Whitemud Drive Posted Speed Limit

Traffic Safety Assessment and Feasibility Analysis Report

Office of Traffic Safety, Transportation Services, City of Edmonton

Report Submitted to
Transportation Committee
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OFFICE of TRAFFIC SAFETY
EDMONTON, CANADA

List of Abbreviations

AE	Automated Enforcement
AHD	Anthony Henday Drive
CLI	Changing Lanes Improperly
dBA	Decibel A
EB	Eastbound Direction
FOTS	Failed to Observe Traffic Signal
FTC	Followed too Closely
Leq24	24-hour average Equivalent Continuous Sound Level
ME	Manned Enforcement
PDO	Property Damage Only
PL	Photo Laser
PR	Photo Radar
PSL	Posted Speed Limit
TAC	Transportation Association of Canada
UTNP	Urban Traffic Noise Policy
VDS	Vehicle Detection System
WB	Westbound Direction
WMD	Whitemud Drive
YHT	Yellowhead Trail

Executive Summary

At the August 21, 2013 Transportation Committee meeting, a request for a more detailed safety assessment and analysis of Whitemud Drive (WMD) for potential speed limit changes was assigned to the City of Edmonton's Office of Traffic Safety for review and evaluation. WMD is a main east to west freeway that serves as an important commuter route through the city of Edmonton from the city's eastern limit (0.8 kilometres (km) east of 17 Street) to its western limit (231 Street). Any change in the posted speed limit (PSL) will impact safety, mobility and accessibility for all road users. Therefore, a comprehensive analysis was conducted to determine the suitability of a PSL increase based on six factors: (1) segmentation of WMD, (2) transition zones, (3) collision, speed, volume and enforcement statistics, (4) road design, (5) noise and emission impact and (6) merging and exiting issues. Based on the outcome of this investigation, the Office of Traffic Safety does not recommend an increase in the 80 kilometres per hour (km/h) PSL on any segment along WMD, as it will negatively impact the safety of all road users. This report summarizes the traffic safety assessment and feasibility analysis for the WMD PSL.

In order to determine whether the PSL can be increased along any segment of the WMD, several factors were examined simultaneously: (1) collision distribution, (2) road design and (3) speed profile. For this analysis, WMD was divided into six zones based on collision frequency. Only one zone (17 Street, eastern city limit) had a collision profile that could support an increase in the PSL. However, this segment is too short (0.8 km) to warrant an independent speed zone. Additionally, there are road design constraints, such as sharp horizontal curves, vertical curves of overpasses and underpasses and closely-spaced interchanges, which do not support a PSL increase. Finally, the speed profile and speeding violations are spread out over the whole stretch of WMD. Therefore, no specific segments along WMD are suitable for a higher PSL.

There are current connectivity concerns that exist at the transition zones at the city's eastern and western boundaries, Township Road 522 and Highway 628, respectively. At the eastern city limit, WMD connects with Anthony Henday Drive (AHD) and then turns into Township Road 522. On the first section of WMD after the eastern city limit, drivers encounter vehicles entering and exiting AHD; this is followed by another section on which traffic is reduced to one lane and the PSL is lowered to 70 km/h prior to a signalized intersection. This creates a bottleneck that prevents upstream traffic flow, causing traffic queues and increasing the risk of collisions due to short vehicle gaps, abrupt lane changing and sudden stops. At the western section of WMD, the PSL is reduced from 80 to 70 km/h between 200 metres east of Guardian Road/207 Street and

200 metres west of Winterburn Road/215 Street[1] and then increases to 80 km/h until the western city limit. Additionally, in the western section, WMD is reduced from six lanes to one lane and turns into Highway 628. This change in road design causes a bottleneck with similar traffic safety concerns as the eastern transition section. If the PSL along WMD is increased, then these safety concerns will be further magnified as the speed gap between WMD and the transition sections will be wider.

Collision, speed, volume and enforcement data was collected and investigated. The collision analysis highlighted that the speed differential between WMD through lanes and WMD entrance/exit lanes will result in a high frequency of not only Followed too Closely (FTC) collisions on ramps but also Changing Lanes Improperly (CLI) collisions in the right curb lane. Raising the speed limit would increase the speed differential, and, therefore, increase the collision risk. Finally, a collision comparison among WMD, AHD and Yellowhead Trail (YHT) revealed that WMD experiences a higher collision level compared to similar roads: its intersection collision rate (collisions per million vehicles entering the intersection) is 3.6 times higher than AHD and 1.1 times higher than YHT, while the WMD midblock collision rate (collisions per million vehicle-kilometers) is 4.5 times higher than AHD and 1.4 times higher than YHT.

Speed statistics revealed that a large proportion of vehicles travel at speeds exceeding the PSL. Intuitively, the number of high-speed drivers will increase along with a higher speed limit, which tends to incur more severe injury and fatal collisions. Meanwhile, it is estimated that at a PSL of 100 km/h, the travel time would only be reduced by eight seconds/km compared to existing conditions. However, this calculation does not take into consideration the impact of queuing due to the wider speed differential, particularly between merging/exiting traffic and through lane traffic. Volume statistics indicated that a 10 km/h PSL increase would likely increase the traffic volume by 50 vehicles per lane per hour during peak hours. This insignificant increase would not be consistent throughout non-peak hours of the day. Additionally, speeding violations are widespread across the entire stretch of WMD, according to statistics from both automated enforcement (AE) by Photo Radar (PR) and Photo Laser (PL) and manned enforcement (ME) by the Edmonton Police Service.

If a PSL increase is authorized, then certain WMD segments must be redesigned and/or reconstructed. The horizontal curves north of Quesnell Bridge and south of 53 Avenue need to be realigned. The left-hand exiting ramp at Terwillegar Drive needs to be redesigned into a right-

[1] City of Edmonton, Speed Zone Bylaw No. 6894, Consolidated on May 22, 2013.

side exiting ramp; therefore, the ramp needs to be reconstructed. Moreover, closure of some entrances/exits is required to increase the spacing of interchanges from 91 Street to 111 Street, and several underpasses and vertical curves with limited sight distance at 106 Street and 111 Street need to be redesigned. These road design changes are essential to support an increase in the PSL, which will also involve extending the current property lines, which are already restricted by existing land-use developments. These changes can only be completed at extremely high costs, and, therefore, are not recommended.

Raising the current PSL will also have a negative impact on noise and vehicle emissions. Existing reports and studies show that the current noise level of many neighborhoods along WMD has already exceeded the normal range, and both noise levels (Decibel A [dBA]) and exhaust emission levels (grams per mile) will continue to increase if speed increases.

Merging and exiting concerns were identified from both road design and traffic operational aspects. First, a comparison between current design dimensions and guidelines showed that the current WMD acceleration lanes used for merging and deceleration lanes used for exiting must be extended to accommodate any speed limit increase. However, this extension is not recommended given the current property line constraints as well as acquisition and construction costs. Also, a traffic operational data analysis suggested that a higher PSL would widen the speed gap between WMD through lanes and ramps, which makes merging and exiting even more challenging and causes safety issues near on- and off-ramps due to abrupt braking and acceleration. Also, the future higher density of land use of urban areas along WMD requires more frequent entering, exiting and interweaving traffic and will cause more traffic congestion, and, as such, does not support higher speeds.

In conclusion, all assessments and data statistics from the perspectives of segregation, connectivity, collision and traffic operational data statistics, road design, noise and emission levels, merging/exiting concerns and future land-use developments support the recommendation that the current PSL of 80 km/h should be maintained throughout WMD.

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1 Introduction

On May 15, 2013, the Transportation Committee requested a review of the existing posted speed limit (PSL) along the Whitemud Drive (WMD) corridor. Transportation Services conducted a preliminary analysis and recommended that the speed limit remain as posted; the results were summarized in the CR_238 report and were discussed at the August 21, 2013 meeting. However, the Transportation Committee requested a more detailed safety assessment and analysis of WMD for potential speed limit changes. This request was assigned to the Office of Traffic Safety for review and evaluation.

The analysis was expected to address six factors:

- Identify WMD corridors with the potential for PSL changes
- Transition zones
- Spatial and temporal speed, volume, enforcement and collision statistics
- Road design concerns related to potentially changing the PSL
- Noise and emission impact
- Merging and exiting issues

The following report describes the traffic safety assessment that was conducted to determine the feasibility of increasing the PSL along WMD. The potential segmentation of WMD is discussed in the second chapter. The third chapter summarizes the concerns associated with transition zones. The collision, speed, volume and enforcement analyses are summarized in chapter four. The fifth chapter provides an overview of the road design concerns that need to be addressed prior to increasing the PSL. Noise and emission levels, as well as merging and exiting issues are discussed in the sixth and seventh chapters, respectively. Based on all of these aspects, the conclusion and final recommendations are summarized in the eighth and final chapter.

2 Whitemud Drive Segmentation

This chapter summarizes the identification of segments along WMD that are candidates for potential speed limit changes. This segregation was investigated based on (1) collision distribution, (2) road design and (3) speed profile.

2.1 Segregating WMD Based on Collision Analysis

The collision analysis gave five results:

- Collisions were widely distributed along the entire stretch of WMD from 17 Street to 231 Street (see more details in Figure A-1 and Table A-1, Appendix A.1, page 34);

- Based on different collision frequencies (the number of collisions from 2010 to 2012 per km), WMD was divided into six zones. Figure 1 shows the zoning pattern:
    - Zone A, the section of WMD from 99 Street to Quesnell Bridge, with extremely high collisions (200 collisions/km)
    - Zone B, the section of WMD from 66/75 Street to 99 Street (Zone B-1) and the section of WMD from Quesnell Bridge to 170 Street (Zone B-2), with intermediately high collisions (130 to 140 collisions/km)
    - Zone C, the section of WMD from 17 Street to 66/75 Street (Zone C-1) and the section of WMD from 170 Street to the western city limits (Zone C-2), with mildly high collisions (40 to 80 collisions/km)
    - Zone D, the section of WMD from 17 Street to the eastern city limits, with relatively low collisions compared to other zones (5 collisions/km)

- Zone A has an extremely high collision frequency;

- Although Zones B and C have fewer collisions compared to Zone A, these collision frequencies are still high; therefore, increasing the PSL is not recommended in these zones; and

- Only Zone D has lower collision frequencies compared to other zones. However, since the segment length is short (0.8 km), it does not warrant an independent speed zone.

More details regarding the segregation of WMD with respect to the collision distribution is summarized in Appendix A.

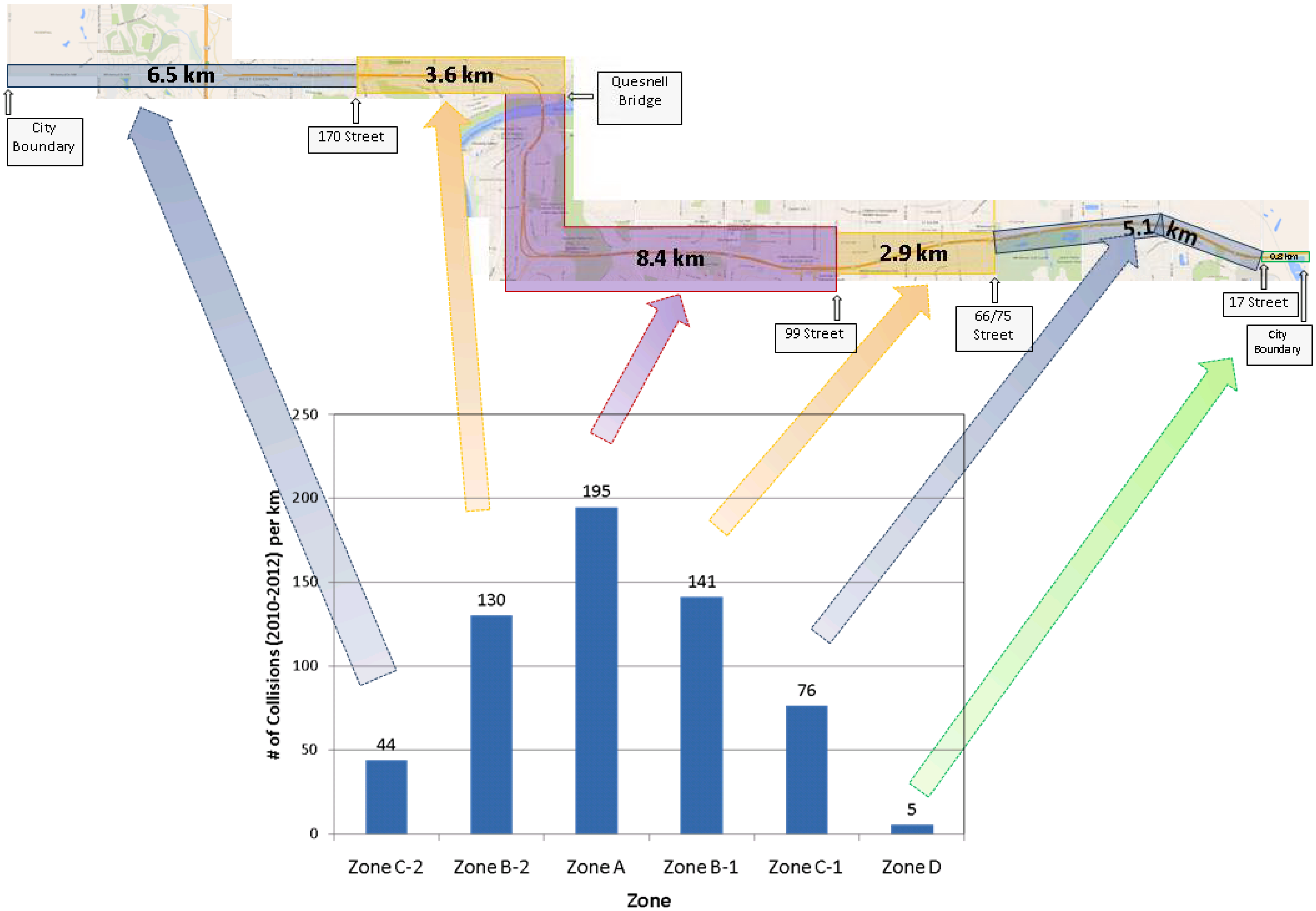


Figure 1 Segmentation of WMD Based on Collisions

2.2 Segregating WMD Based on Road Design

Figure 2 reveals that certain segments along WMD have road design constraints that do not support a PSL increase:

- From its eastern stretch, WMD is separated by consecutive left-hand and right-hand horizontal curves along with upgrade and downgrade vertical slopes at diamond interchanges from 17 Street to 50 Street;

- WMD is frequently separated by interchanges with very close spacing from 91 Street to 111 Street, in addition to constrained vertical curves limiting drivers' sight distance at several underpasses, such as those at 106 Street and 111 Street;

- WMD includes a sharp curve and left-hand exiting ramp at Terwillegar Drive; and

- WMD has sharp horizontal curves north of Quesnell Bridge and south of 53 Avenue.

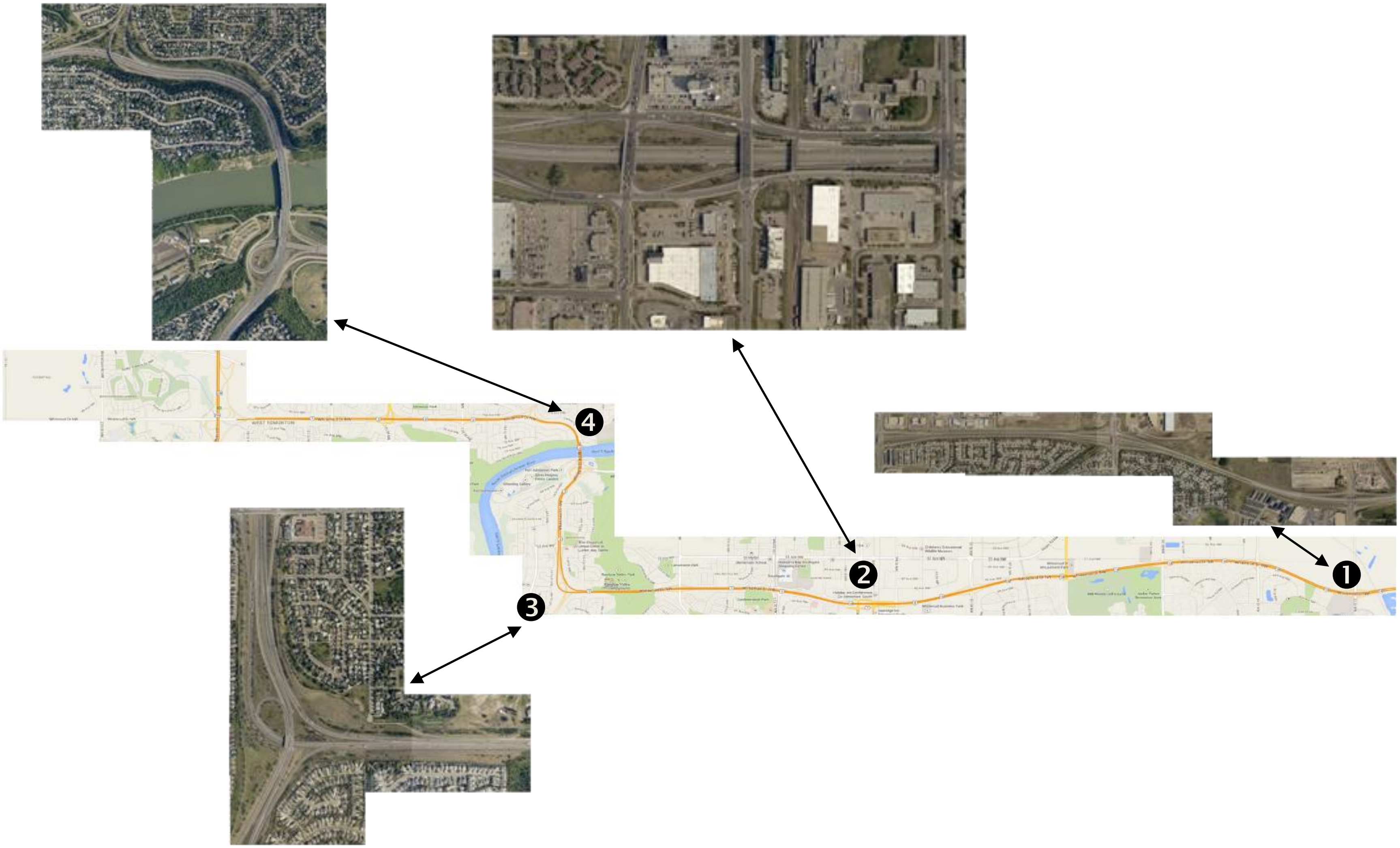


Figure 2 Segmentation of WMD Based on Road Design Constraints

2.3 Segregating WMD Based on Speed Profile and Enforcement

Speed Profile

To analyze the speed profile along WMD, two data sources were used: the Vehicle Detection System (VDS), which consists of permanently installed dual loops, and the NC200s, which are metallic plates that are temporarily installed on the road. Figure 3 shows each site location where data was collected for the purpose of this analysis. Figure 4 shows the spatial distribution of mean speeds from both sources along WMD and illustrates the fluctuation of speeds along different segments of WMD.

In all instances, except for three approaches, the mean speeds were over the 80 km/h PSL. The few segments with relatively lower speeds are preceded with sections with mean speeds above the PSL and are too short to be considered as independent speed zones. The Canadian Guidelines for Establishing Posted Speed Limits recommends the minimum length of a speed zone to be one km if the PSL is 70 km/h or higher. The Geometric Design Guide for Canadian Roads[2] emphasizes the principle that the PSL should be consistent with prevailing topographical and development conditions and subject to reasonable enforcement. Therefore, none of the segments along WMD are candidates for a PSL increase.

[2] Transportation Association of Canada (TAC), 2009

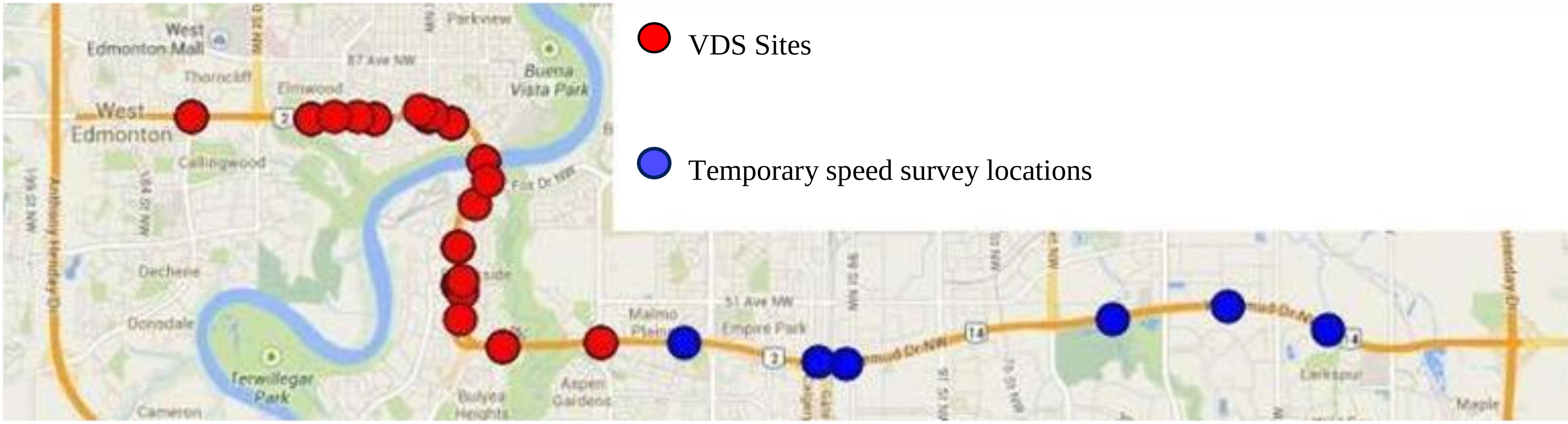
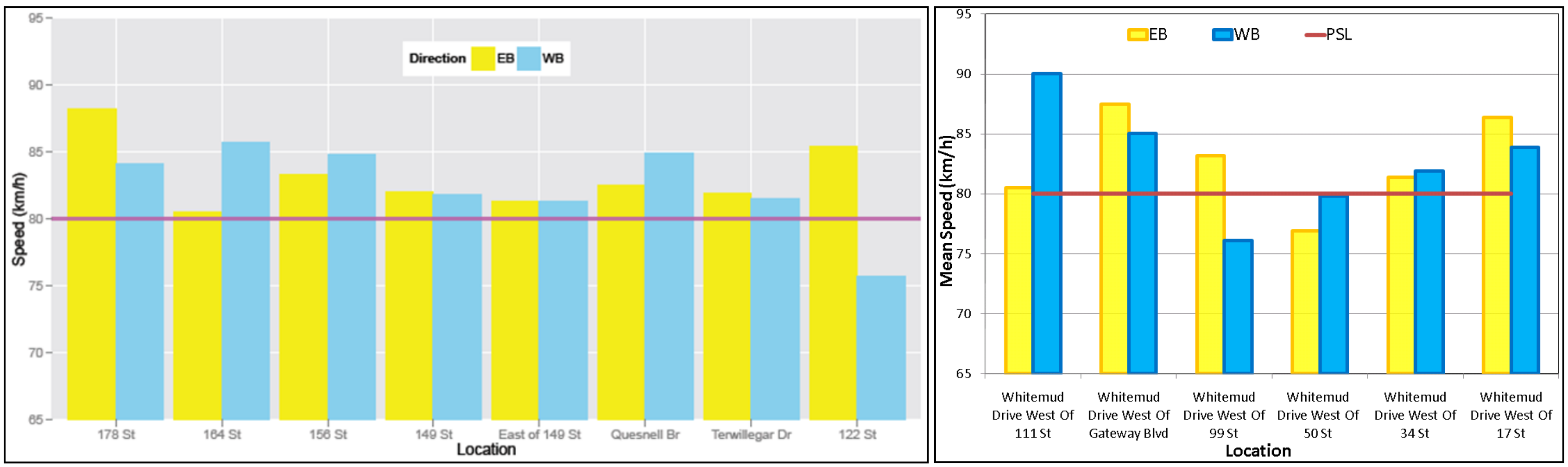


Figure 3 VDS Sites and Temporary Speed Survey Locations along WMD

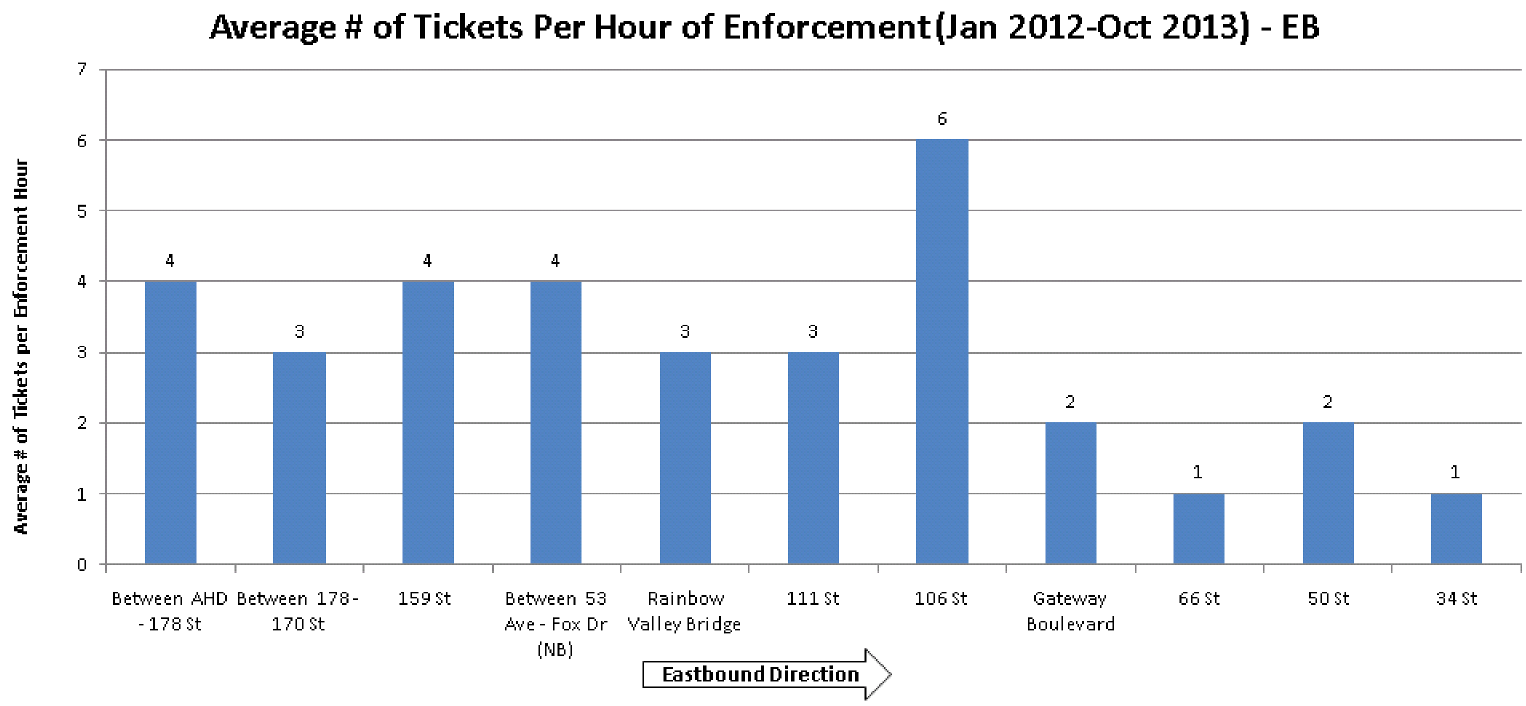


(a) VDS Speed Survey Data (b) Temporary Speed Survey

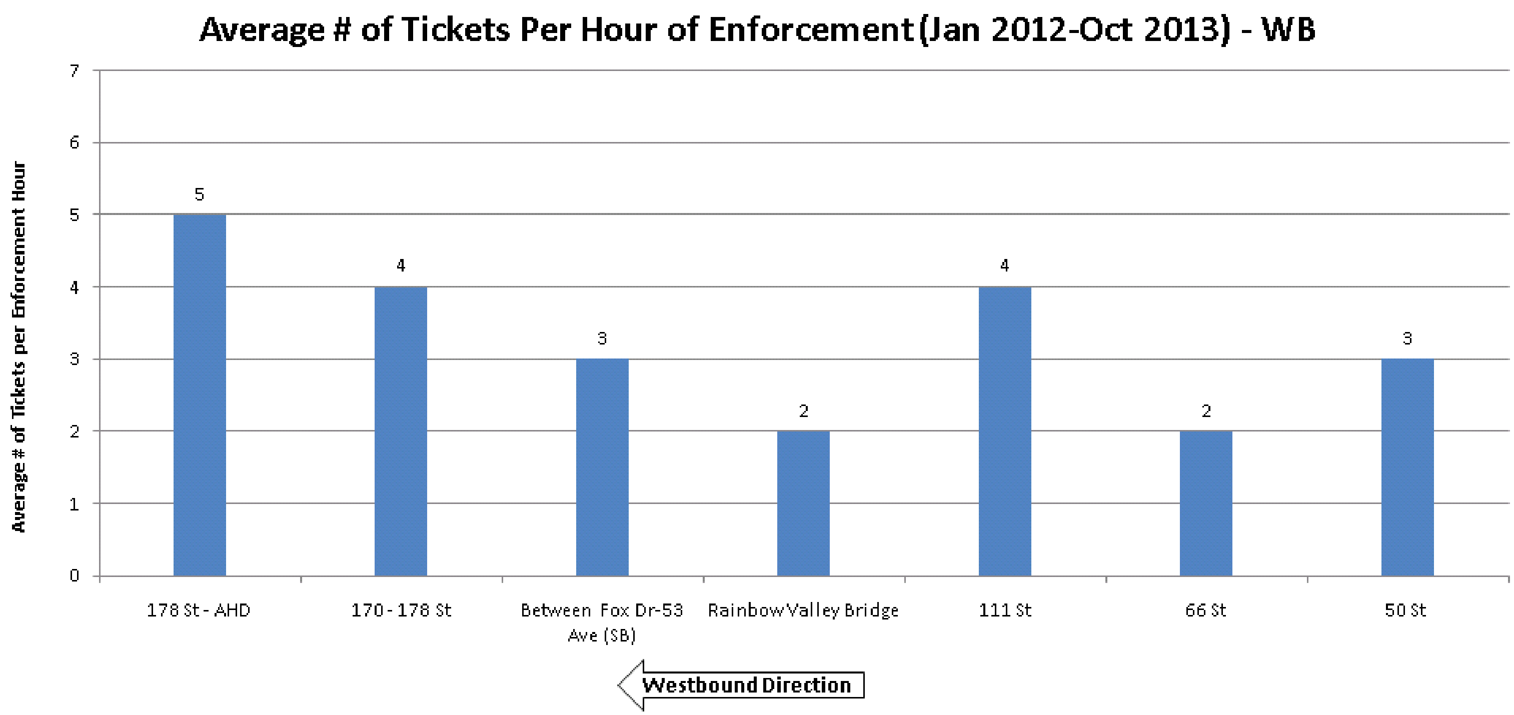
Figure 4 Segmentation of WMD Based on Speed

Speed Enforcement

Figure 5 shows the spatial distribution of speeding violations along WMD caught by automated enforcement (AE) using Photo Radar (PR) for each hour of enforcement.



(a) Eastbound Direction (EB)



(b) Westbound Direction (WB)

Figure 5 Average Number of Speeding Tickets per Hour of Enforcement

The average number of speeding tickets issued is three per each hour of enforcement. Although some sites have a higher number of tickets issued per hour, the speeding concern is widespread along the entire WMD, as evident from Figure 5.

2.4 Summary

The results of the analysis determined that the PSL cannot be increased along any section of the WMD and that all of the findings support keeping the PSL at the current speed of 80 km/h:

- The collisions were distributed throughout the whole stretch of WMD, suggesting that no segregated corridors would be suitable for a PSL increase;

- The road design along the WMD consists of sharp horizontal curves, vertical curves of overpasses and underpasses and closely-spaced interchanges. Only two short segments close to the western and eastern city boundaries could be appropriate for a higher PSL, but they are too short and the subsequent connections have PSLs of either 80 km/h or lower; and

- The speeding violations are spread out over the whole stretch of WMD and the mean speed of vehicles was almost always above the PSL; therefore, no specific segment along the corridor is suitable for a higher speed limit.

3 Transition Zones

WMD is a main east to west freeway that serves as an important commuter route through the city of Edmonton from its eastern to western limits. It is connected to the Anthony Henday Drive (AHD) highway and crosses with major arterial roadways. However, there are currently some design concerns at each of the transition zones at the eastern and western city limits. This chapter summarizes the design and traffic safety concerns that exist at each of these zones.

3.1 Eastern City Limit

At the eastern city limit, shown in Figure 6, WMD connects with AHD and turns into Township Road 522. This portion of the roadway has key characteristics:

- East of AHD, where WMD merges with ramps and turns into Township Road 522, the road is reduced to one lane per direction. This creates a bottleneck that blocks upstream traffic flow, causing traffic queues and increasing the risk of Followed too Closely (FTC) collisions due to short vehicle gaps, abrupt lane changing, hard braking and sudden stops;

- Increasing the WMD PSL will increase the speed differential between WMD and Township Road 522 (which has a PSL of 80 km/h), thus, requiring longer deceleration distances prior to the abovementioned bottleneck, which would result in even longer queues and would cause more delays in travel time. At the same time, the speed differential will increase the occurrence of abrupt braking, trigger more instances of drivers not keeping a safe distance and, consequently, further increase the risk of FTC collisions; and

- There is a signalized intersection where Rural Route 233 crosses Township Road 522 at a lowered 70 km/h PSL, which causes traffic queuing, requiring sudden decelerations for stopped vehicles waiting for the green light.

3.2 Western City Limit

At the western section of WMD, shown in Figure 7, the PSL is lowered from 80 to 70 km/h between 200 metres east of Guardian Road/207 Street and 200 metres west of Winterburn Road/215 Street[3] and then raised to 80 km/h until the western city limit. Additionally, the western section is reduced from six lanes to one lane and turns into Highway 628. This change in road design causes a bottleneck with similar safety and travel time issues as the eastern side of the city. There are additional issues:

- The interchange of WMD and AHD accommodates a large volume of traffic that exits and merges, requiring a high degree of driver workload; and

- Along both sides of WMD from AHD to 215 Street, there are densely developed residential areas with high entering and exiting traffic flows from two major intersections; a higher PSL on WMD will increase the waiting time, decrease accessibility for these two areas and, more importantly, increase the risk of collisions between entering/exiting local and through traffic along WMD.

3.3 Collisions in Transition Zones

The provincial collision statistics from 2009 to 2011[4] (2012 data was not available) on Township Road 522 and Highway 628, which are the eastern and western extensions of WMD outside the city's boundary, respectively, are shown in Figures 6 and 7. Both eastern and western highway sections adjacent to WMD experience a very high frequency of collisions.

Outside the eastern city limit, as shown in Figure 6, the intersection of Range Road 233 and Township Road 522 had 21 Property Damage Only (PDO) collisions and 10 injury collisions from 2009 to 2011. Overall, the intersection had 31 collisions over three years, similar to the collision history of major intersections along WMD, as shown in Figure A-1, Appendix A.1, page 34. Additionally, there were six midblock collisions west of this intersection.

Outside the western city limit, as shown in Figure 7, the segment of Highway 628 between the city's boundary (231 Street/Range Road 261) and Highway 60 had one fatal, five injury and 15 PDO collisions from 2009 to 2011. Overall, the intersection had 21 collisions over three years,

[3] City of Edmonton, Speed Zone Bylaw No. 6894, Consolidated on May 22, 2013.
[4] Office of Traffic Safety, Alberta Transportation.

also similar to the collision history of major intersections on WMD, as shown in Figure A-1, Appendix A.1, page 34.

3.4 Concept Plan

The City of Edmonton prepared a Concept Plan[5] for the western portion of WMD, from the transportation utility corridor (TUC), west of AHD, to the western city limit at 231 Street. This segment will initially be upgraded to four lanes (and then to six lanes in the long term) and transfer at-grade intersections at Guardian Road/Lewis Estates Boulevard, 215 Street and 231 Street into grade separations.

However, since this is a long-term plan, its final completion is at least 10 to 15 years away from the time of this report submission. Prior to completing this plan and improving the road design to bring it up to the standards, the transition and connectivity concerns are still prevalent and do not support increasing the current PSL without negatively impacting the traffic safety of road users.

3.5 Summary

The results of the analysis determined that the PSL cannot be increased at the eastern or western transition zones and that all of the findings support keeping the PSL at the current speed of 80 km/h:

- The transition zones on the eastern and western city limits connect to external infrastructure and have their separate traffic safety concerns;

- The transition zone at the eastern city limit connects WMD with an AHD interchange and turns into Township Road 522 where traffic is restricted to one through lane and there is a speed reduction of 80 to 70 km/h prior to a signalized intersection at Range Road 233. All of these factors contribute to frequent queuing, short gaps between vehicles and increased collision risk;

- The transition zone at the western city limit results in a reduction in the number of lanes to a one through lane with similar traffic safety concerns as the eastern transition zone; and

[5] WMD West Planning Update Study. City of Edmonton: Road Project. http://www.edmonton.ca/transportation/road_projects/whitemud-west.aspx.

- Both transition zones have traffic safety issues relating to PDO, injury and fatal collisions.

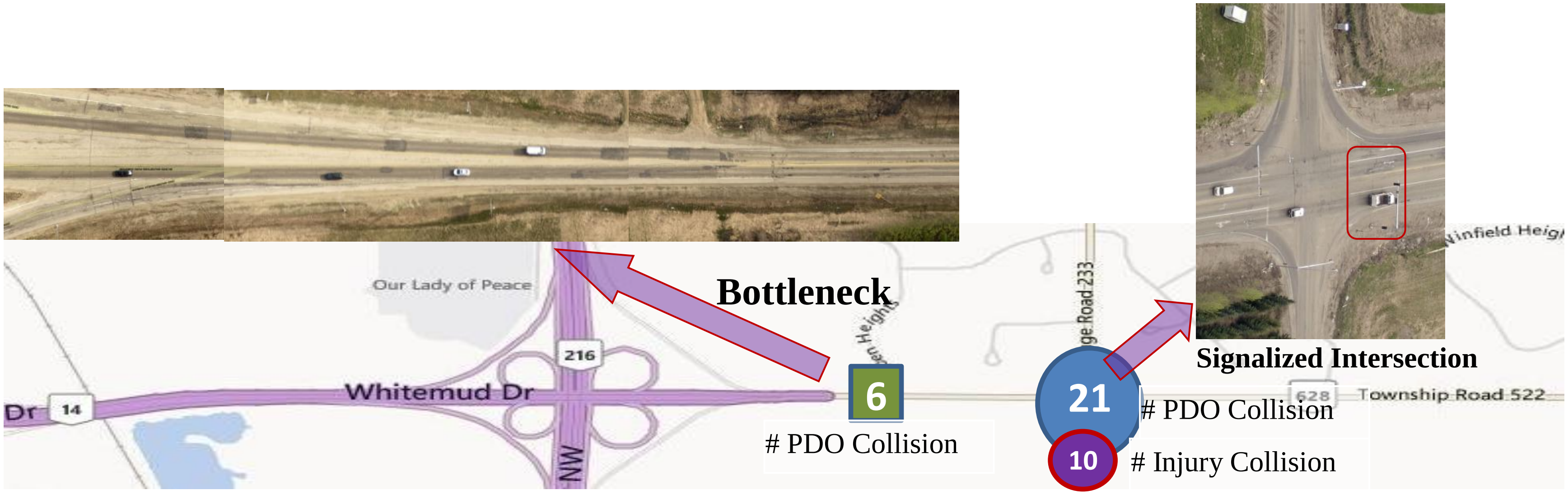


Figure 6 WMD Transition Zones beyond the Eastern City Limit

Figure 7 WMD Transition Zones beyond the Western City Limit

4 Statistics Regarding Whitemud Drive

This chapter summarizes the collision, speed, volume and enforcement analysis that was conducted along WMD.

4.1 Collision Analysis

Collision temporal analysis

Based on a monthly collision analysis of WMD, as shown in Figure A-3, Appendix A.2, page 36, seasonal trends are observed:

- Total monthly collisions (2010 to 2012) along WMD changed from 214 in June to 356 in December;
- Monthly injury collisions (2010 to 2012) along WMD changed from 29 in May to 57 in September;
- For those months with relatively lower total collisions, such as April and June, collision severities were relatively high (defined as percentage of injury collisions among total collisions; see equation in Figure A-3, Appendix A.2, page 36); and
- For those months with relatively higher total collisions, such as November, December and January, collision severities were relatively low.

In summary, the traffic safety concerns, whether they were high collision frequencies or high collision severities, existed throughout the whole year.

Based on a weekly collision analysis of WMD, as shown in Figure A-4, Appendix A.2, page 37, weekly trends are observed:

- The frequency of total collisions showed a strong weekly profile, increasing from Monday to Friday, and then dropping during the weekend;
- Friday had the highest frequency of collisions; and

- Sunday had the lowest frequency of collisions, but had extremely high collision severities.

In summary, the collision profile was consistent throughout the week.

Based on an hourly collision analysis of WMD, as shown in Figure A-5, Appendix A.2, page 37, hourly trends are observed:

- The frequency of collisions showed two peak periods: morning peak hours from 07:01 to 09:00 and afternoon peak hours from 15:01 to 18:00; and

- Off-peak periods, such as the early morning, evening and night time, showed a lower frequency of collisions, but tended to have a higher severity level.

In summary, there are no specific time periods in which the collision profile was significantly better than others.

<u>Collision spatial and collision cause analysis</u>

Figure 8 shows a cross-sectional distribution of WMD collisions (2010 to 2012) by driving lanes and major causes of most collisions (this distribution does not include all possible driving lanes and all collision causes). Figure 8 shows that the top driving-lane-to-collision-cause pairs are: FTC collisions in the right turn bay (including right-turn ramps), second lane from curb (the second most right through lane of WMD), right curb lane (the most right through lane of WMD) and Changing Lanes Improperly (CLI) collisions in the second lane from curb.

Among these, the top driving-lane-to-collision-cause pair (FTC collisions in the right-turn bay/ramp) is potentially attributed to the speed differential between speeds on the through lanes and speeds on the bay/ramp. Additionally, FTC collisions in the right most lane and CLI collisions in the second most right lanes imply that the conflict between the slower entering or exiting traffic and through lane traffic could be a contributing cause of collisions. A higher PSL would result in higher speeds on WMD and further widen the speed differential between vehicles traveling along WMD and entering/exiting traffic flows, which would increase the probability of higher FTC and CLI collisions.

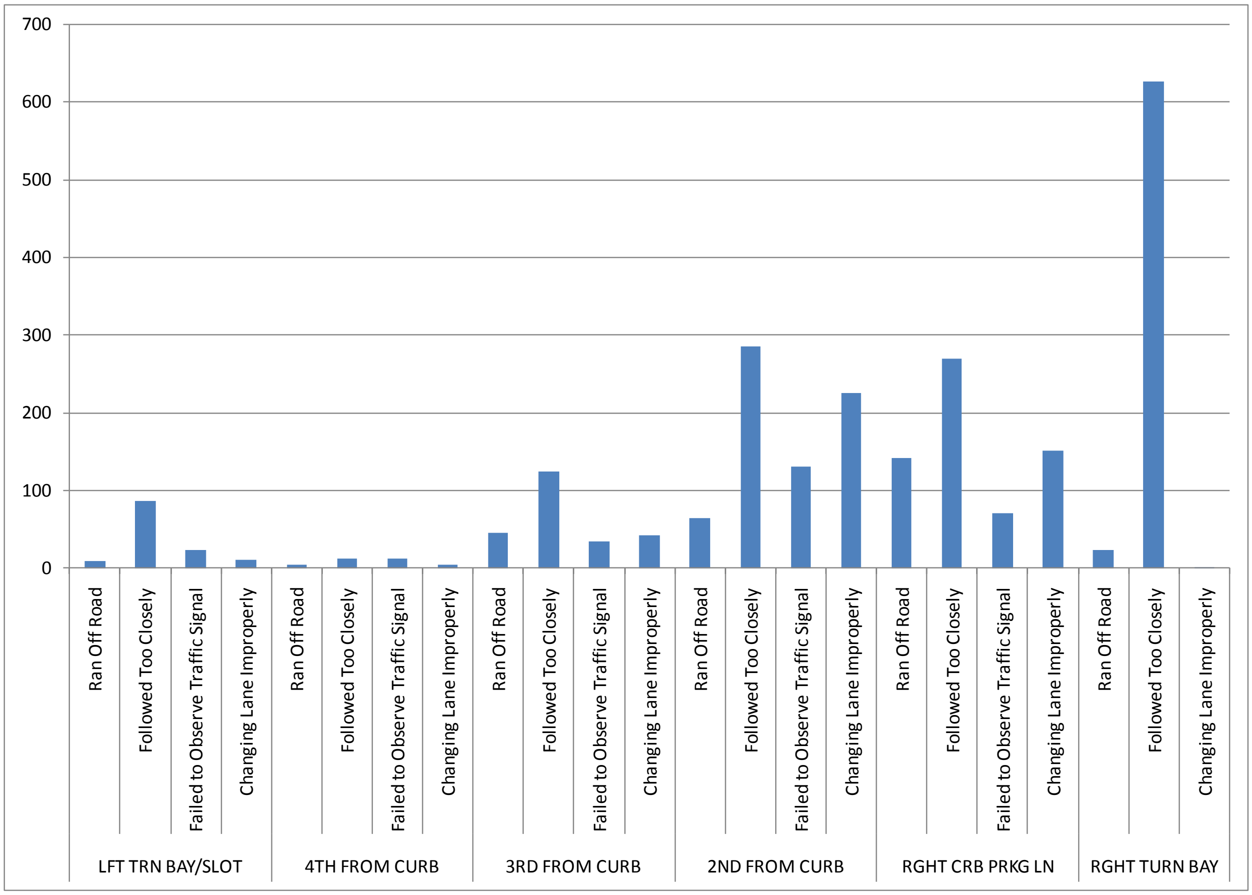


Figure 8 WMD Collision Distribution by Driving Lane and Cause

Figure 9 represents the hourly speed differential (defined as the speed standard deviation of a certain hour obtained from speed data collected at the VDS sites, in km/h) and major causes of collisions on WMD (2010 to 2012) by hour. The figure shows that the highest frequencies of FTC and CLI collisions occurred in the same time periods (08:00 and 18:00), where the speed differential was the greatest (14 km/h). Two other major collision causes, Ran off Road (ROR) and Failed to Observe Traffic Signal (FOTS), did not exhibit the same patterns. The time periods with the highest speed differentials were also the peak hours in terms of traffic volume. Therefore, the interaction of high volume, high speed differentials and narrow gaps could be a contributing factor (but not necessarily a causal factor) to the high frequency of FTC and CLI collisions. Due to the lack of data, the impact of the PSL on the speed differential along WMD could not be investigated.

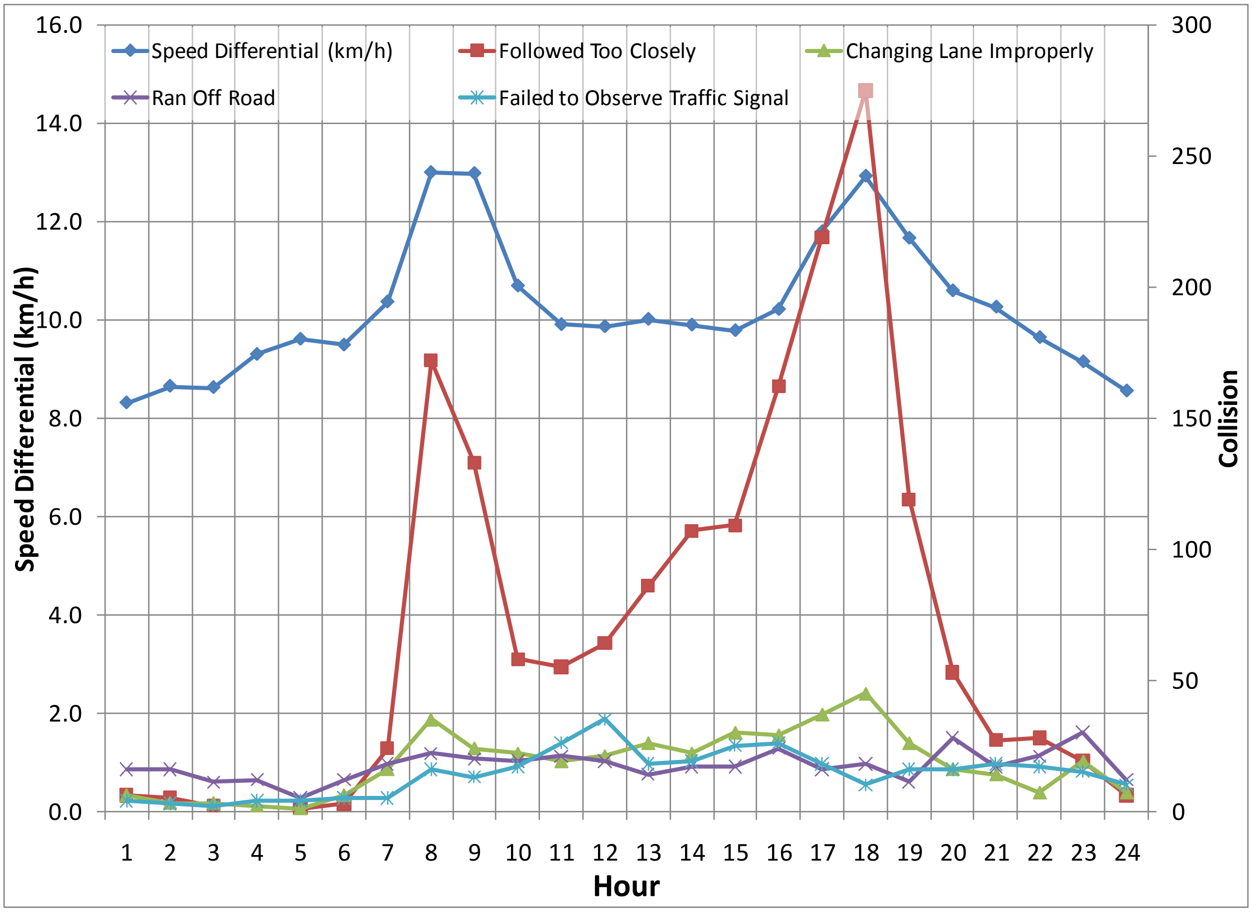


Figure 9 WMD Collision Distribution by Hour and Collision Cause

Collision comparison with similar roads

Table 1 lists the WMD collision rates and shows a comparison of similar roads, namely AHD and YHT. Two key observations are evident:

- WMD has the highest intersection collision rate (collisions per million vehicles entering the intersection) among the three major roads. It was expected that AHD would have a much lower intersection collision rate, since it is functionally classified as a highway and not an urban road. Also, it has less intersection/interchange density. Although YHT has a higher intersection density, it still has a lower collision rate than WMD; and

- WMD has the highest midblock collision rate (collisions per million vehicle-kilometers) among the three major roads. Its midblock collision rate is 4.5 times higher than AHD and 1.4 times higher than YHT.

In conclusion, WMD has a significantly higher collision rate than similar roads.

Table 1 Collision Rate Comparison among Similar Roads*

	Intersection Collision Rate (collisions per million vehicles entering the intersection)	Midblock Collision Rate (collisions per million vehicle-kilometers)
WMD	1.021	1.695
AHD	0.281	0.373
YHT	0.977	1.190

*The collision rate for each road is the average value from sites with available collision rate data for 2010 to 2012 from the City's Web Intelligence Rich Client database system; numbers of available sites varied from road to road.

4.2 Speed Analysis

Data from the VDS and NC200 sites along WMD was collected and analyzed. For the purpose of comparison, VDS data along YHT was also analyzed and included to provide context. A more detailed analysis is provided in Appendix B. As shown in Figure 10, the speed statistics illustrate that a large proportion of vehicles travel at speeds exceeding the PSL and that the speed limit compliance ratios are relatively consistent with different roads that have different speed limits. If this phenomenon remains unchanged for a higher speed limit, e.g. 100 km/h, it is expected that the number of high-speed drivers will increase, which tends to incur more severe injury and fatal collisions.

Figure 10 illustrates that the mean speed along WMD is 83.1 km/h under an 80 km/h PSL. Based on a hypothesis that the speed differential between mean speed and the PSL would remain consistent, the mean speed is estimated at 93.1 km/h for a 90 km/h PSL and 103.1 km/h for a 100km/h PSL. The length of the WMD from its eastern to western city limits is approximately 27.3 km. To drive through the city under these estimated mean speeds, it would take roughly 19.7 minutes under an 80 km/h PSL, 17.6 minutes under a 90 km/h PSL and 15.9 minutes under a 100 km/h PSL. This amounts to 2.1 minutes (or 4.6 seconds/km) travel time difference for a 90 km/h PSL and 3.8 minutes (or 8.4 seconds/km) for a 100 km/h PSL compared to the current PSL. However, this calculation does not take into consideration the impact of queuing due to the wider speed differential, particularly between merging/exiting traffic and through lane traffic. Therefore, this reduction in travel time is considered to be insignificant.

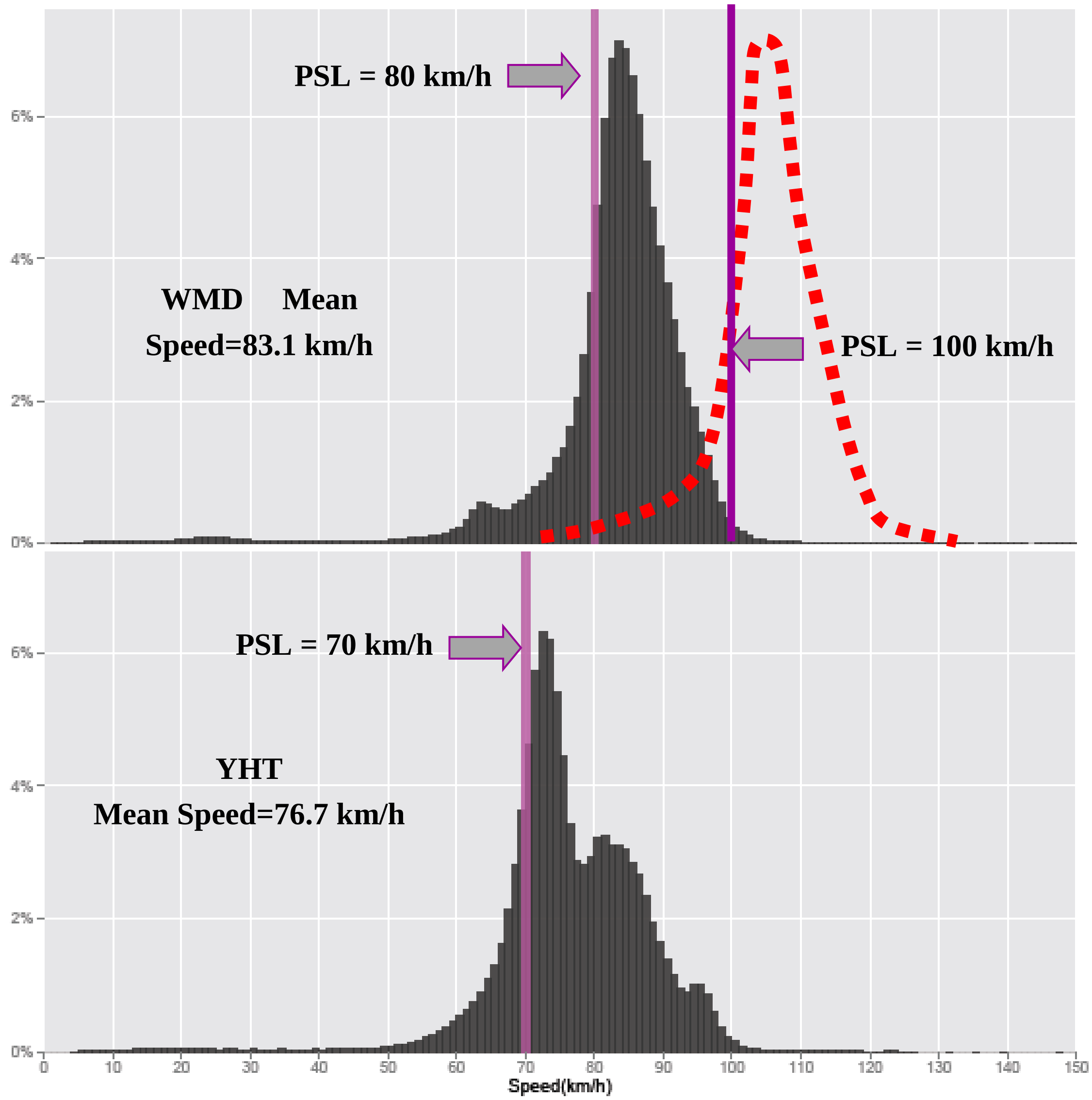


Figure 10 Speed Distribution Histograms Based on Different PSLs

4.3 Volume Analysis

The volume analysis of WMD was compared to the volume analysis of YHT, as shown in Figure 11. The results indicate that traffic volume for one lane in one hour will not change significantly due to different PSLs (70 km/h on YHT and 80 km/h on WMD). From Figure 11, it can be observed that the widest gap in traffic volume (vehicle/lane/hour) was observed at peak hours: 06:00 to 07:00 and 15:00 to 16:00. However, even the largest differentials were only 50 vehicles per lane per hour. During off-peak hours, the volume gap was much narrower, and, especially for the time period from 22:00 to 06:30, WMD had even smaller volumes per lane per hour than those on YHT.

In summary, raising the PSL will not necessarily increase the traffic volume and, if it did, it would not be consistent throughout the day.

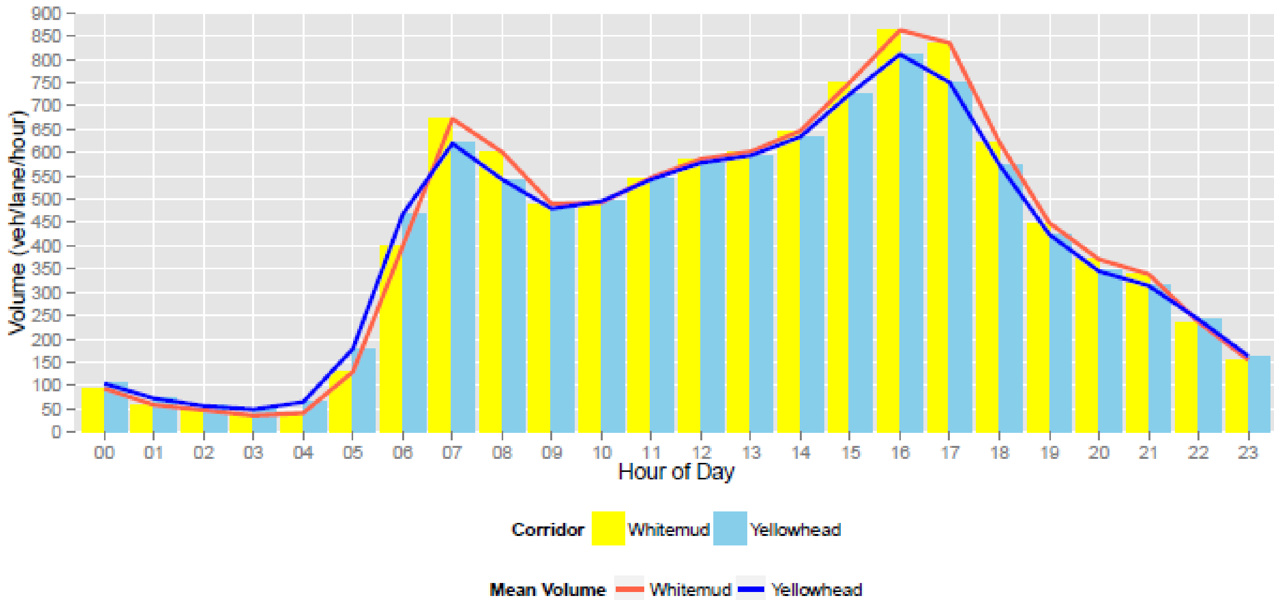


Figure 11 Mean Volume by Hour of Day

Temporal statistics and comparisons of traffic volumes and speeds (summarized in Appendix B) provide some findings related to potentially increasing the PSL. If the PSL along WMD is raised, several patterns are expected for speed and traffic volume:

- In all months of the year, all days of the week and all hours of the day, the speed would increase on average;
- In all months of the year, all days of the week and all hours of the day, the total traffic volume would increase on average;
- The increase in traffic volume would be more evident in summer months and peak hours; and
- Increasing the PSL would attract more daily commute trips to WMD, rather than non-commute trips.

4.4 Enforcement Analysis

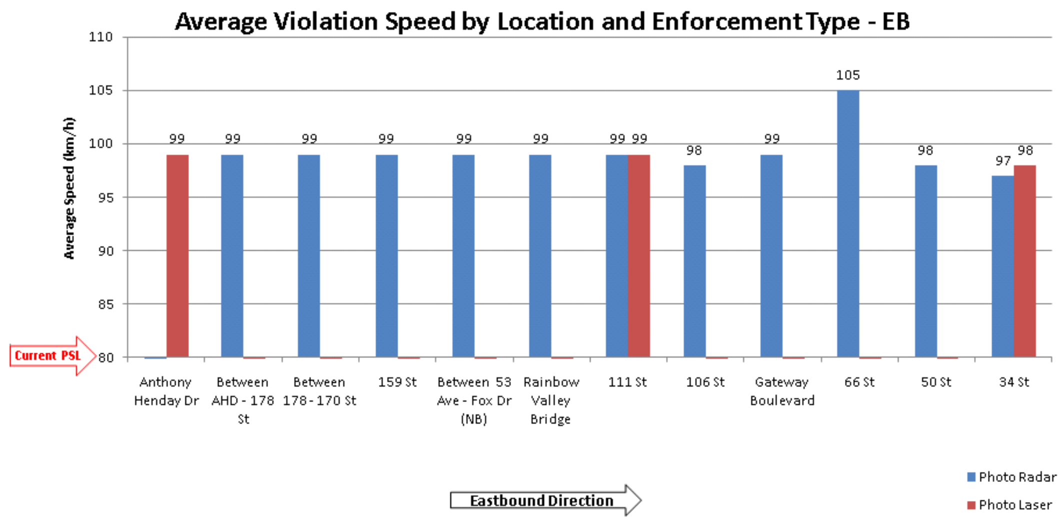
Speeding ticket data was collected and analyzed, from both AE by PR and Photo Laser (PL) and manned enforcement (ME) by the Edmonton Police Service. A more detailed enforcement analysis is summarized in Appendix C.

Automated enforcement

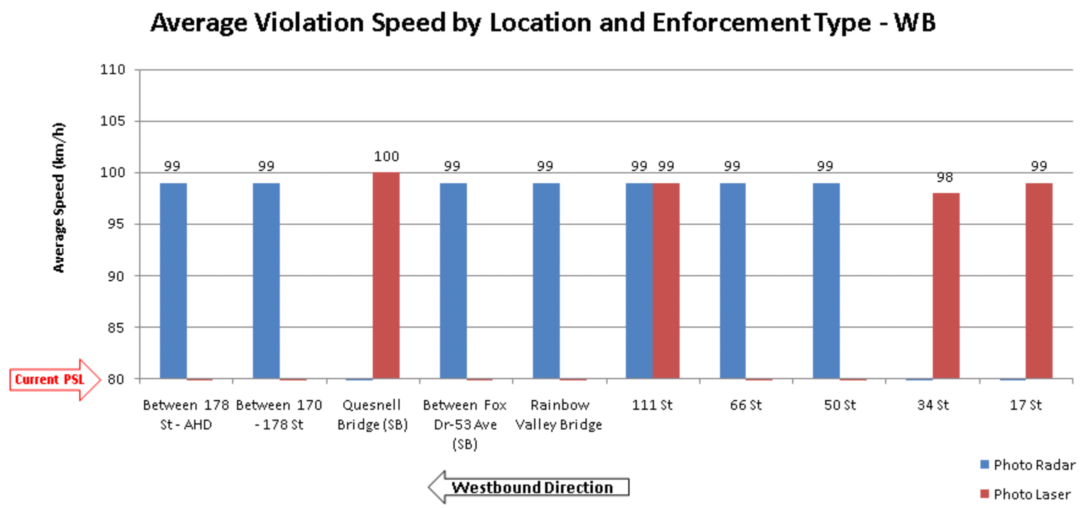
Figure 12 shows the average violation speed along WMD from both PR and PL. Figure 12 reveals that most violation speeds along WMD are overwhelmingly consistent at 100 km/h, which is 20 km/h above the PSL. Along with the findings shown in Figure 10, it can be inferred from this profile that if the PSL was raised to 100 km/h, the average violation speed would not remain at 100 km/h, but is predicted to be 20 km/h above the PSL, resulting in speeds of 120 km/h. The current collision profile shows a high frequency of collisions occurring along the WMD. Traveling at higher speeds (i.e., 120 km/h vs 100 km/h) increases the severity of collisions. Therefore, raising the PSL would further magnify traffic safety concerns for all road users.

Manned enforcement

ME speeding and other traffic violation data taken from 2012 to 2013 along WMD was analyzed. Figure 13 shows the top five ME traffic infractions along WMD from 2012 to 2013. It is obvious that "exceed maximum speed limit, TSA 115(2)(p)" is the top concern, with the overwhelming majority of infractions; where TSA 115(2) refers to the Traffic Safety Act Section 115(2).



(a) EB



(b) WB

Figure 12 Average Violation Speed along WMD

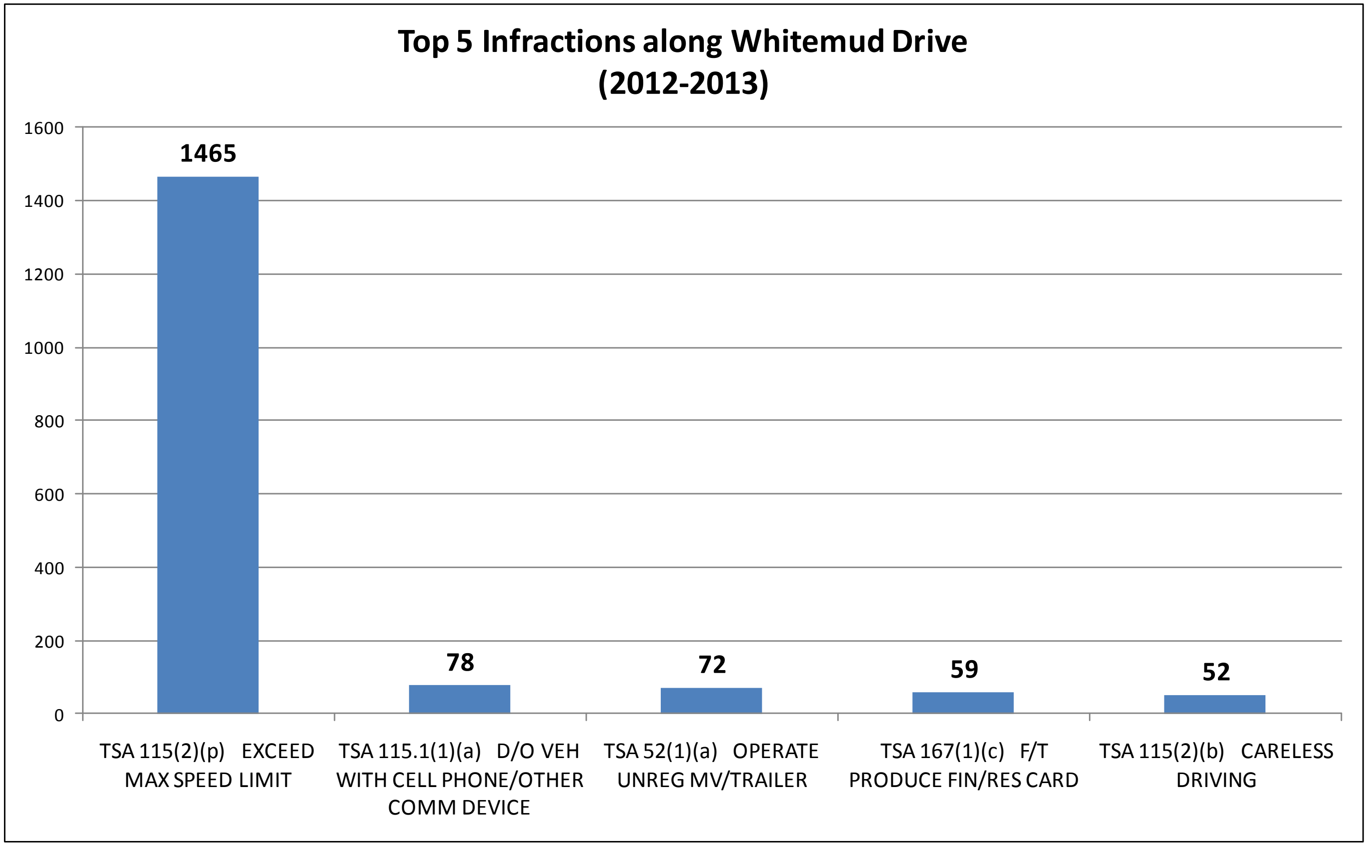


Figure 13 Top 5 Traffic Infractions of WMD (2012 to 2013)

Figure 14 shows the spatial distribution of the number of speeding tickets, including those locations with five or more speeding tickets given by ME, from 2012 to 2013. This distribution is similar to the pattern observed with the AE data: speeding tickets fluctuate along different segments of WMD; but, in general, speeding violations were widespread across the entire stretch of WMD.

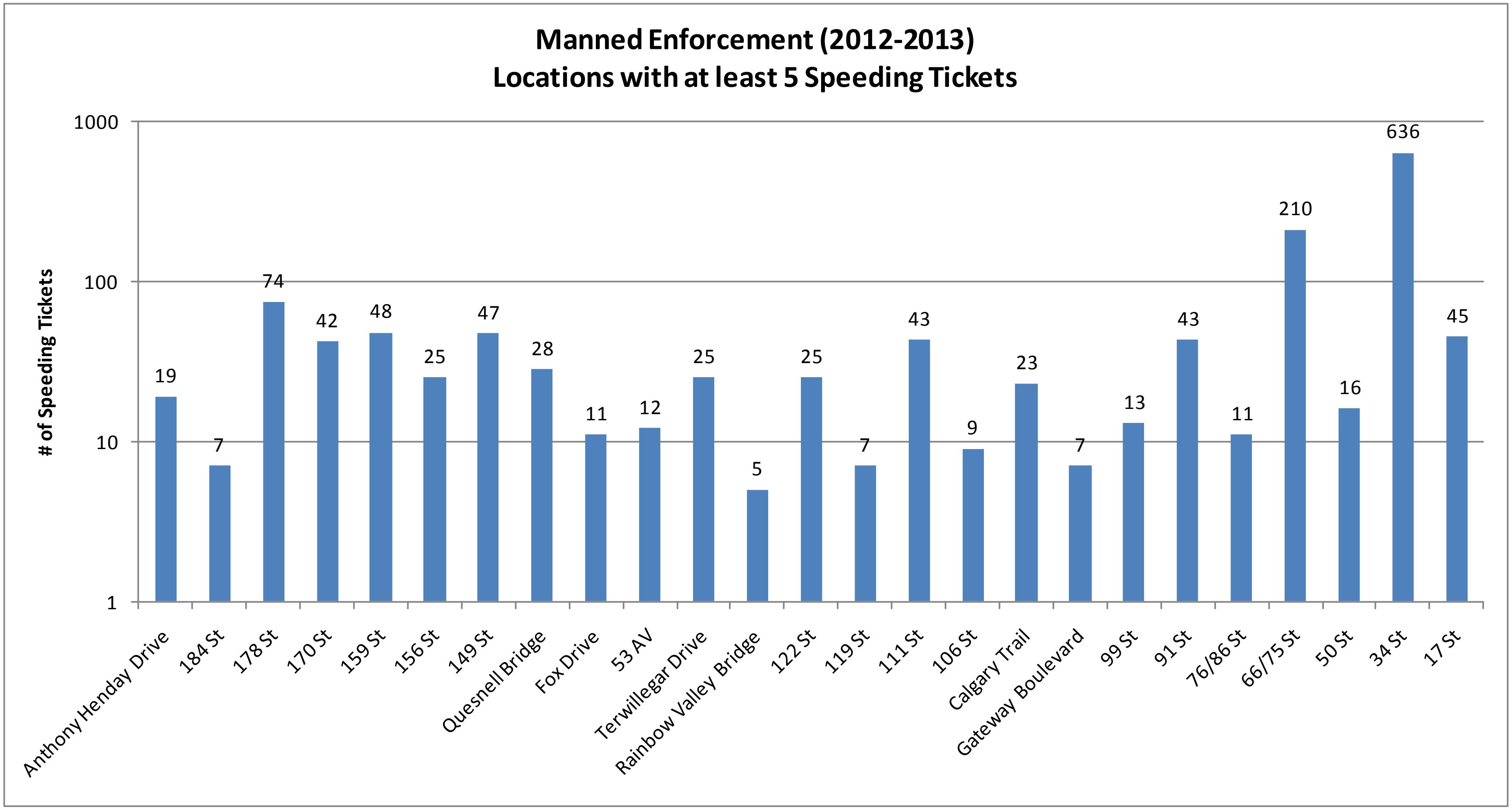


Figure 14 Locations of WMD with 5 or more ME Tickets 2012 to 2013

4.5 Summary

The analysis results determined that the PSL cannot be increased along any section of the WMD and that all the findings support keeping the PSL at the current speed of 80 km/h:

- Collisions are spread throughout all seasons of the year, all days of the week and all hours of the day. There is no particular time frame that is significantly safer than others;

- There is a spatial speed differential along WMD between through lanes and entrance/exit lanes, which caused a high frequency of FTC collisions on ramps and CLI collisions in the right curb lane. Raising the speed limit would increase this type of speed differential, and, therefore, cause a higher collision risk;

- Collision comparisons among WMD, AHD and YHT revealed that WMD experiences a higher collision level compared to similar roads;

- A large proportion of vehicles travel at speeds exceeding the PSL. As a result, the number of high-speed drivers will increase along with a higher speed limit, which tends to incur more severe injury and fatal collisions;

- The travel time reductions that would result from increasing the PSL are negligible and likely offset by queuing and merging/exiting activities;

- Raising the PSL will not necessarily increase the traffic volume and, if it did, it would not be consistent throughout the day; and

- Speeding violations were widespread across the entire stretch of WMD, according to statistics both from AE by PR and PL and from ME by the Edmonton Police Service.

5 Road Design Impact

Transportation Services report CR_238 summarized some critical geometric constraints that support keeping the PSL as is. Accordingly, some major road design changes are required to increase the PSL (including, but not limited to):

- Realignment of the horizontal curves north of Quesnell Bridge and south of 53 Avenue

- Redesign and reconstruction of the left-hand exiting ramp at Terwillegar Drive into a right-side exiting ramp.

More importantly, there are at least two design constraints that can only be changed at extremely high costs:

- Close some entrances/exits so as to increase the spacing of interchanges from 91 Street to 111 Street

- Redesign several underpasses and vertical curves with limited sight distance, such as those at 106 Street and 111 Street.

6 Noise and Emission Impact

According to a report (Transportation Department 2009TD0150) submitted to the Transportation and Public Works Committee on July 27, 2009, noise levels at multiple neighborhoods along WMD have exceeded 60 dBA Leq_{24} (the 24-hour average Equivalent Continuous Sound Level), which is the standard for a noise attenuation wall to be warranted under the Urban Traffic Noise Policy (UTNP) City Policy C506. By using 20 years projected noise level data as an index, the report estimated noise levels in many neighborhoods, such as Laurier Heights, West Rio Terrace, Rio Terrace, Quesnell Heights, Brander Gardens and Brookside, may exceed 65 dBA Leq_{24}.

There are two key findings of this report:

- The current noise level of many neighborhoods along WMD has already exceeded the normal range; and

- Considering the extremely high cost and the potential loss of green space, only very few locations can be protected by a noise attenuation wall.

In summary, under these circumstances, the noise impact on residents living along WMD will worsen if the noise level continues to increase. More importantly, existing studies[6] show that noise levels (dBA) would increase if speed increased from 80 to 100 km/h (approximately 50 to 62 mph, as shown in Figure 15).

[6] Handbook of Transportation Engineering, M. Kutz (2004)

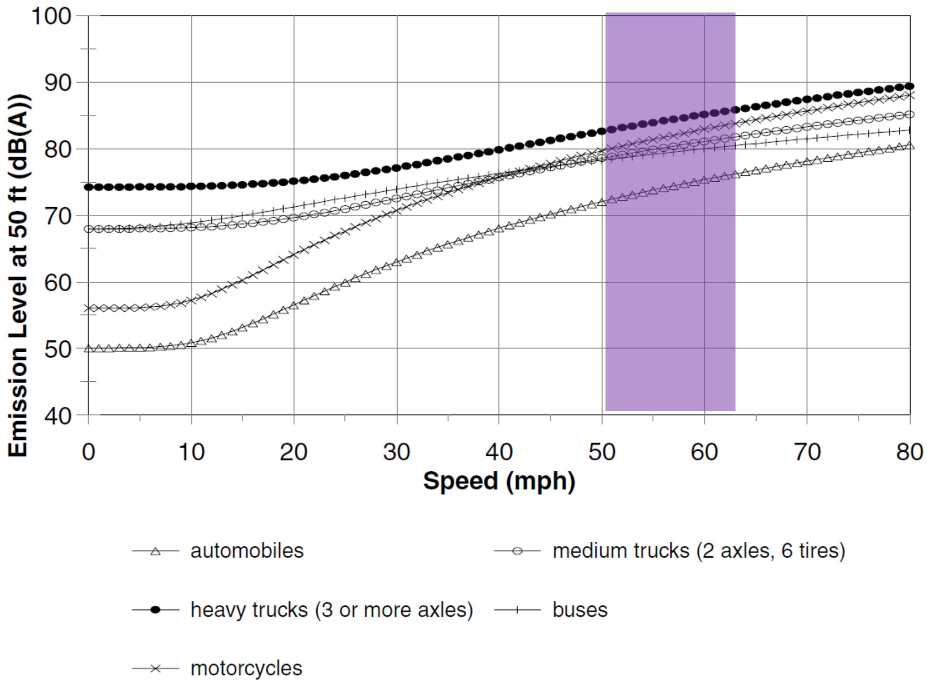
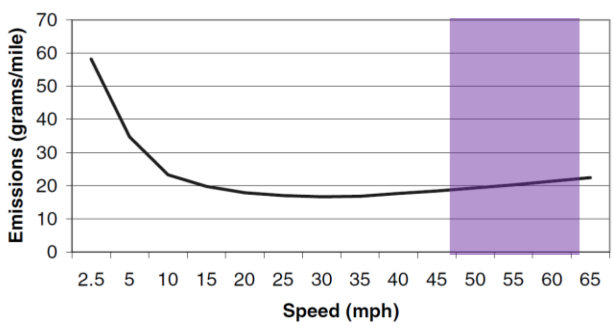
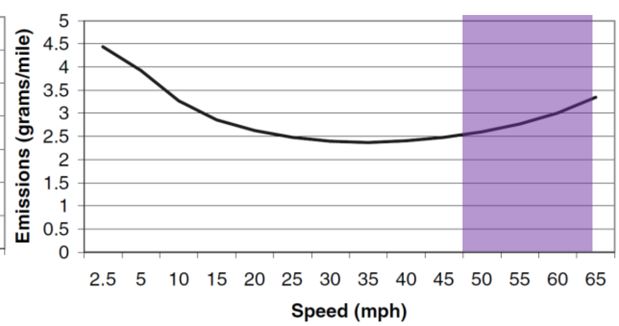


Figure 15 Noise Emission Levels (dBA) as a Function of Speed

Figure 16 shows that exhaust emission levels (grams per mile) will increase if speed increases from 80 to 100 km/h (about 50 to 62 mph, as shown in Figure 16).



(a) CO



(b) NO_x

Figure 16 Exhaust Emission Levels as a Function of Speed

7 Merging and Exiting Issues

7.1 Road Design-Related Issues

A comparison between current design dimensions and guidelines from the Geometric Design Guide for Canadian Roads showed that the WMD's current acceleration lanes used for merging and deceleration lanes used for exiting must be extended to accommodate any speed limit increase. Given the current property line constraints as well as acquisition and construction costs, an increase in the PSL is not recommended.

7.2 Traffic Operation-Related Issues

Detailed traffic operations related to speed and volume are summarized in Appendix B. Based on the traffic volume and speed analysis on through lanes, on-ramps and off-ramps along WMD, seasonal trends are observed:

- In all the months of the year, the mean speed is higher on through lanes than on ramps. The speed gap between vehicles in the through lanes and the on-ramps is significantly wider than the gap between vehicles in the through lanes and the off-ramps. In summer months, on-ramp mean speed is slightly higher than off-ramp mean speed, while in winter months, these two speeds are similar on average;

- For all days of the week, the mean speed is much higher on through lanes than on ramps; on-ramp speed is slightly higher than off-ramp speed. The mean speed of vehicles during the weekends is slightly higher than during weekdays on through lanes, while on both types of ramps, the speed is consistent over the whole week; and

- The hourly speed distribution (Figure B-9, Appendix B.1, page 42) shows that the mean speed on both ramps is similar, while the speed on through lanes is much higher than the speed on ramps in all hours of the day. The on-ramp mean speed is higher than the off-ramp mean speed during the night time, but lower during the day time.

7.3 Summary

According to the aforementioned statistics and data, if the PSL increased, then critical merging, exiting and connecting issues could develop:

- In the current geometric alignments and prevailing driving conditions along WMD and nearby entrances and exits, a PSL increase could cause safety issues near on- and off-ramps, such as more abrupt braking and acceleration; and

- If the PSL increased, then the speed gap between WMD and ramps would become wider, which would make merging and exiting even more challenging.

8 Conclusion

1. No specific segment along WMD was found to be suitable for a PSL increase with respect to collision, speed, traffic volume and road design.
2. WMD has significantly higher collision rates compared to similar roads and increasing the speed limit would make its safety performance even worse.
3. A higher speed limit will not lower the compliance ratio, and, therefore, would encourage excessively high speeds.
4. Road design constraints support keeping the speed limit as is.
5. Noise and emission levels would be negatively impacted by a higher speed limit.
6. Increasing the speed limit would widen the speed gap and increase safety risks for exiting, entering and connecting traffic.
7. In the future, the higher density of land use of urban areas along WMD will require more frequent entering, exiting and interweaving traffic, which will cause more traffic congestion and does not support higher speeds.

The final recommendation is to maintain the current PSL of 80 km/h throughout the WMD corridor.

List of Appendices

Appendix A. Collision Statistics
Appendix B. Speed and Volume Statistics
Appendix C. Speeding Enforcement Statistics

Appendix A. Collision Statistics

Appendix A.1 Segregating WMD Based on Collisions

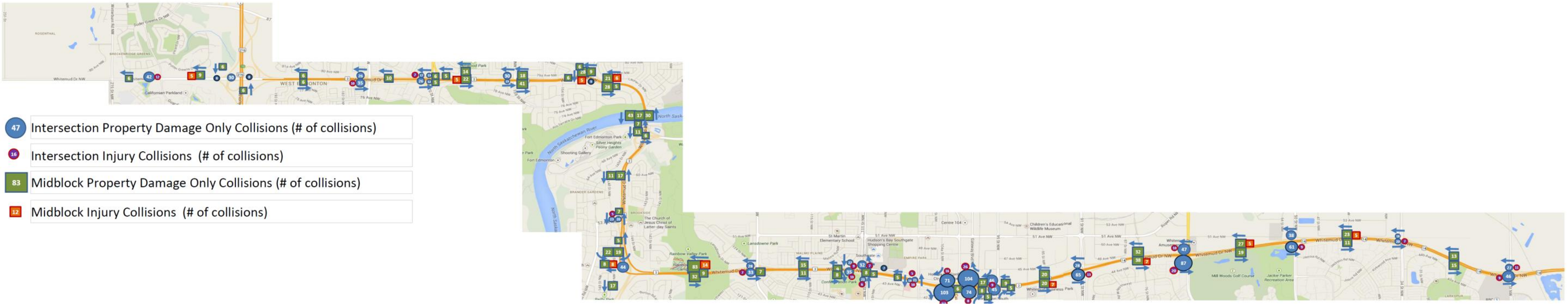


Figure A-1 WMD 2010 to 2012 Collision Distribution[7]

Table A-1 WMD Safety Concerns Based on Collision Distribution

Location	Concerned Segments	Concerned Traffic Movements
Whitemud Dr, 99 St-Gateway Blvd-Calgary Tr-106 St	interchange, midblock, intersection	eastbound, westbound, merging, diverging
Whitemud Dr & 111 St	interchange, midblock	eastbound, westbound, southbound, northbound, merging, diverging
Whitemud Dr, 122 St–Termillegar Dr	midblock	eastbound, westbound
Whitemud Dr & 75/66 St	interchange, midblock	eastbound, westbound
Whitemud Dr, Termillegar Dr-53 Ave	midblock, interchange	southbound, northbound, merging, diverging
Whitemud Dr, Fox Dr-Quesnell Bridge	bridge, interchange	southbound, northbound, merging, diverging
Whitemud Dr & 91 St	intersection, midblock	eastbound, westbound
Whitemud Dr & 50 St	interchange, midblock	eastbound, westbound
Whitemud Dr & 149 St	interchange, midblock	eastbound, westbound, merging, diverging
Whitemud Dr & 170 St	interchange, midblock	eastbound, westbound
Whitemud Dr & 17 St	interchange	eastbound, westbound
Whitemud Dr & Lewis Estates Blvd	intersection, midblock	all

[7] Figure A-1 includes only locations with at least five collisions in each direction within the three year period (2010 to 2012).

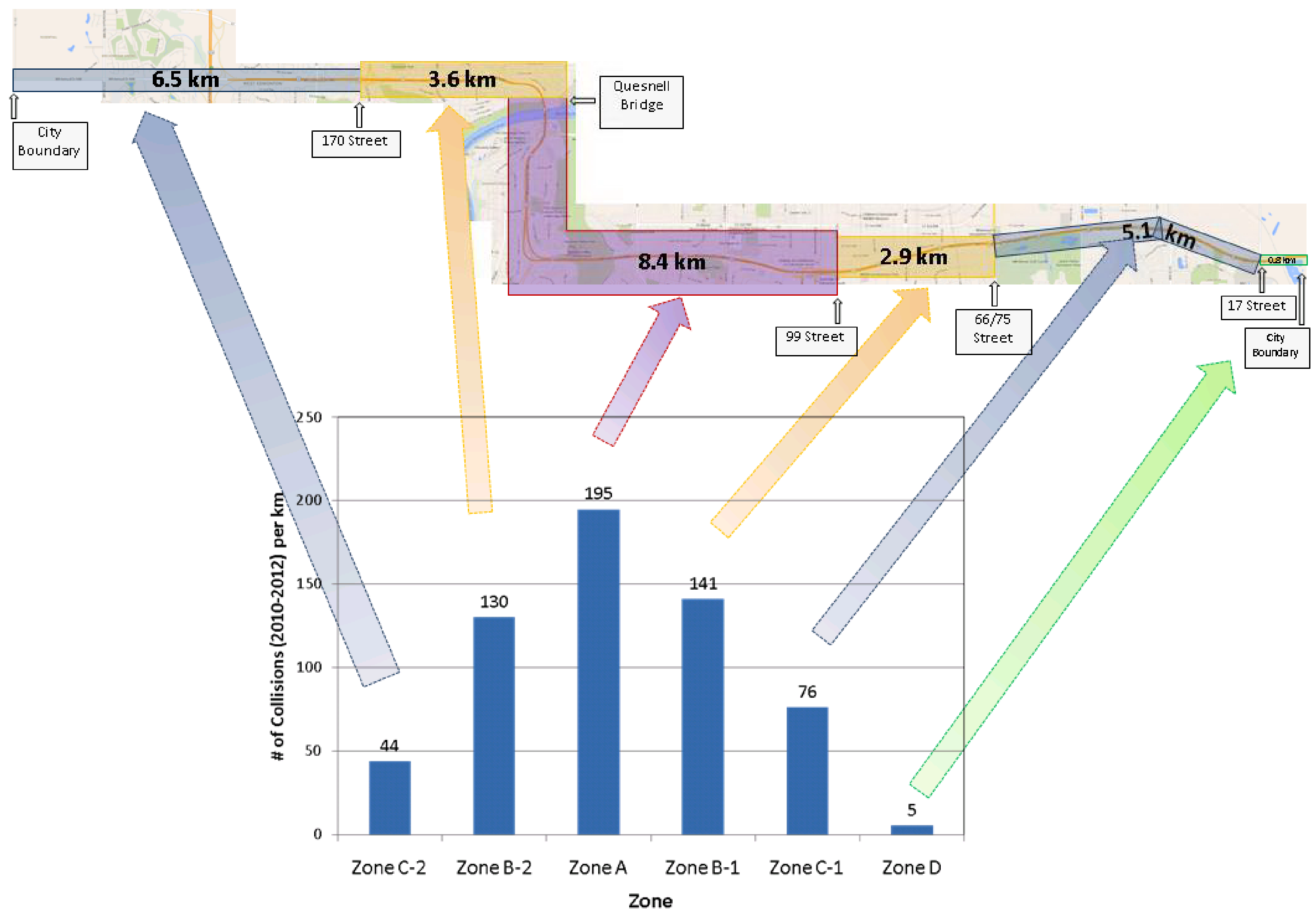


Figure A-2 Segmentation of WMD Based on Collisions

Table A-2 WMD Collision Segmentation and Characters

Segments	Length (km)	Boundaries*	Cateogry	Character	# of Collisions (2010 to 2012) per km
Zone D	**0.8**	**[Eastern City Limit, 17 St)**	D	Relatively low collisions	5.0
Zone C-1	**5.1**	**[17 St, 75/66 St)**	C	Mildly high collisions	Between 40 and 80
Zone B-1	**2.9**	**[75/66 St, 99 St)**	B	Intermediately high collisions	Between 130 and 140
Zone A	**8.4**	**[99 St, Quesnell Bridge]**	A	Extremely high collisions	Close to 200
Zone B-2	**3.6**	**(Quesnell Bridge, 170 St]**	B	Intermediately high collisions	Between 130 and 140
Zone C-2	**6.5**	**(170 St, Western City Limit]**	C	Mildly high collisions	Between 40 and 80

* “[” and “]” - inclusive boundaries; “(” and “)” - exclusive boundaries

Appendix A.2 Collision Statistics

The monthly collision distribution is shown in Figure A-3.

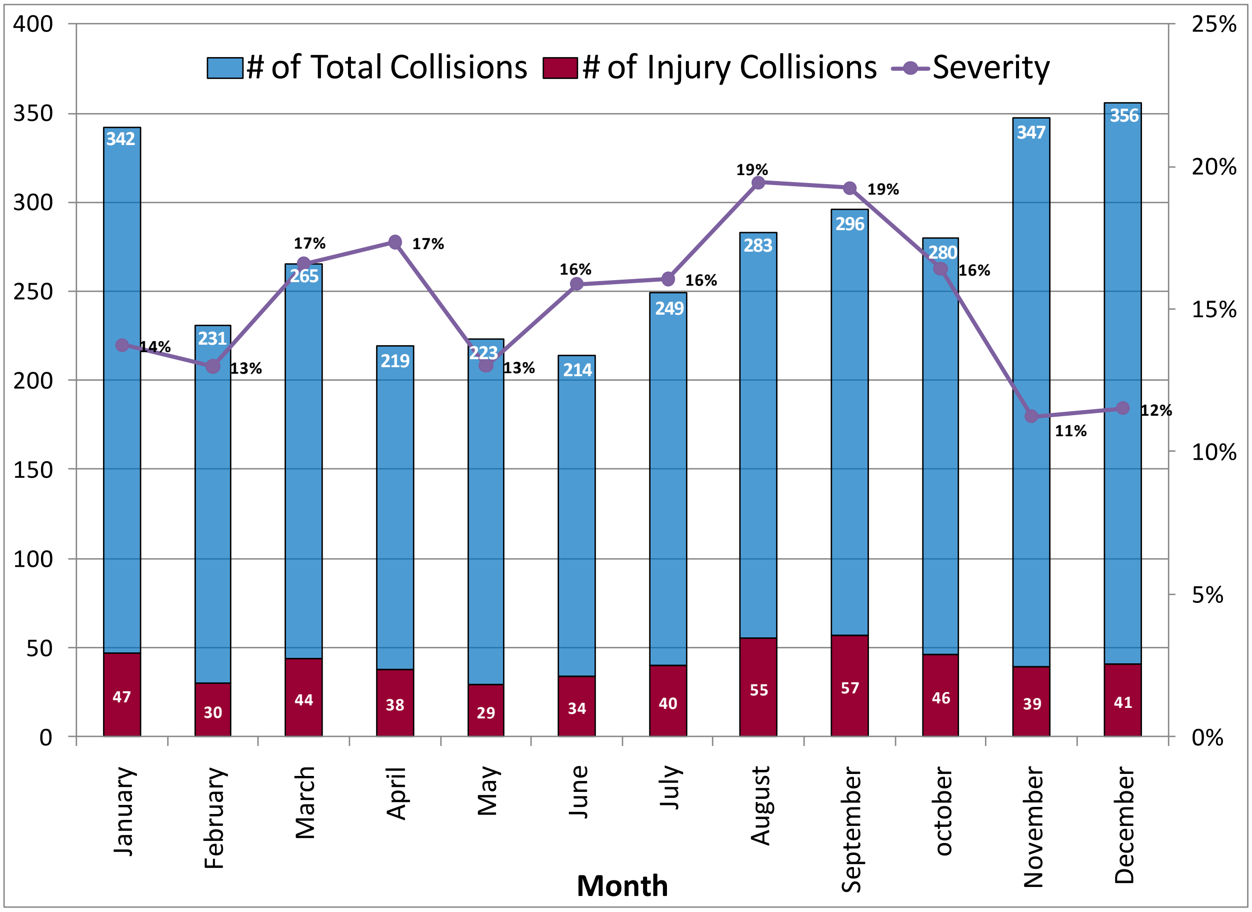


Figure A-3 Monthly Distribution of WMD 2010 to 2012 Collisions

The collision severity was defined as:

$$\textbf{Severity} = \frac{\#\,\textbf{Injury Collisions}}{\#\,\textbf{Total Collisions}} \times 100\%$$

The weekday collision distribution is shown in Figure A-4.

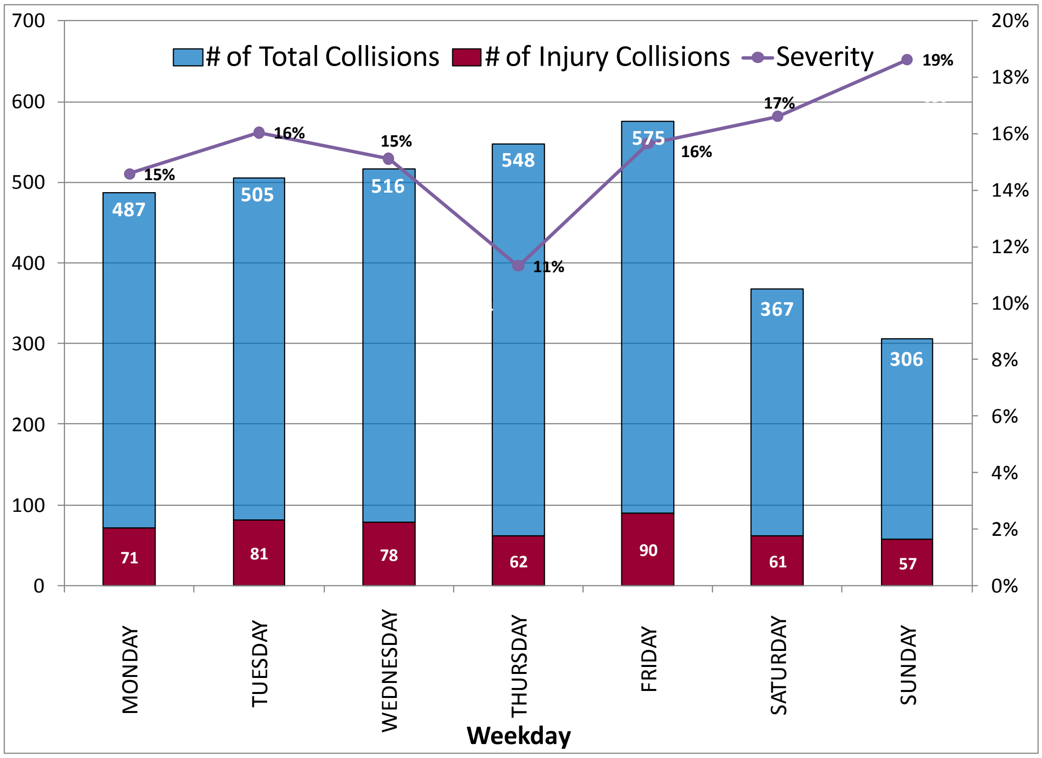


Figure A-4 Weekly Distribution of WMD 2010 to 2012 Collisions

The hourly collision distribution is shown in Figure A-5. Here, the hour of "14" means 13:01 to 14:00, inclusively.

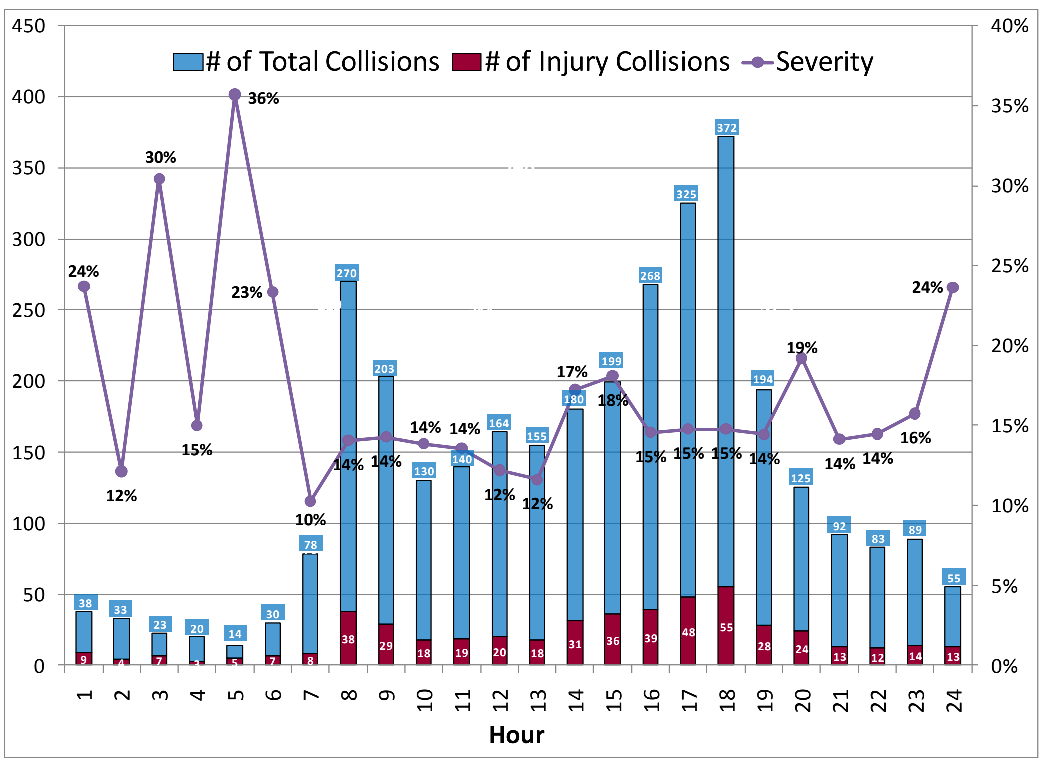


Figure A-5 Hourly Distribution of WMD 2010 to 2012 Collisions

Appendix B. Speed and Volume statistics

Appendix B.1 VDS Data and Statistics

The city of Edmonton uses a Vehicle Detection System (VDS), also called a dual loop device, to collect continuous traffic flow data, including speed and volume. VDS sites in the city are shown in Figure 3, Section 2.3, page 7 of the main report. Some of these sites are on WMD through lanes and others are on WMD on-ramps or off-ramps.

All speed and volume data was analyzed and, for the purpose of comparison, VDS data along YHT was also collected and analyzed.

<u>VDS data temporal analysis and comparison</u>

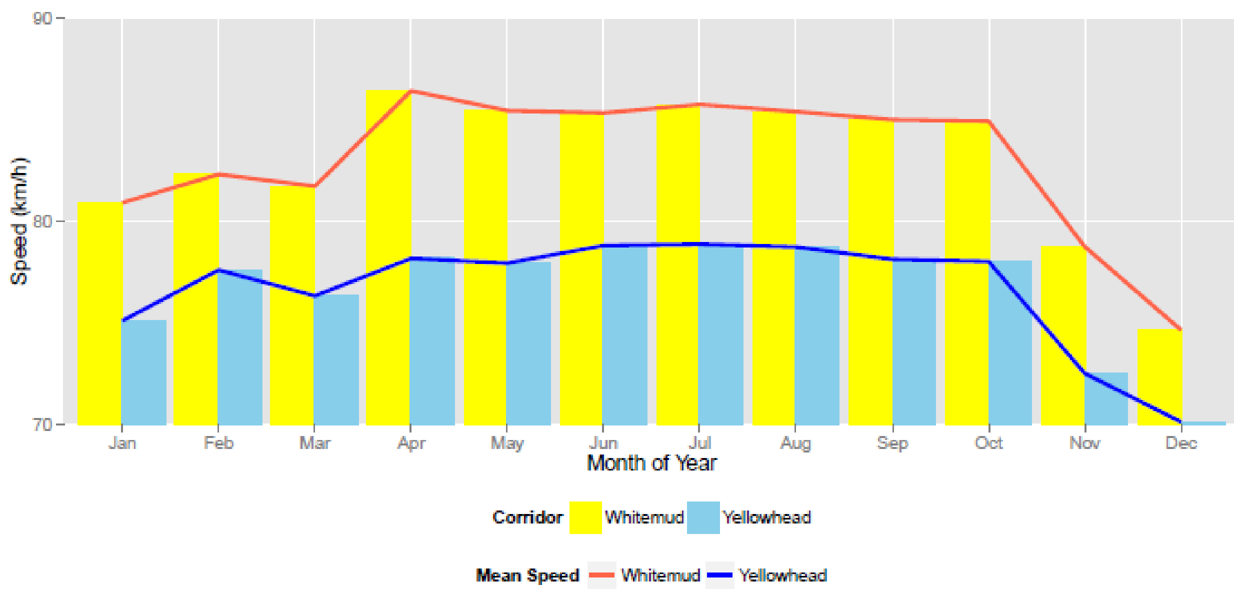


Figure B-1 Mean Speed by Month of Year

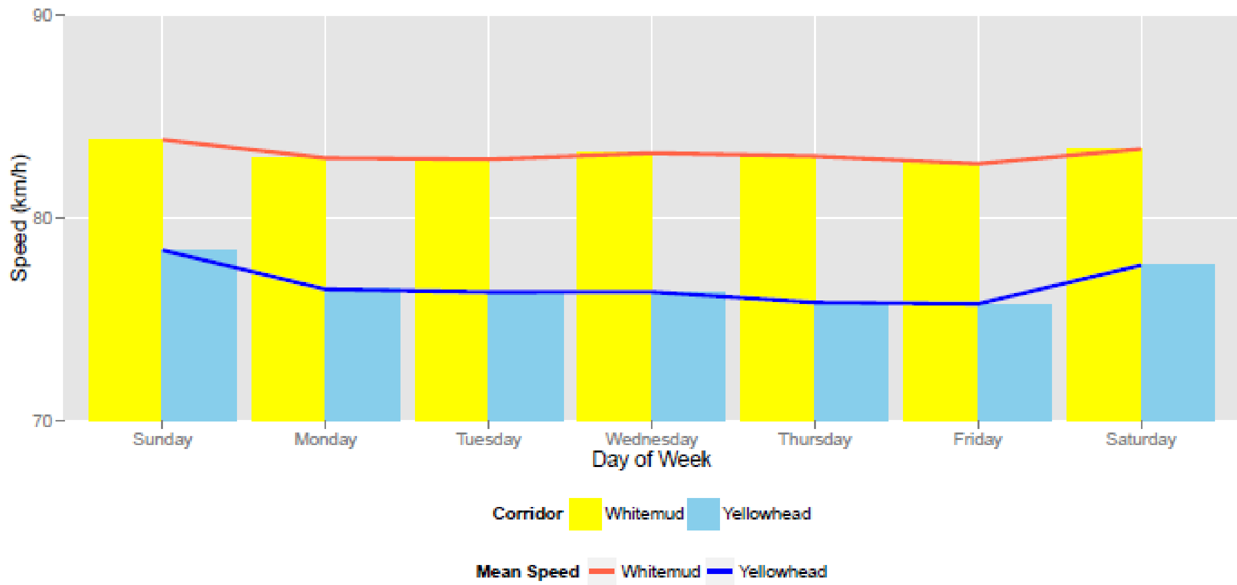


Figure B-2 Mean Speed by Day of Week

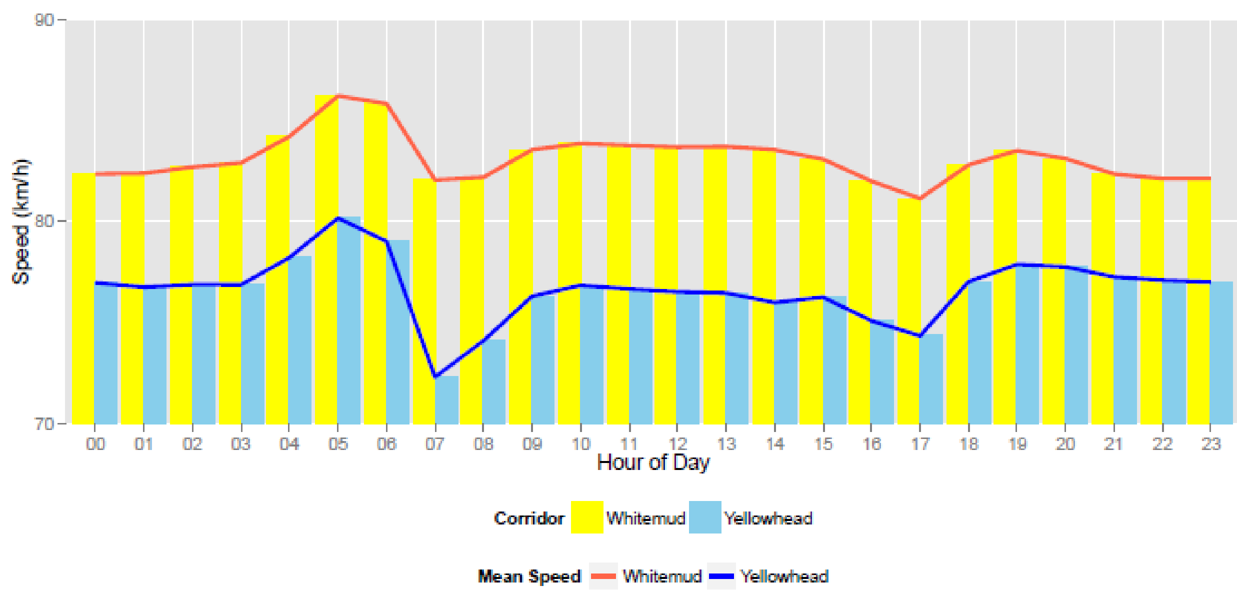


Figure B-3 Mean Speed by Hour of Day

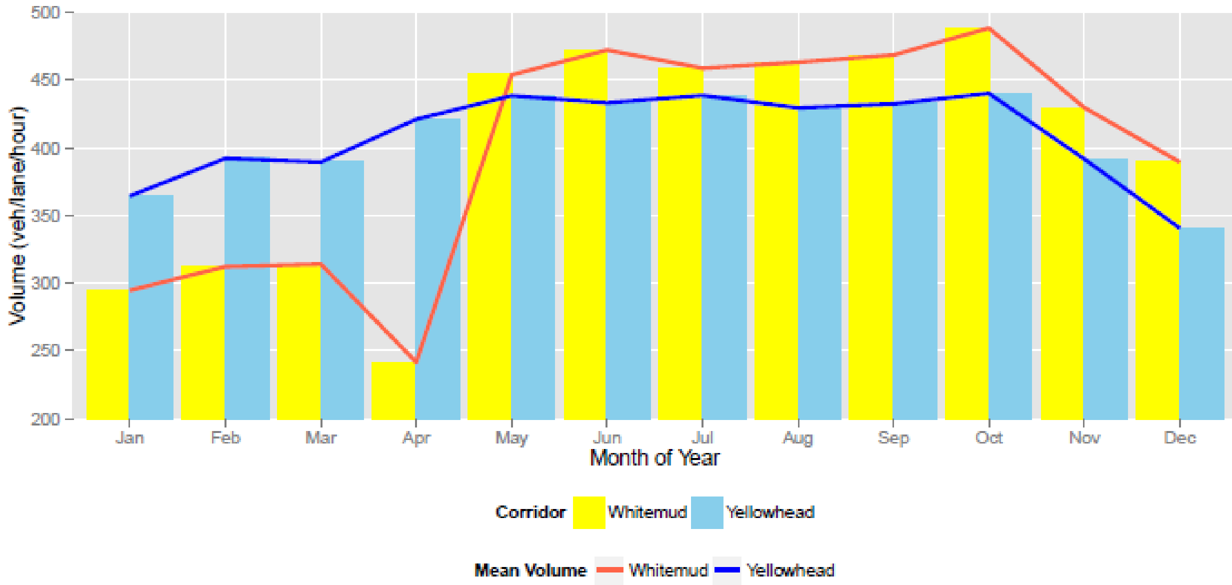


Figure B-4 Mean Volume by Month of Year

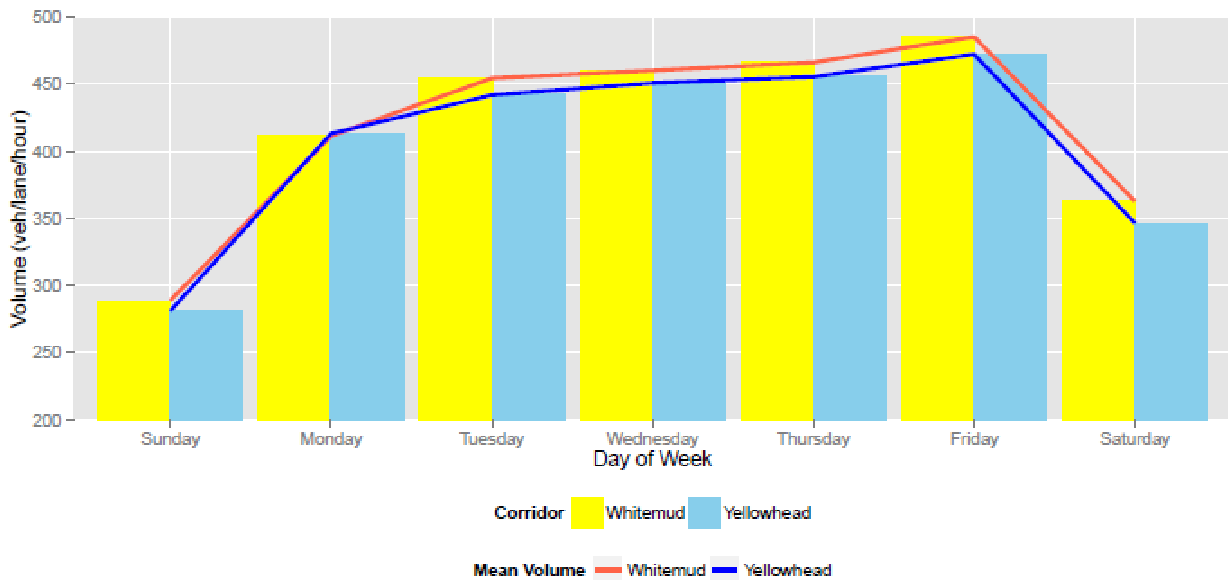


Figure B-5 Mean Volume by Day of Week

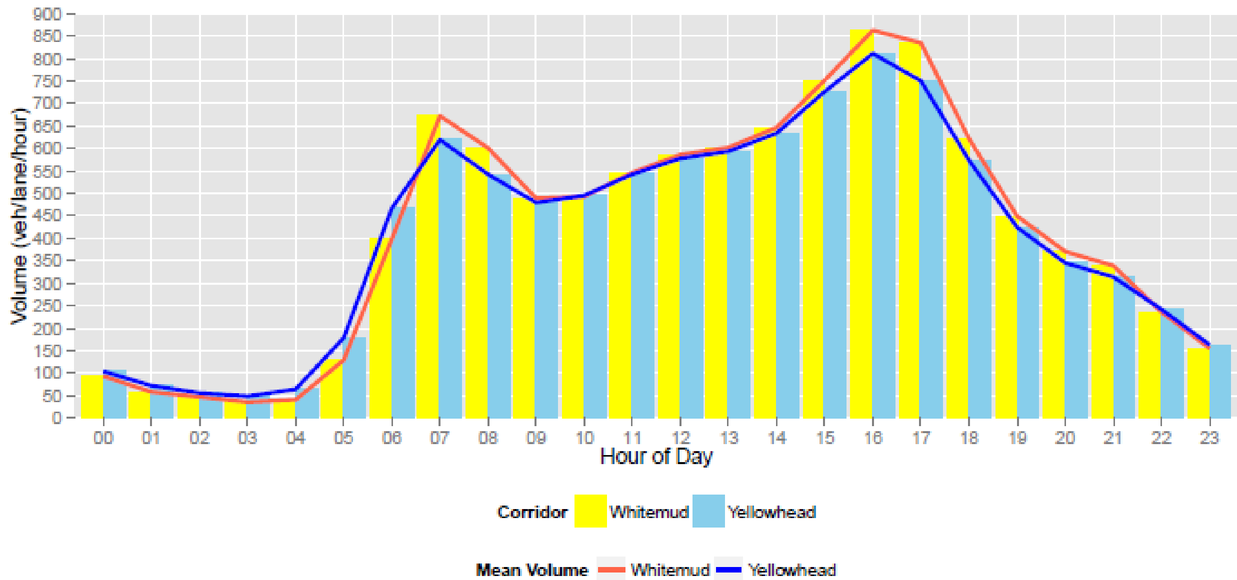


Figure B-6 Mean Volume by Hour of Day[8]

WMD VDS data analysis on through lanes, on- and off-ramps

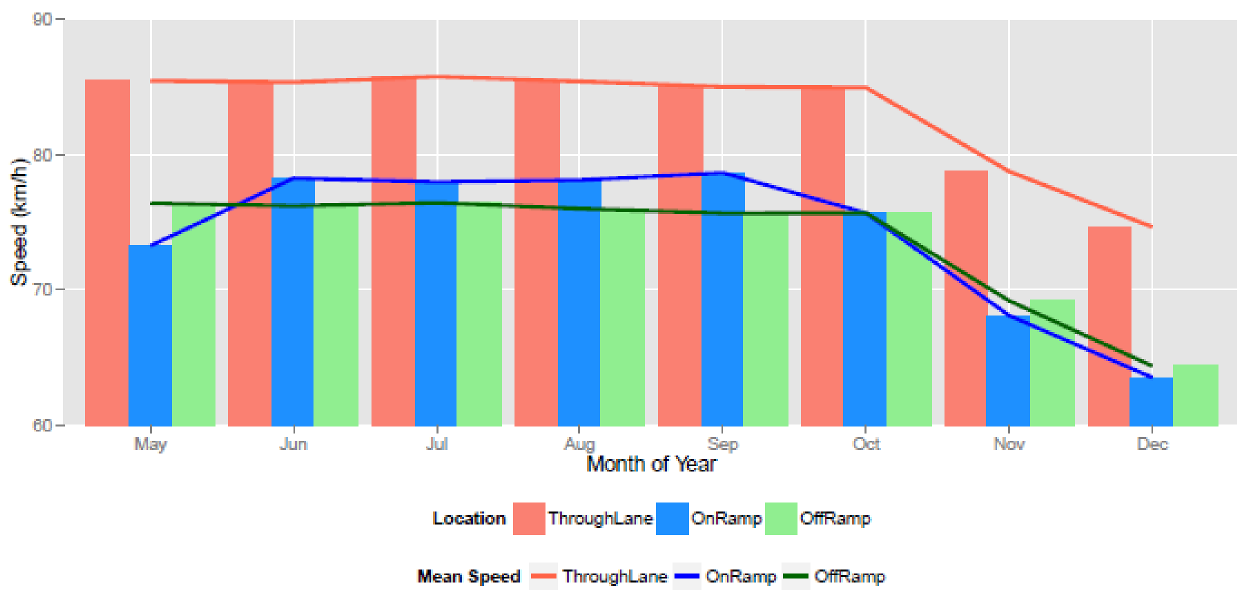


Figure B-7 Monthly Speed Distributions of Through Lanes, On-Ramps and Off-Ramps

[8] The pattern in Figure B-6 is similar to the pattern in Figure 11, Section 4.3, page 22 of the main report.

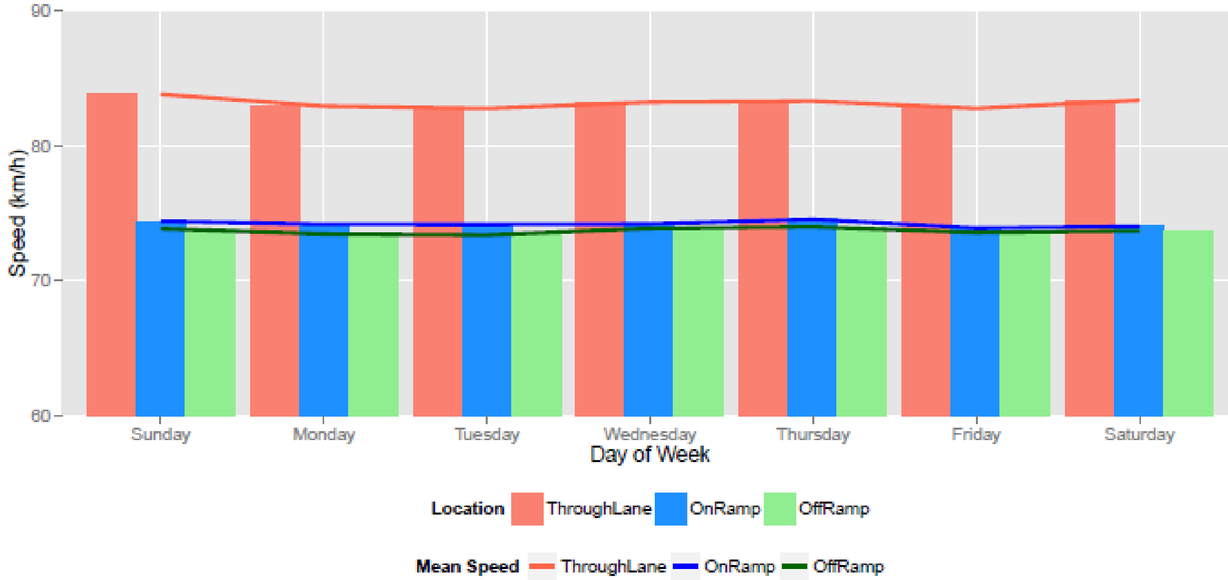


Figure B-8 Weekly Speed Distributions of Through Lanes, On-Ramps and Off-Ramps

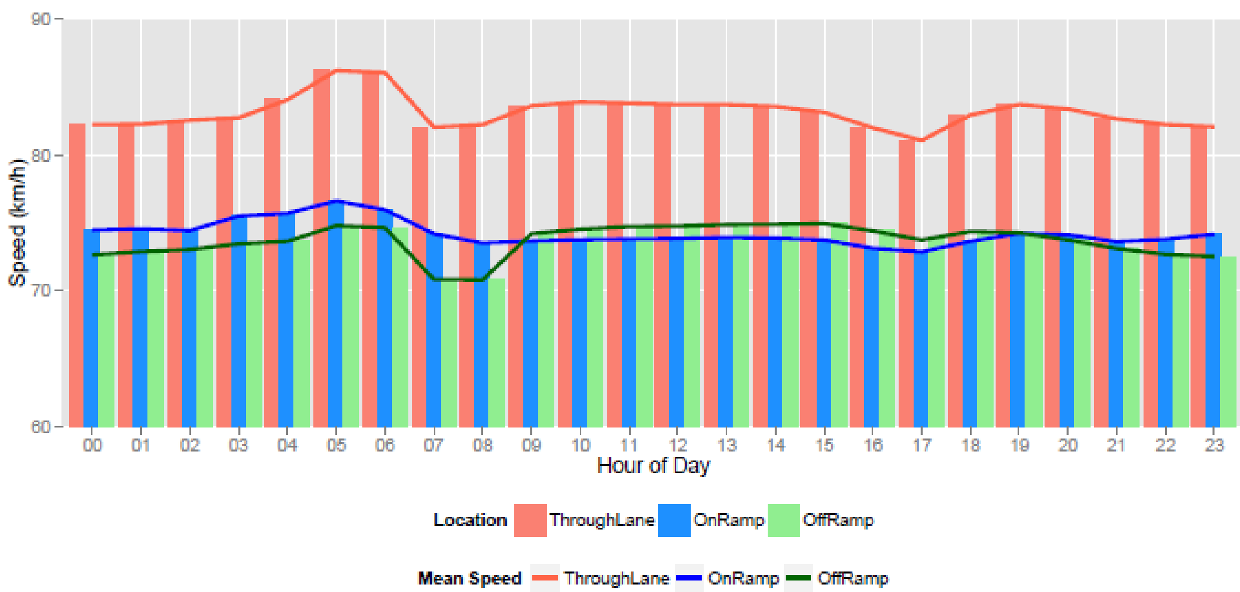


Figure B-9 Hourly Speed Distributions of Through Lanes, On-Ramps and Off-Ramps

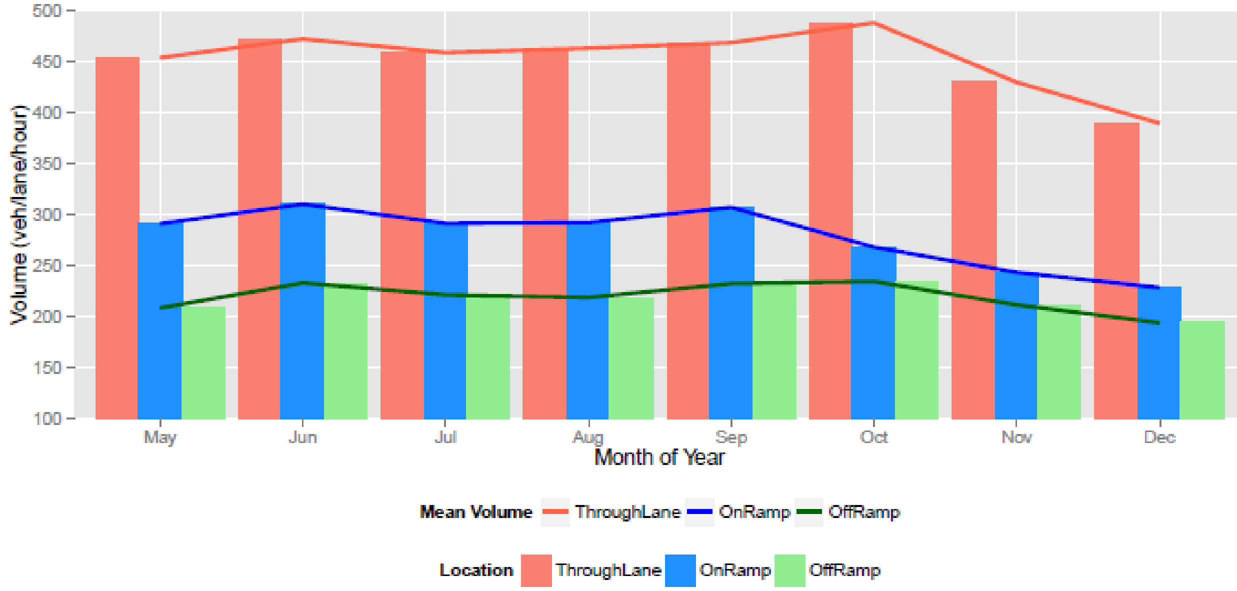


Figure B-10 Monthly Volume Distributions of Through Lanes, On-Ramps and Off-Ramps

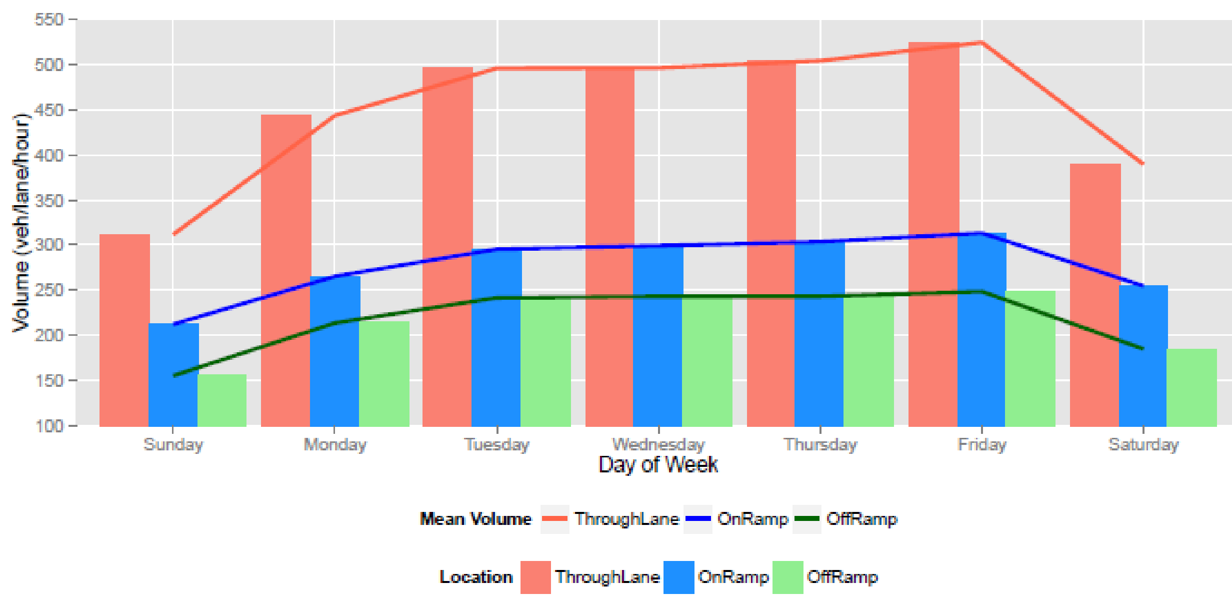


Figure B-11 Weekly Volume Distributions of Through Lanes, On-Ramps and Off-Ramps

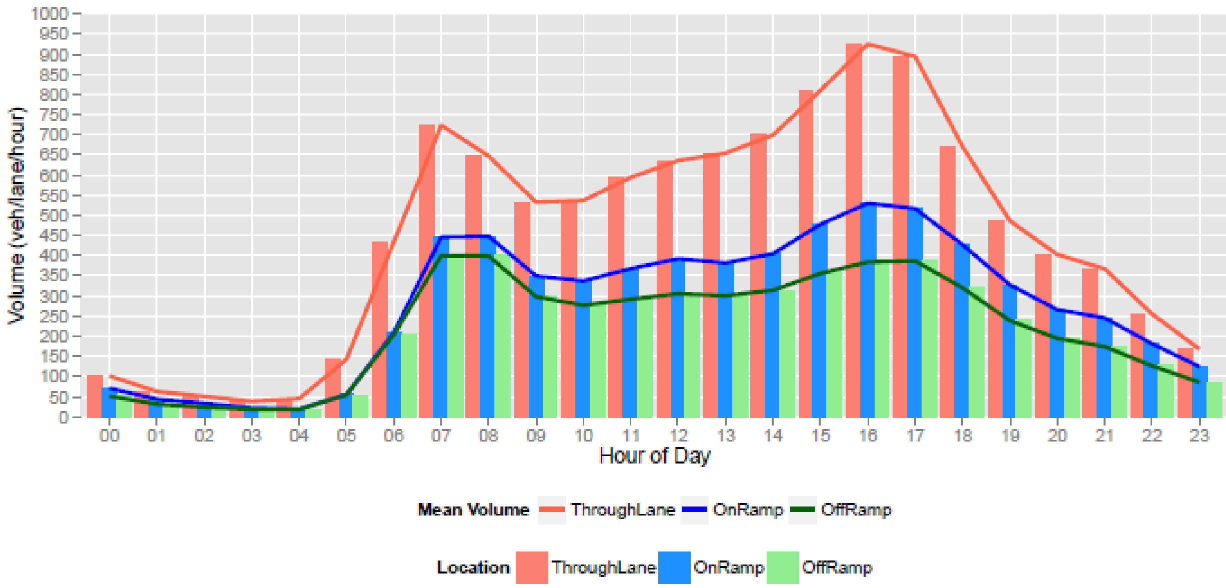
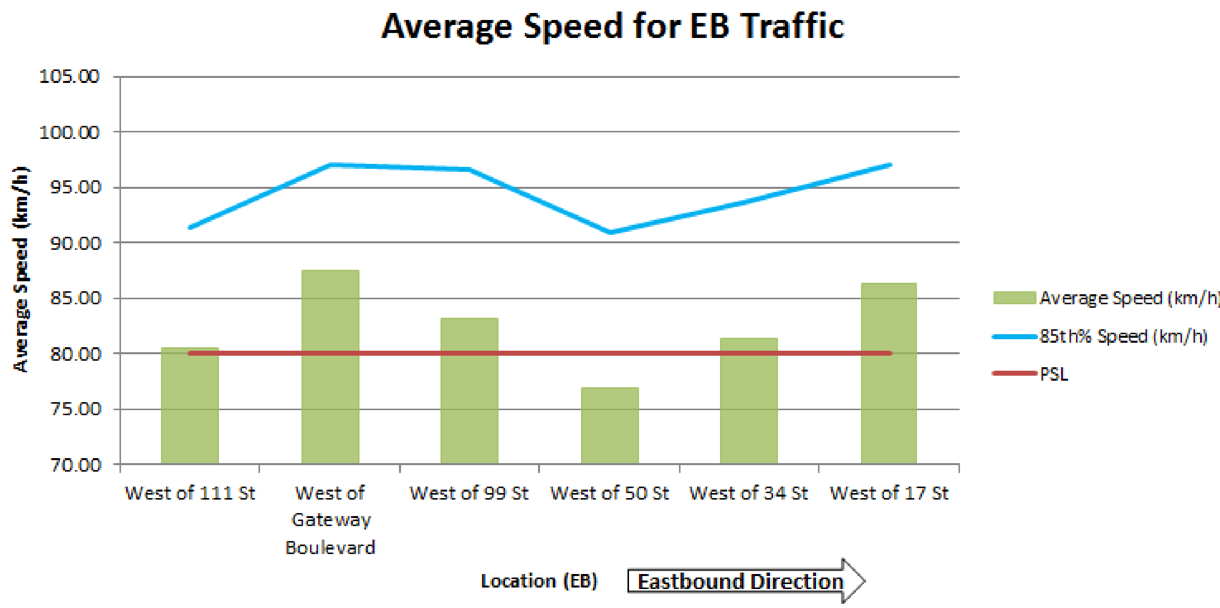


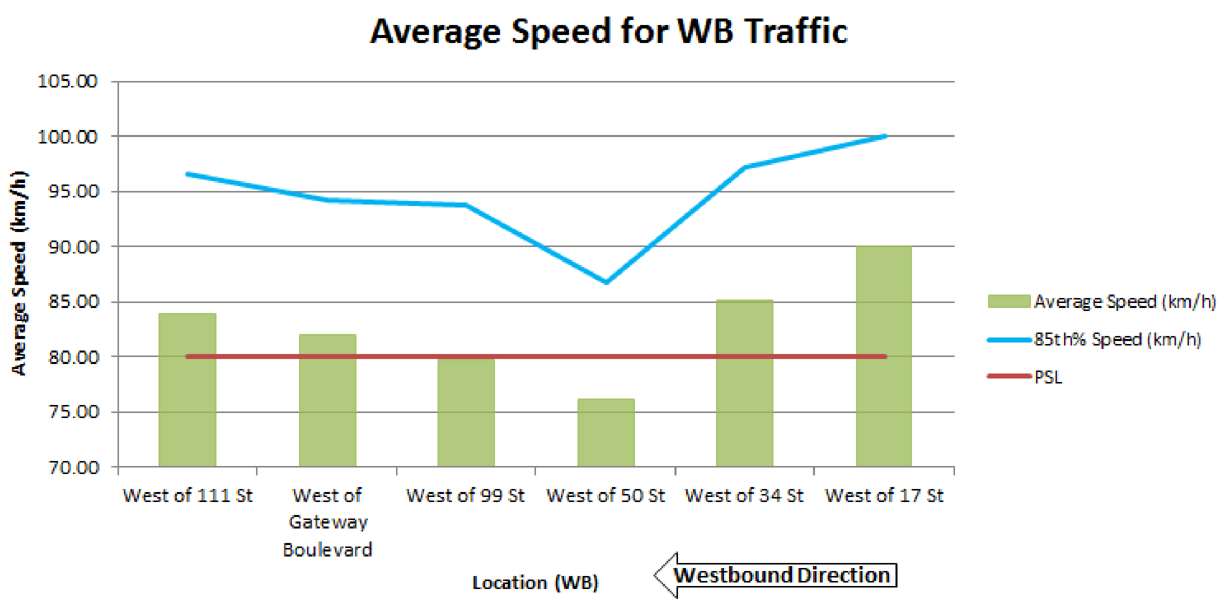
Figure B-12 Hourly Volume Distributions of Through Lanes, On-Ramps and Off-Ramps

Appendix B.2 Temporary Speed Survey Data and Statistics

The city of Edmonton conducts temporary speed surveys via specialized equipment, such as NC200. The temporary speed surveys along WMD were also analyzed.



(a) EB



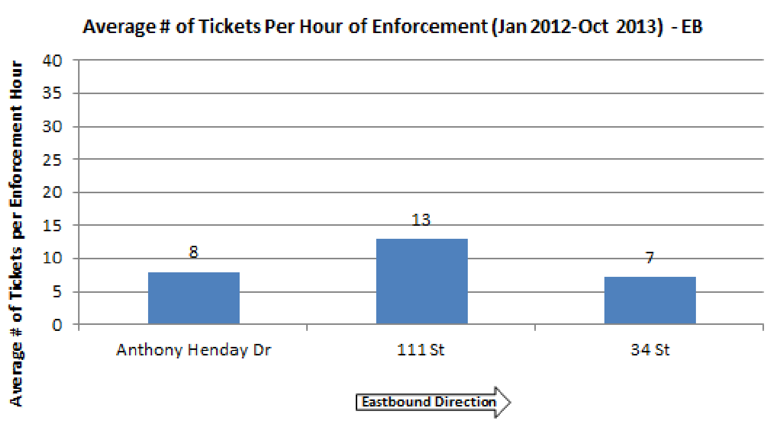
(b) WB

Figure B-13 Distribution of Temporary Speed Survey Data: WMD EB

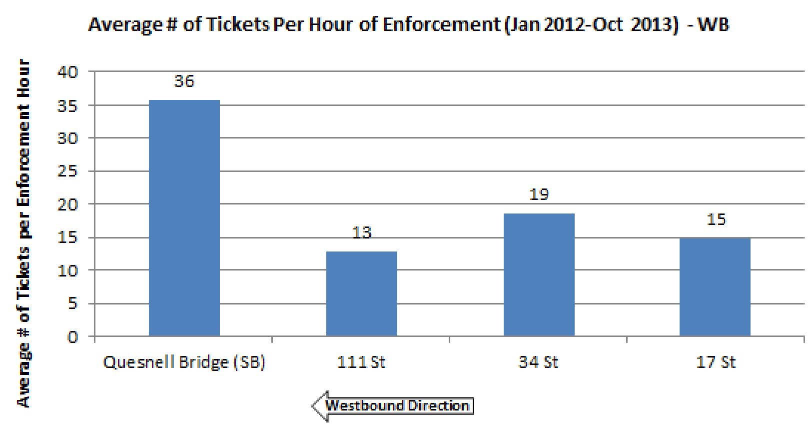
Appendix C. Speed Enforcement statistics

Appendix C.1 Automated Enforcement

Figure C-1 shows the distribution of speeding tickets per enforced hour from AE by PL. On average, the speeding violations detected using PL are significantly higher than those detected using PR. In the EB direction, WMD and 111 Street experienced the highest frequency of tickets issued per hour of enforcement, at 13. In the WB direction, WMD and Quesnell Bridge experienced the highest frequency of tickets per hour of enforcement, at 36. These high frequencies are an indication of the severity of the speeding concern at key locations along WMD.



(a) EB



(b) WB

Figure C-1 Distribution of Speeding Tickets Enforced by Photo Laser

The pattern shown in Figure C-1 is similar to the pattern shown in Figure 5, Section 2.3, page 8-9, in the main report: speeding violations, represented by the number of tickets per enforced hour, fluctuated along different segments and different directions of travel along WMD. However, in general, speeding violations were issued throughout the whole stretch of WMD.

AE speeding violations (number of violations per enforced hour by either PR or PL) by monthly distribution is shown in Figure C-2.

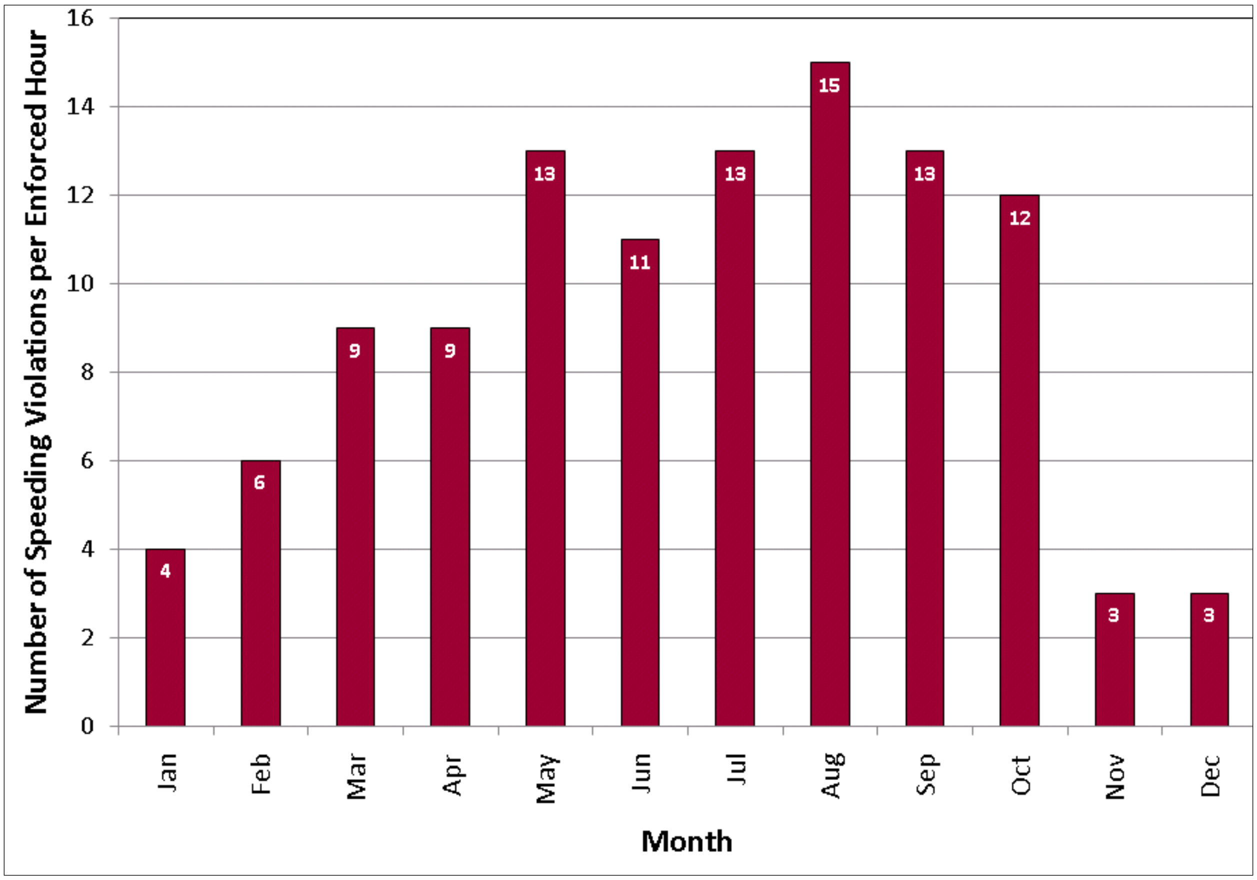


Figure C-2 Monthly Distribution of WMD AE Speeding Violations

AE speeding violations (number of violations per enforced hour by either PR or PL) by day of week distribution is shown in Figure C-3.

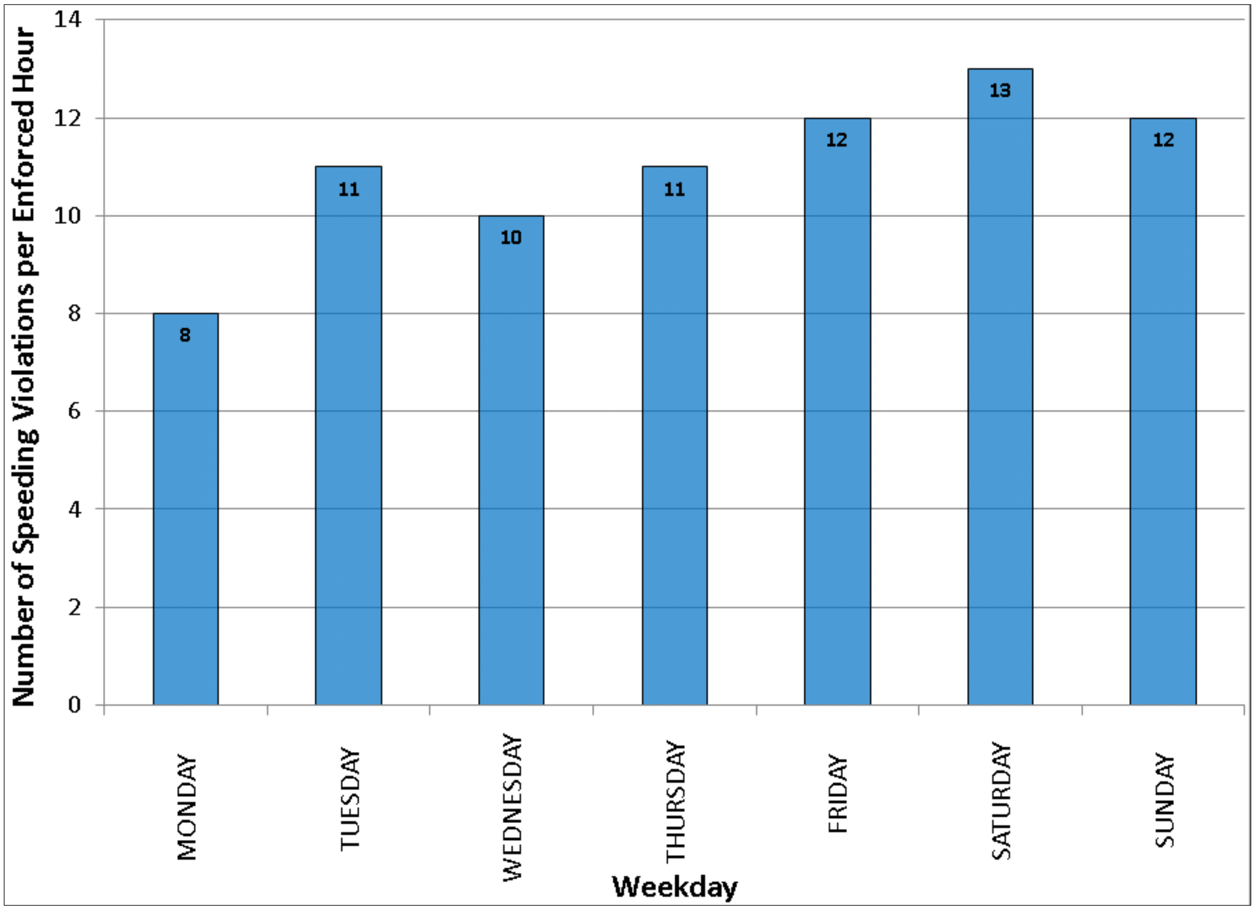


Figure C-3 Weekly Distribution of WMD AE Speeding Violations

AE speeding violations (number of violations per enforced hour by either PR or PL) by hourly distribution is shown in Figure C-4.

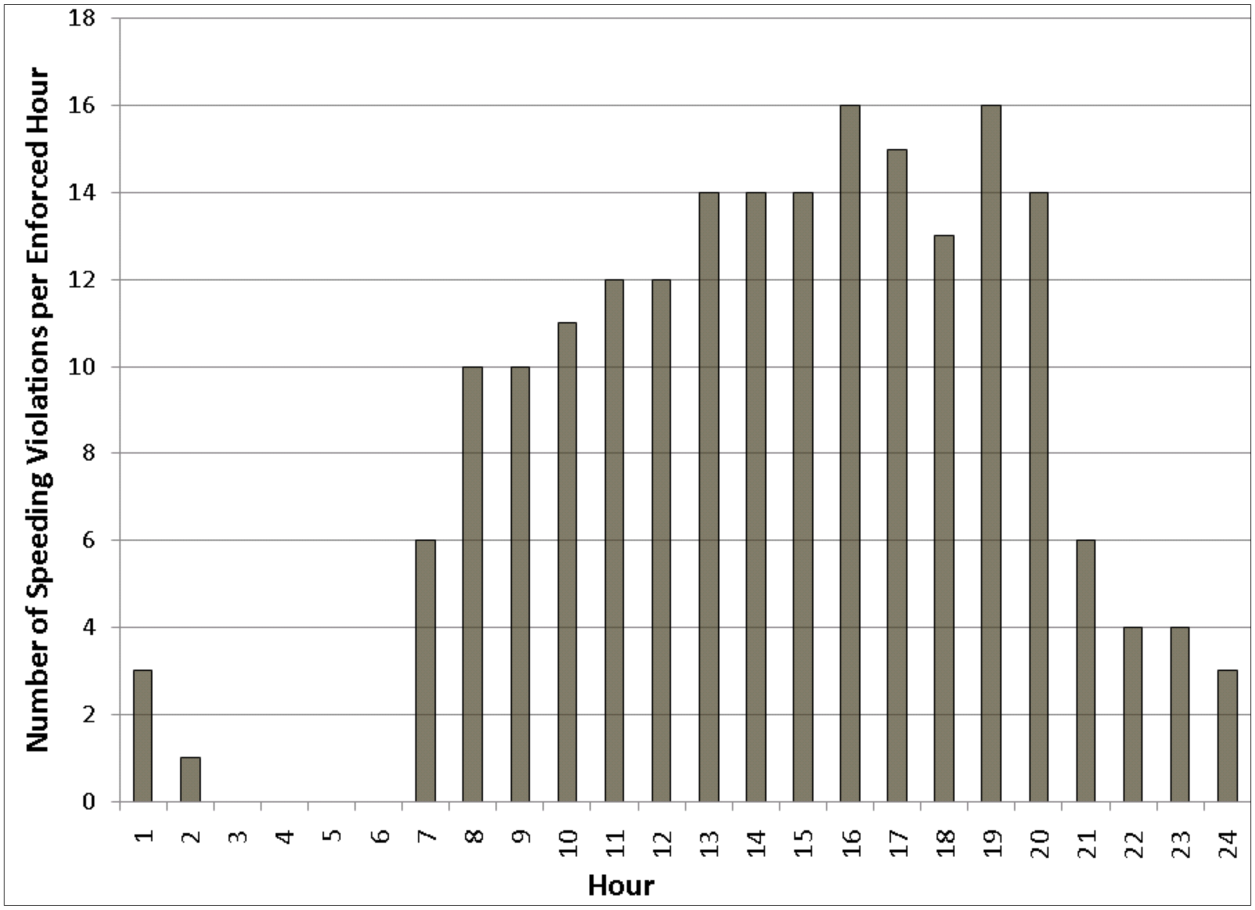


Figure C-4 Hourly Distribution of WMD AE Speeding Violations

Appendix C.2 Manned Enforcement

Figure C-5 shows the top 10 speed violation locations along WMD from 2012 to 2013. WMD and 34 Street and 66/75 Street are the two locations with the highest frequency of speed violations.

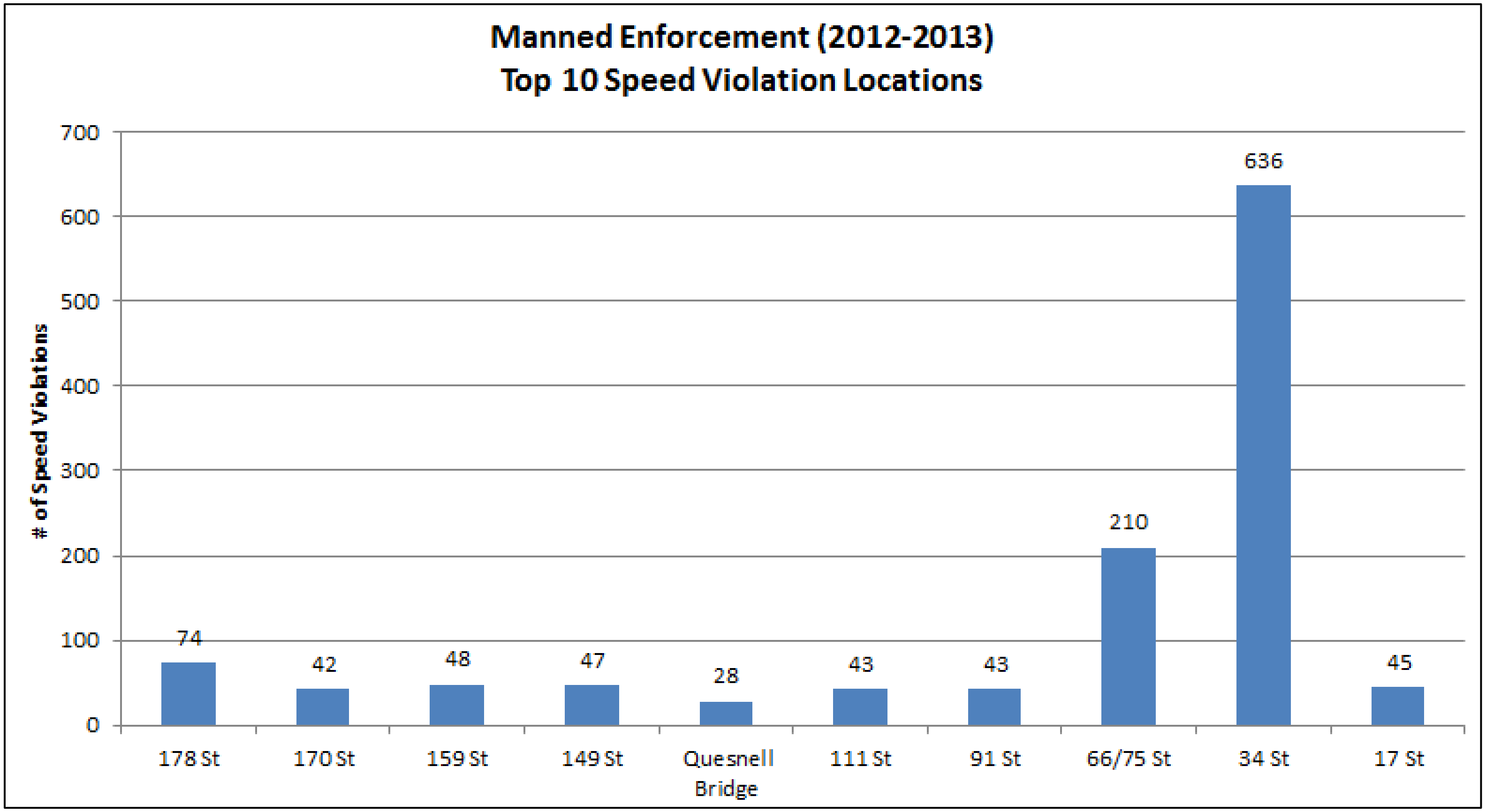


Figure C-5 Top 10 Speed Violation Locations WMD (2012 to 2013)

The monthly distribution of ME speed violations from 2012 to 2013 is shown in Figure C-6. The frequency of speed violations was rather consistent throughout all of the months of the year with an increase in the summer months.

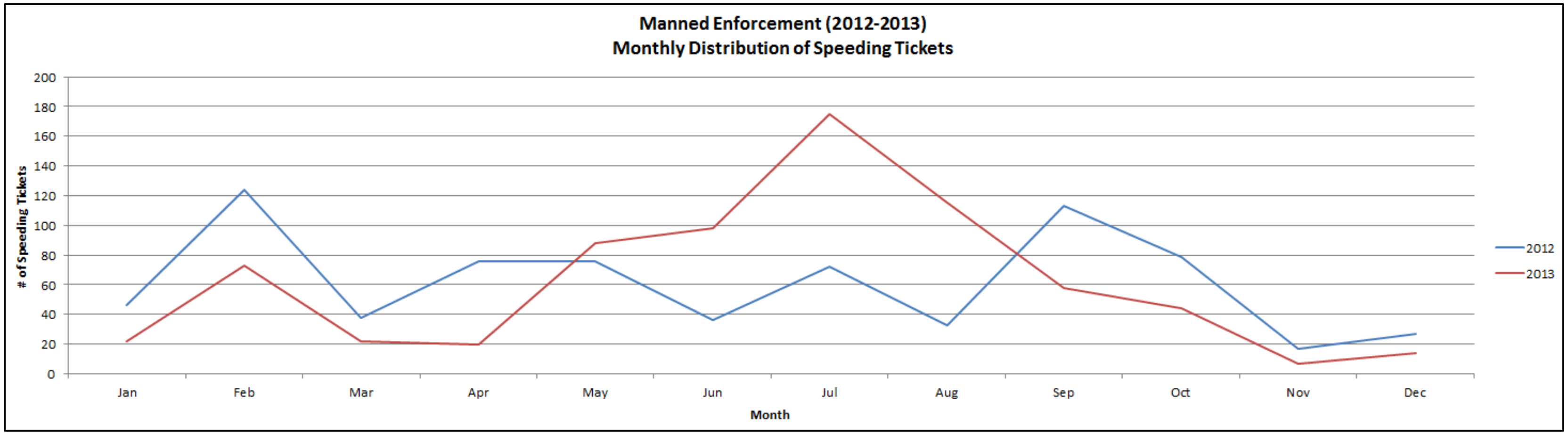


Figure C-6 Monthly Distribution of WMD ME Speeding Violations

The ME speed violation distribution of weekdays vs. weekends is shown in Figure C-7. As expected, the frequency of speeding violations was higher during off-peak periods in general, and more specifically during the weekdays.

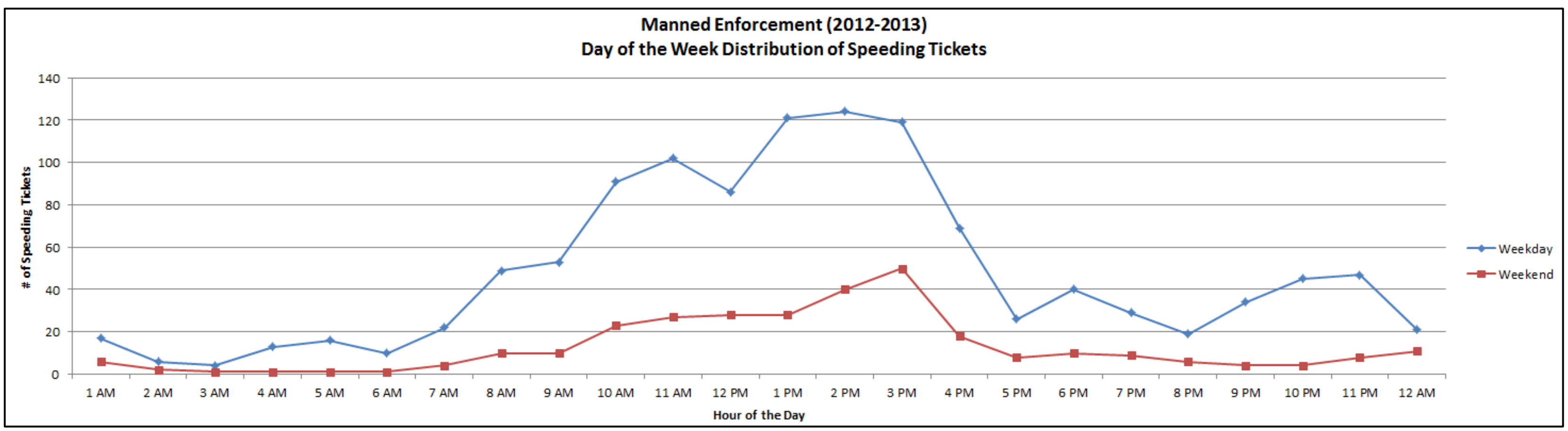


Figure C-7 Distribution of WMD ME Speeding Violations: Weekdays vs. Weekends

The hourly distribution of ME speed violations from 2012 to 2013 is shown in Figure C-8. There was little difference between the frequencies of speed violations in 2012 compared to 2013. The hourly distribution is quite consistent; the highest frequencies were during the off-peak periods during the day when there is more traffic traveling at free-flow speed.

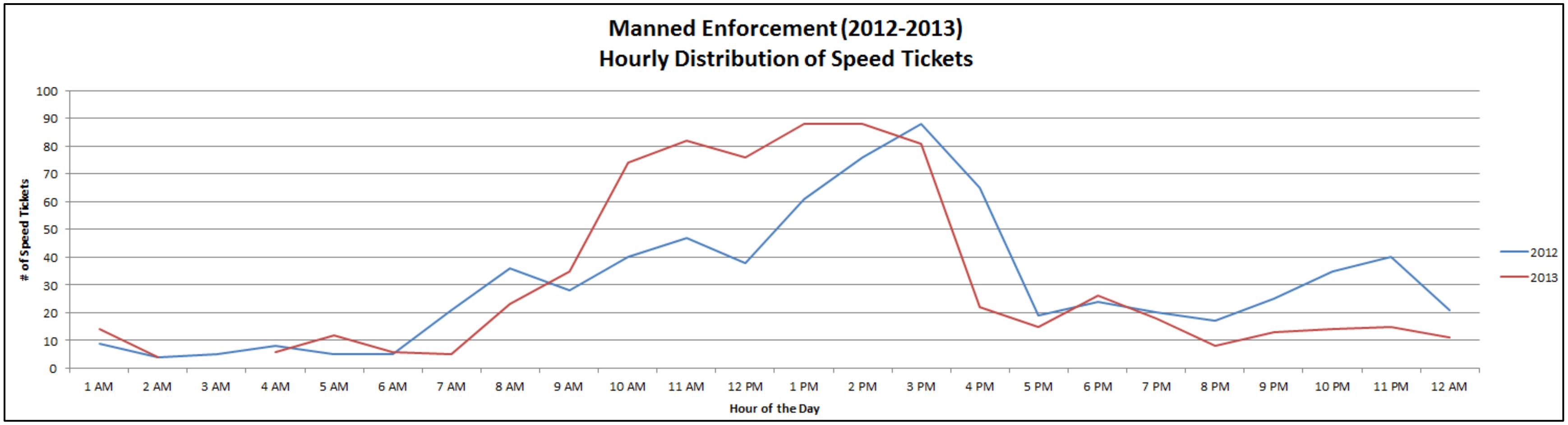


Figure C-8 Hourly Distribution of WMD ME Speeding Violations