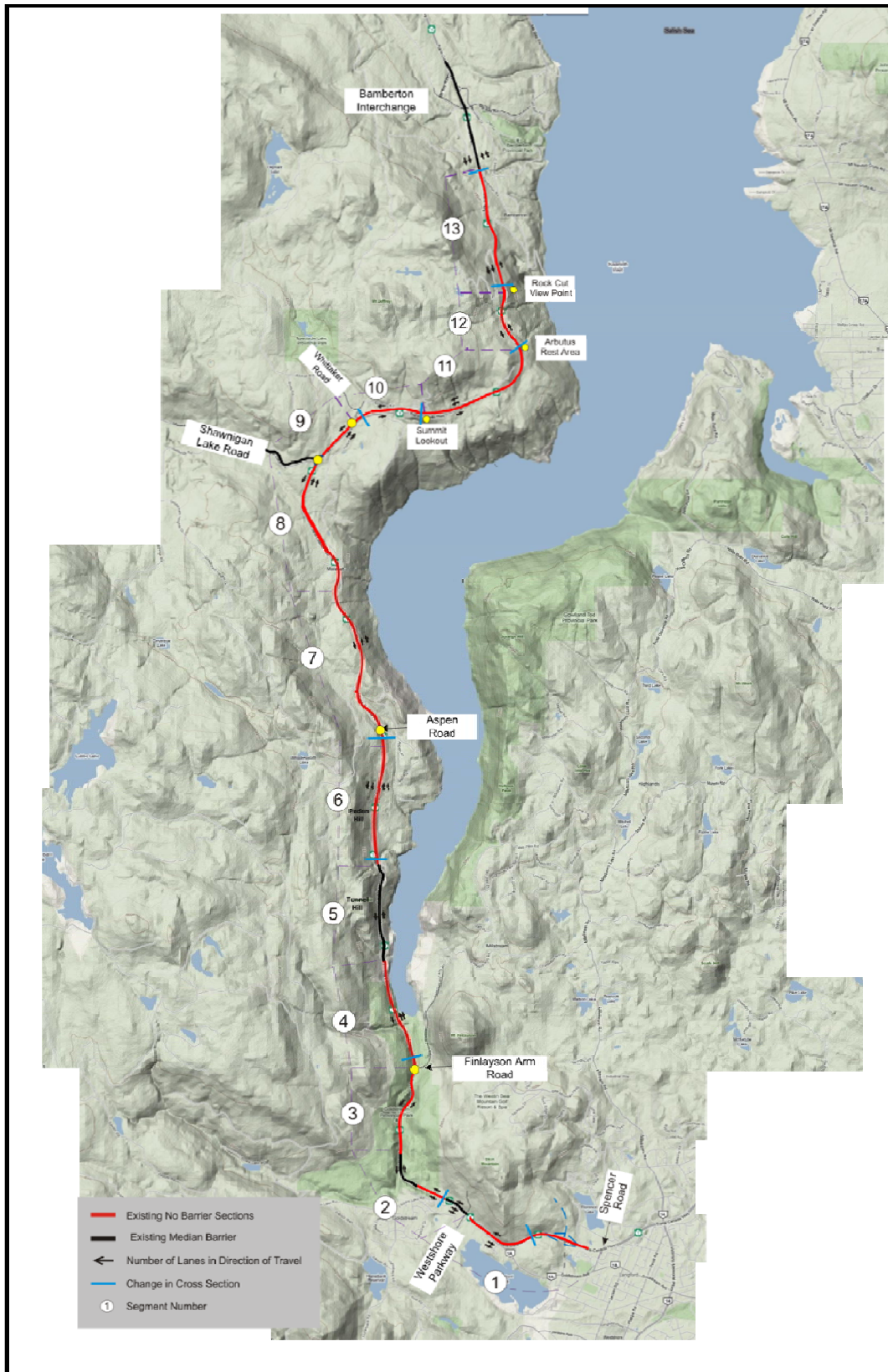


Figure 2: Existing conditions along review corridor

5.1. SEGMENT 1: SPENCER ROAD TO WEST SHORE PARKWAY

Existing Conditions

As previously mentioned, this segment is outside the limits of the Malahat but has been included as part of the review since it is the only undivided section of Highway No. 1 south of the Malahat. This section of Highway No. 1 transitions from a 4-lane highway to a 3-lane highway with one northbound lane and two southbound lanes. Existing median barrier is provided on the north approach of the Spencer Road intersection but terminates approximately 400 m from the new Leigh Road Overpass. The total length of this segment is 2.3 km.

Safety Performance Measures and Benchmarks

Safety Performance Measures

- Collision Frequency on the Segment = 13.0 collisions per year
- Collision Rate on the Segment = 0.53 collisions per MVKm
- Collision Severity index (CSI) = 5.29

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.54 collisions per MVKm
- Critical Collision Rate = 0.62 collisions per MVKm
- Provincial Average CSI = 6.65

Assessment

Even though the safety performance measures indicate that this segment is operating at a level at or better than Provincial benchmarks, the installation of concrete median barrier in the Leigh road interchange area in the short term could be considered as it is an area that is already wide enough to accommodate median barrier with little environmental and or geographic constraints.

Recognizing that the remainder of this section is located in a narrow corridor with significant rock bluffs on each side, installing median barrier on the remainder of this section may be considered in the longer term.

5.2. SEGMENT 2: WEST SHORE PARKWAY TO MEDIAN BARRIER

Existing Conditions

This section of the Malahat is primarily a two-lane highway with one lane of travel in each direction. Approximately 1.0 km of concrete median barrier is provided at the start and end of this section with the exception of a 400 m gap north of Sooke Lake Road. The total length of this Segment 2 is 1.45km.

Safety Performance Measures and Benchmarks

Safety Performance Measures

- Collision Frequency on the Segment = 4.60 collisions per year
- Collision Rate on the Segment = 0.41 collisions per MVKm
- Collision Severity index (CSI) = 4.72

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.32 collisions per MVKm
- Critical Collision Rate = 0.41 collisions per MVKm
- Provincial Average CSI = 7.17

Assessment

The collision rate for this segment is somewhat higher than the provincial average safety performance benchmarks. This appears to be attributable to congestion, as evidenced by a high proportion of rear-end type collisions. This is also supported by a severity index lower than the provincial average, which is characteristic of lower speed congestion incidents.

It is also noted that a previous history of collisions at Sooke Lake Road has been addressed with the subsequent closure at Highway 1 over the past two years.

Consideration may be given to the installation of median barrier in the short term to provide a continuous stretch of median barrier within this segment. This will improve safety by significantly reducing the potential for cross over type collisions, and will also eliminate two existing barrier ends. Longer term improvements could include widening of the roadway and the installation of concrete roadside barrier.

5.3. SEGMENT 3: MEDIAN BARRIER TO FINLAYSON ARM ROAD

Existing Conditions

This segment of the Malahat is an existing two-lane section through the Goldstream Provincial Park. An existing unsignalized T-Intersection is located at Finlayson Arm Road that provides access to and from the park. A southbound left turn lane is provided at Finlayson Arm Road. A moderate horizontal curve exists south of the Finlayson Arm Road intersection. The segment has no existing median barrier. The alignment is constrained by a rock bluff on the west and a creek on the east making construction challenging through this segment. The total length of this segment is 1.48 km.

Safety Performance Measures and Benchmarks

Safety Performance Measures

- Collision Frequency on the Segment = 9.70 collisions per year
- Collision Rate on the Segment = 0.80 collisions per MVKm
- Collision Severity index (CSI) = 6.10

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.32 collisions per MVKm
- Critical Collision Rate = 0.41 collisions per MVKm
- Provincial Average CSI = 7.17

Assessment

As the main entrance to Goldstream Provincial Park, the Finlayson Arm intersection attracts a substantial amount of traffic. The relatively poor safety performance for this segment appears to be largely attributed to Finlayson Arm intersection, however there have also been a considerable number of 'off road right' type accidents which are more typical of highway segments with challenging vertical and horizontal alignments.

In order to address the relatively high collision rate within this segment, consideration could be given to enhancing the Finlayson Arm intersection, which is the main entrance to the park, by construction of acceleration and deceleration lanes and the installation of a flashing beacon with street lights.

Providing median barrier within this segment would be challenging in the short term and other options such as the installation of inlaid pavement markings along the paint markings could be considered to enhance delineation and improve safety.

In the longer term, improvement options could include the construction of a Protected-T intersection at Finlayson Arm Road to assist the left-out movements as well as installation of median barrier though it is recognized that construction in this area has environmental and geotechnical constraints due to Goldstream creek and high rock bluffs.

5.4. SEGMENT 4: FINLAYSON ARM ROAD TO MEDIAN BARRIER

Existing Conditions

This segment of the Malahat is an existing three-lane section with no median barrier. There are two northbound lanes and one southbound lane. The total length of this segment is 1.33 km.

Safety Performance Measures and Benchmarks

Safety Performance Measures

- Collision Frequency on the Segment = 1.80 collisions per year
- Collision Rate on the Segment = 0.16 collisions per MVKm
- Collision Severity index (CSI) = 5.00

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.32 collisions per MVKm
- Critical Collision Rate = 0.41 collisions per MVKm
- Provincial Average CSI = 7.17

Assessment

Even though the safety performance measures indicate that this section currently exceeds provincial benchmarks, the installation of concrete median barrier in the short term is considered a proactive measure to prevent any future incidents, reduce closure frequencies and thereby enhance the reliability of the corridor. Median barrier along this segment also provides improved continuity by connecting to the existing Tunnel Hill barrier to the north.

To achieve this in the short term, the highway cross-section could be reconfigured from a three-lane section to a two-lane section (single lane northbound, single-lane southbound) from Finlayson Arm Road to the start of the existing concrete median barrier to the north. It is noted that beyond this section there is approximately 10 km of 'two-lane' northbound highway which will provide ample opportunity for passing in a divided (median barrier present) highway environment. This short term improvement will reduce the potential consequences of aggressive driving/passing manoeuvres in this undivided section.

Longer term improvements could include widening of the roadway to add an additional northbound lane and the installation of concrete roadside barrier where appropriate.

5.5. SEGMENT 5: MEDIAN BARRIER TO END OF MEDIAN BARRIER

Existing Conditions

Segment 5, also known as Tunnel Hill, is an existing three-lane section with two northbound lanes and one southbound lane. Median barrier exists within this segment. The total length of segment 5 is 2.01km.

Safety Performance Measures and Benchmarks

Safety Performance Measures

- Collision Frequency on the Segment = 4.80 collisions per year
- Collision Rate on the Segment = 0.30 collisions per MVKm
- Collision Severity index (CSI) = 8.88

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.32 collisions per MVKm
- Critical Collision Rate = 0.40 collisions per MVKm
- Provincial Average CSI = 7.17

Assessment

The crash severity for this segment is higher than the provincial average. The north end of the Tunnel Hill section where the southbound lanes merge into one lane has been identified as a area of concern due to the long merge section before a horizontal curve Safety improvements could include a redesign to provide better guidance to southbound traffic, eliminate driver confusion and reduce merge speeds. Longer term improvements could include widening of the roadway to provide additional width for the southbound lane and the installation of concrete roadside barrier where appropriate.

5.6. SEGMENT 6: END OF MEDIAN BARRIER TO ASPEN ROAD

Existing Conditions

Segment 6 is the only four-lane section of the Malahat with two lanes per direction. There is no median barrier within this segment however the median is already sufficiently wide to allow for barrier installation for the majority of the segment with the exception of 500m which will require widening. The total length of Segment 6 is 2.06 km.

Safety Performance Measures and Benchmarks

Safety Performance Measures

- Collision Frequency on the Segment = 5.1 collisions per year
- Collision Rate on the Segment = 0.32 collisions per MVKm
- Collision Severity index (CSI) = 8.41

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.32 collisions per MVKm
- Critical Collision Rate = 0.40 collisions per MVKm
- Provincial Average CSI = 7.17

Assessment

A higher than average collision severity index is a result of two fatalities that have occurred in this location during the January 01 2002 to December 31 2011 study period, which involved motorcycles that crashed in the area of the attenuator at the end of the median barrier. This location is also characterized by a lane drop (two lanes to one) in the southbound direction.

The extension of the concrete median barrier north to Aspen Road would be an effective measure to reduce incidents and could help to reduce the existing conflict between aggressive passing manoeuvres at the lane drop and the existing barrier termination point for the southbound direction. Similar to other segments, minimizing the potential for incidents would also serve to enhance the overall reliability of this corridor segment.

Longer term improvements could include the installation of concrete roadside barrier and intersection improvements at Aspen Road.

5.7. SEGMENT 7: ASPEN ROAD TO PETRO CANADA ACCESS

Existing Conditions

Segment 7 is an existing three-lane section with two northbound lanes and one southbound lane. There is no median barrier within this segment. The west side of the highway currently abuts an existing rock bluff approximately 20 m high. In addition, the rock bluff is located on the inside of a horizontal curve slightly restricting the sight distance for southbound traffic. The total length of Segment 7 is 2.19 km.

Safety Performance Measures and Benchmarks

Safety Performance Measures

- Collision Frequency on the Segment = 2.10 collisions per year
- Collision Rate on the Segment = 0.12 collisions per MVKm
- Collision Severity index (CSI) = 9.14

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.32 collisions per MVKm
- Critical Collision Rate = 0.39 collisions per MVKm
- Provincial Average CSI = 7.17

Assessment

The severity index is elevated within this segment due to the combination of a relatively low collision rate and the occurrence of a fatal incident.

The installation of median barrier in the short term along this segment would be challenging due to the existing rock bluff and geographic constraints. However, other safety improvements such as enhanced delineation and signing could be considered to mitigate cross over collisions in the short term with the long term strategy including the installation of median and roadside barrier.

5.8. SEGMENT 8: PETRO CANADA ACCESS TO SHAWNIGAN LAKE ROAD

Existing Conditions

Segment 8 is an existing three-lane section with two northbound lanes and one southbound lane. There is no median barrier within this segment. The total length of this segment is 2.25 km.

There are several accesses located within this segment primarily providing access to the Malahat Village on the east side of the highway. The Malahat Village includes a Petro Canada gas station and the Malahat Mountain Inn restaurant and hotel. On the west side of the highway and across from the Petro Canada gas station is an access to the KOA Campground. Further north an access is provided to the Malahat Mountain Meadows Resort.

The entrance is located on the inside of a sharp horizontal curve and may be obstructed by vegetation. There is no deceleration facility for the northbound right turn movement and traffic needs to reduce speed significantly in order to successfully turn into the gas station thus increasing the probability for rear-end collisions to occur.

A designated U-Turn route for northbound traffic to access properties on the west side of the highway is provided at McCurdy Road. This U-Turn route requires northbound traffic to make the right-in and left-out movements which are not desirable.

Safety Performance Measures and Benchmarks

Safety Performance Measures

- Collision Frequency on the Segment = 8.30 collisions per year
- Collision Rate on the Segment = 0.45 collisions per MVKm
- Collision Severity index (CSI) = 7.72

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.32 collisions per MVKm
- Critical Collision Rate = 0.39 collisions per MVKm
- Provincial Average CSI = 7.17

Assessment

Within the Malahat Village portion of this segment, a slightly higher collision rate and severity index is primarily attributable to the high level of access on this segment and the movements associated with the access locations. Safety improvement strategies for consideration may include access management/consolidation, the construction of acceleration and deceleration lanes and improved signage and sight distances at the existing Petro Canada access.

Other highway safety improvement strategies may include the installation of median barrier in combination with Protected-T intersection improvements to assist the left-in and left-out

movements. A review of potential U-Turn facilities could be included as part of a median barrier assessment.

5.9. SEGMENT 9: SHAWNIGAN LAKE ROAD TO WHITTAKER ROAD

Existing Conditions

Segment 9 is an existing three-lane section with two northbound lanes and one southbound lane. There is no median barrier within this segment. The total length of this segment is 0.85km. There are two unsignalized stop-controlled T-intersection located at Shawnigan Lake Road and Holker Place.

An existing overhead flashing beacon is installed at the Shawnigan Lake Road intersection. The eastbound right-turn movement from Shawnigan Lake Road to the Malahat Highway is channelized and yield-controlled, though it intersects the highway at a fairly flat angle and motorists may have difficulty seeing traffic approaching from the north.

The existing Holker Place intersection is slightly hidden from the approaching highway traffic (northbound and southbound) due to a slight vertical crest curve and vegetation. It also lacks a northbound deceleration facility thus motorists have to reduce speed significantly in the slow lane before turning right into Holker Place.

Safety Performance Measures and Benchmarks

Safety Performance Measures

- Collision Frequency on the Segment = 2.20 collisions per year
- Collision Rate on the Segment = 0.34 collisions per MVKm
- Collision Severity index (CSI) = 5.09

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.32 collisions per MVKm
- Critical Collision Rate = 0.44 collisions per MVKm
- Provincial Average CSI = 7.17

Assessment

The safety performance along this segment is relatively consistent with the provincial average safety performance benchmarks, although the collision severity index is performing better than average.

Safety improvements for consideration in the short term could include intersection upgrades to the Shawnigan Lake Road intersection by providing a southbound right turn acceleration lane. Longer term improvements could include the installation of median and roadside barrier, roadway widening, the construction of a Protected-T intersection at Shawnigan Lake Road and upgrades to the Holker Place intersection.

5.10. SEGMENT 10: WHITTAKER ROAD TO SUMMIT LOOKOUT

Existing Conditions

Segment 10 is an existing two-lane section with one lane in each direction. There is no median barrier within this segment. The total length of this segment is 1.14km.

Whittaker Road is an unsignalized stop controlled intersection located on the west side of the highway. There is an existing northbound left turn lane and southbound right turn deceleration lane. The right turn movement from Whittaker Road to the Malahat Highway is yield-controlled, though it intersects the highway at a fairly flat angle and motorists may have difficulty seeing traffic approaching from the north.

Safety Performance Measures and Benchmarks

Safety Performance Measures

- Collision Frequency on the Segment = 2.50 collisions per year
- Collision Rate on the Segment = 0.26 collisions per MVKm
- Collision Severity index (CSI) = 4.60

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.32 collisions per MVKm
- Critical Collision Rate = 0.42 collisions per MVKm
- Provincial Average CSI = 7.17

Assessment

This segment is operating at an acceptable level of safety and no immediate short term improvements are suggested. However, long term safety improvements could include the installation of concrete median and roadside barrier, the construction of an additional northbound lane to increase the total number of lanes to three through this segment and intersection improvements at Whittaker Road.

5.11. SEGMENT 11: SUMMIT LOOKOUT TO ARBUTUS REST AREA

Existing Conditions

Segment 11 is an existing three-lane section with two southbound and one northbound lane. There is no median barrier within this segment. The total length of this segment is 2.24km.

The Summit Lookout is located on the east side of the highway and provides a scenic view of the inlet. A separate entrance and exit is provided since there is not enough width to allow vehicles to turn around within the lookout and enter and exit the lookout from a common access. A right turn deceleration lane is provided at the entrance to the lookout for northbound traffic. The lookout exit intersects the highway at a fairly flat angle and motorists may have difficulty seeing traffic approaching from the south when exiting the lookout. The lookout area is separated from the highway with a concrete roadside barrier and is not accessible to southbound traffic. Immediately across from the lookout on the west side of the highway is a high rock bluff that will increase the costs of improvements in this area.

Safety Performance Measures and Benchmarks

Safety Performance Measures

- Collision Frequency on the Segment = 2.60 collisions per year
- Collision Rate on the Segment = 0.15 collisions per MVKm
- Collision Severity index (CSI) = 12.08

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.32 collisions per MVKm
- Critical Collision Rate = 0.39 collisions per MVKm
- Provincial Average CSI = 7.17

Assessment

Although not considered a collision prone location based on the collision rate, the collision severity index of over 12 reflects the occurrence of two fatal type collisions along this segment. A significant number of collisions are also attributed to the access and egress of the Summit lookout particularly by southbound traffic.

Safety improvements for consideration within this segment include improving channelization at the viewpoint to prevent the left-in and left-out movements to and from the Summit Lookout.

The Ministry may also want to consider exploring further options at the Summit Lookout, Arbutus Rest Area and Rock Cut Viewpoint to determine appropriate access management strategies for all three sites or the amalgamation of the three sites into one or more improved sites. Longer term considerations could include widening the roadway to install concrete median barrier, though the installation of median barrier along this segment will be challenging due to the existing rock bluff.

5.12. SEGMENT 12: ARBUTUS REST AREA TO ROCK CUT VIEWPOINT

Existing Conditions

Segment 12 is an existing two-lane section with one lane in each direction. There is no median barrier within this segment. The total length of this segment is 0.76km.

The Arbutus Rest Area is located on the east side of the highway. A separate entrance and exit is provided since there is not enough width to allow vehicles to turn around within the rest area and enter and exit the rest area from a common access. A right turn deceleration lane is provided at the entrance to the rest area for northbound traffic although this is not well defined. The rest area exit intersects the highway at a fairly flat angle and motorists may have difficulty seeing traffic approaching from the south when exiting the rest area.

The rest area is separated from the highway with a concrete roadside barrier and is not accessible to southbound traffic. Immediately across from the rest area on the west side of the highway is a rock bluff that will increase the challenges of providing improvements in this area.

Safety Performance Measures and Benchmarks

Safety Performance Measures

- Collision Frequency on the Segment = 2.80 collisions per year
- Collision Rate on the Segment = 0.43 collisions per MVKm
- Collision Severity index (CSI) = 12.89

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.32 collisions per MVKm
- Critical Collision Rate = 0.44 collisions per MVKm
- Provincial Average CSI = 7.17

Assessment

Both the collision rate and the collision severity are worse than provincial average safety performance benchmarks. The higher collision severity index is primarily attributable to the left-in and left-out movements to and from the Arbutus Rest Area and to cross over incidents.

Safety improvements for consideration within this segment could include eliminating the left-in and left-out movements to and from the Arbutus Rest Area.

Similar to the Summit Lookout to Arbutus Rest Area segment, the Ministry may also want to consider exploring further options at the Summit Lookout, Arbutus Rest Area and Rock Cut Viewpoint to determine appropriate access management strategies for all three sites or the amalgamation of the three sites into one or more improved sites. The installation of median barrier along this segment, roadway widening and the construction of an additional northbound lane to

increase the total number of lanes to three through this segment and intersection could be considered as part of a long term strategy.

5.13. SEGMENT 13: ROCK CUT VIEWPOINT TO MEDIAN BARRIER

Existing Conditions

Segment 13 is an existing three-lane section with one northbound and two southbound lanes. There is no median barrier within this segment. The total length of this segment is 1.83km.

The Rock Cut Viewpoint is located at the south end of this segment on the east side of the highway. A separate entrance and exit is provided since there is not enough width to allow vehicles to turn around within the viewpoint and enter and exit the viewpoint from a common access. A right turn deceleration lane is provided at the entrance to the rest area for northbound traffic. The rest area exit intersects the highway at a fairly flat angle and motorists may have difficulty seeing traffic approaching from the south when exiting the rest area.

The rest area is separated from the highway by an existing rock bluff that is likely a remnant of the through cut created when the highway was constructed. Immediately across from the viewpoint on the west side of the highway is a high rock bluff that pose significant challenges to short term improvements.

The alignment through this section consists of a northbound left hand horizontal curve that is delineated with chevron warning signs in both directions.

Safety Performance Measures and Benchmarks

Safety Performance Measures

- Collision Frequency on the Segment = 5.00 collisions per year
- Collision Rate on the Segment = 0.22 collisions per MVKm
- Collision Severity index (CSI) = 4.78

Provincial Safety Benchmarks

- Provincial Average Collision Rate = 0.32 collisions per MVKm
- Critical Collision Rate = 0.38 collisions per MVKm
- Provincial Average CSI = 7.17

Assessment

The safety performance of this section of roadway is significantly better than the provincial average; however the Rock Cut Viewpoint area has a history of crashes. Safety improvements for consideration within this segment may include implementing channelization to prevent the left-in and left-out movements to and from the Rock Cut Viewpoint.

As mentioned previously, the Ministry may also want to consider exploring further options at the Summit Lookout, Arbutus Rest Area and Rock Cut Viewpoint to determine appropriate access management strategies for all three sites or the amalgamation of the three sites into one or more improved sites. The installation of median barrier along this segment will be challenging due to the physical constraints of the rock bluffs and steep slopes but may be a consideration in the long term.

5.14. CORRIDOR WIDE IMPROVEMENTS

In addition to the individual segment improvements that have been identified, there are a number of corridor wide improvements that the Ministry may want to consider. These include the installation of enhanced delineation such as roadside delineators and improved paint markings throughout the corridor; the installation of high tech advance weather warning systems at key locations; improving sightlines, and assessing and performing a safety review of all the accesses and driveways along the corridor.

A comprehensive needs assessment of U-Turn facilities along the corridor could also be performed in combination with median barrier placement on the various segments. It is critical for both emergency response and corridor reliability that appropriate facilities are provided to ensure that emergency vehicles do not become blocked by incidents within divided sections of the corridor.

6.0 CONCLUSION

Collision data along the corridor and on a segment by segment basis were analyzed and compared to Provincial safety averages or benchmarks to determine how the corridor is performing. These safety measures were then used to identify both short and long term safety improvements along individual segments and corridor wide based as discussed in **Section 5.0** of the report. The short term improvements are effective measures that can be implemented within a one to two year time horizon, whereas the suggested long term improvements may need to address environmental or other constraints, are larger scale and would require more detailed analysis.

In summary the short term improvements that the Ministry may want to consider include the following:

- Installation of concrete median barrier in areas of relatively less challenging construction constraints;
- Safety improvements at key intersections such as Finlayson Arm Road and Shawnigan Lake Road and the Malahat Village area, Summit Lookout, Arbutus Rest Area and Rock Cut View Point ;
- Installation of enforcement pullouts;
- Enhanced signing and delineation along the corridor.

In the long term it is recommended that the Ministry consider:

- Further barrier installation at priority locations from a safety and reliability perspective;
- Further intersection improvements at Finlayson Arm and other priority intersections along the corridor; and
- Further access management strategies, particularly on the section between Summit Lookout and the Rock Cut Viewpoint.

APPENDIX A: SAFETY PERFORMANCE MEASURES AND BENCHMARKS

1.0 Safety Performance Measurement

The safety performance of the Malahat corridor was evaluated using the historical collision records for the corridor. Several safety performance measures are used to assess the corridor as presented below.

1.1 The Collision Frequency Measure

The collision frequency measure (CF) is a very simple safety performance measurement that is defined as the number of collisions per location during a specific time period. The CF measure is usually expressed as collision per year (coll./yr), as shown in the formula in equation 1 below and is typically separated into collision severity categories (i.e., fatal collisions, injury collisions or property damage only (PDO) collisions).

$$C_F = \frac{N_C}{T} \quad \text{Equation (1)}$$

Where: N_C = Number of collisions (collisions)
 T = Observed time period (years)

Proponents of using the collision frequency measure to identify collision prone locations argue that locations identified by this method have a high number of collisions and therefore, these locations have a higher risk than other locations with fewer collisions. However, the problem with using the frequency method is that it does not account for the effect of traffic exposure. For example, a location that has 10 collisions per year may be considered 'high' for a section of highway that carries 5,000 vehicles per day but it may be considered 'low' for another section of highway carrying 20,000 vehicles per day.

1.2 The Collision Rate Measure

The collision rate measure (C_R) is defined as collisions per million-vehicle-kilometers (MVKm) for highway sections ($C_{R(S)}$), given in equation (3) below and collisions per million entering vehicles (MEV) for intersections ($C_{R(I)}$), as shown in equation (4) below.

Segments:

$$C_{R(S)} = \frac{N_c \times 10^6}{L \times AADT \times T \times 365}$$

Equation (3)

Intersections:

□

$$C_{R(I)} = \frac{N_c \times 10^6}{AADT \times T \times 365}$$

Equation (4)

Where:

□

N_c = Number of collisions (collisions)

T = Observed time period (years)

L = Length of segment (kilometres)

$AADT$ = Average Annual Daily Traffic volume (vehicles per day)

The advantage of using collision rates is that it allows comparisons to be made between sites with similar characteristics but with different levels of exposure. However, although the use of CR addresses the exposure effect, it can introduce another bias in the identification of collision prone locations when applied to low volume roads. For example, it only takes a few collisions on a low volume road to produce a high collision rate. Another problem with the use of collision rates is the assumption of a linear relationship between collisions and traffic volume, which may not always be correct.

1.3 The Collision Severity Measure

A Collision Severity Index (CSI) is used as a measure of collision severity levels, which is defined as the weighted sum of fatal (F), injury (I), and property-damage-only (PDO) collisions, as shown in equation (5) below.

$$CSI = \frac{100 \times (F) + 10 \times (I) + 1 \times (PDO)}{(F) + (I) + (PDO)}$$

Equation (5)

Where:

□

F = Number of fatal collisions (collisions)

I = Number of injury collisions (collisions)

PDO = Number of property damage only collisions (collisions)

2.0 Safety Performance Benchmarks

Critical for the assessment of the safety performance is the comparison to reliable benchmarks of normal or expected safety performance. The following safety performance benchmarks are the most commonly used to determine the performance of a corridor.

2.1 Average Collision Rate

An average collision rate is simply an average of the calculated collision rates for a large group of similar locations that can be used as the basis for comparison. Typically, the average collision rates are generated by road classification (e.g., RAU2, UFD4, etc.) and further disaggregated by traffic volume level (e.g., 0 – 5000 vehicles per day, 5001 – 10,000 vehicles per day, etc.). The BC MoT's Collision Information System (CIS) is capable of generating average collision rates by road class and traffic volume level. A sample of some average collision rates (collision rate tables) for the BC MOT can be found at <http://www.th.gov.bc.ca/publications/planning/index.htm#safety>.

2.2 Critical Collision Rate

The critical collision rate (C_{CRIT}), which is based on statistical quality control procedures, has been the most widely used statistical technique among highway agencies to identify collision prone locations. The technique defines a location as collision prone if the observed collision rate exceeds a critical collision rate, which is based on the average collision rate. The formulation for C_{CRIT} is provided in equation 6 below.

$$C_{CRIT} = C_{AVE} + k \sqrt{\frac{C_{AVE}}{M} + \frac{1}{2M}} \quad \text{Equation (6)}$$

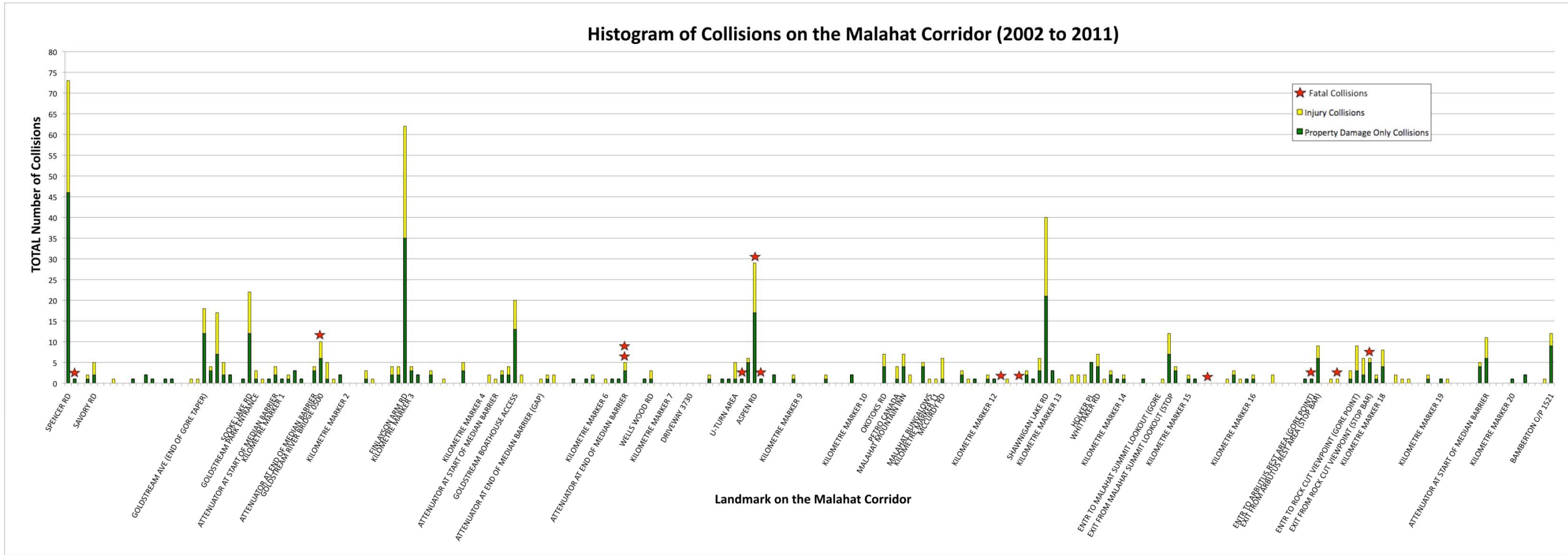
Where:

C_{AVE}	= Average collision rate (Coll/MVKm or MEV)
k	= A constant related to the level of significance (1.645)
M	= Traffic exposure (Coll/MVKm or MEV)

2.3 Average Collision Severity Index (CSI)

An average collision severity index is simply an average of the calculated collision severity indices for a large group of similar locations that can be used as the basis for comparison. Similar to average collision rates, the average CSI are often generated by road classification (e.g., RAU2, UFD4, etc.). The BC MoT's Collision Information System (CIS) is capable of providing the data necessary to produce the Average CSI for provincial highways.

APPENDIX B: HISTOGRAM OF COLLISIONS ALONG THE MALAHAT CORRIDOR



Appendix B: HISTOGRAM OF COLLISIONS ALONG THE MALAHAT CORRIDOR