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**Final Report**

# **State Farm Intersection Safety Studies**

**Lake Otis Parkway at Tudor Road**

**New Seward Highway at Fireweed Lane**

**Old Seward Highway at Dimond Boulevard**

**New Seward Highway at 36<sup>th</sup> Avenue**

**Northern Lights Boulevard at Boniface Parkway**

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16. Abstract The Municipality of Anchorage (MOA), the Alaska Department of Transportation, and the State Farm Mutual Insurance Companies have identified the intersections of Lake Otis Parkway at Tudor Road, New Seward Highway at Fireweed Lane, Old Seward Highway at Dimond Boulevard, New Seward Highway at 36 <sup>th</sup> Avenue, and Northern Lights Boulevard at Boniface Parkway as intersections that have relatively poor safety records, and might benefit from intersection safety reviews. The goals of the intersection safety reviews are to analyse the subject intersections, identify traffic safety problems (if any), develop strategic solutions to the identified problems, evaluate the technically feasible solutions, and recommend appropriate actions. The study method followed a systematic process to review physical, traffic, collision and conflict characteristics, and to generate and evaluate improvement options.			
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# Table of Contents

Table of Contents .....	i
<b>Executive Summary.....</b>	<b>iv</b>
LOP at Tudor Road Intersection .....	v
NSH at Fireweed Lane.....	viii
OSH at Dimond Boulevard .....	xi
NSH at 36 <sup>th</sup> Avenue .....	xiii
NLB at Boniface Parkway .....	xvi
Global Safety Issues .....	xviii
Claims Data.....	xix
<b>1.0 Introduction.....</b>	<b>1</b>
1.1 Study Areas .....	1
1.2 Study Goal .....	4
1.3 Method.....	4
A. Collision Analysis .....	7
B. Claims Data .....	8
C. Conflict Data.....	9
D. Solutions.....	9
E. Economic Evaluation.....	10
<b>2.0 Lake Otis Parkway at Tudor Road.....</b>	<b>11</b>
2.1 Site Characteristics .....	11
2.2 Collision Analysis .....	12
2.3 Traffic Conflict Analysis .....	15
2.4 On-site Observations .....	16
2.5 Identified Safety Problems and Issues.....	18
2.6 Improvement Strategy .....	19
2.7 Economic Evaluation.....	20
<b>3.0 New Seward Highway at Fireweed Lane.....</b>	<b>21</b>
3.1 Site Characteristics .....	21
3.2 Collision Analysis .....	23
3.3 Traffic Conflict Data .....	24
3.4 On-site Observations .....	25

3.5	Identified Safety Problems and Issues.....	27
3.6	Improvement Strategy .....	28
3.7	Economic Evaluation .....	29
<b>4.0</b>	<b>Old Seward Highway at Dimond Boulevard .....</b>	<b>31</b>
4.1	Site Characteristics .....	31
4.2	Collision Analysis .....	32
4.3	Traffic Conflict Data .....	34
4.4	On-site Observations .....	34
4.5	Identified Safety Problems and Issues.....	37
4.6	Improvement Strategy .....	37
4.7	Economic Evaluation .....	38
<b>5.0</b>	<b>New Seward Highway at 36<sup>th</sup> Avenue .....</b>	<b>40</b>
5.1	Site Characteristics .....	40
5.2	Collision Analysis .....	42
5.3	Traffic Conflict Data .....	44
5.4	On-site Observations .....	44
5.5	Identified Safety Problems and Issues.....	47
5.6	Improvement Strategy .....	48
5.7	Economic Evaluation .....	49
<b>6.0</b>	<b>Northern Lights Boulevard &amp; Boniface Parkway Intersection .....</b>	<b>51</b>
6.1	Site Characteristics .....	51
6.2	Collision Analysis .....	52
6.3	Traffic Conflict Data .....	54
6.4	Site Observations .....	56
6.5	Identified Safety Problems and Issues.....	56
6.6	Improvement Strategy .....	57
6.7	Economic Evaluation .....	57
<b>7.0</b>	<b>Global and Network Safety Issues .....</b>	<b>60</b>
7.1	Street Network Connectivity.....	60
7.2	Speed Zoning.....	61
7.3	Intersection Related Issues.....	62
7.5	Driver Behavior.....	63
7.6	Vehicle Fleet .....	63
7.7	Integrating Safety .....	64
<b>8.0</b>	<b>Claims Data Analysis .....</b>	<b>65</b>

9.0	Conclusions.....	67
	Appendix A.....	71
	Traffic Conflict Technique and Methodology .....	72
	Traffic Conflict Observation Period.....	74
	Appendix B.....	76
	Calculation of the Critical Collision Rate .....	77
	Chi-square Test .....	78
	Appendix C.....	79

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## Executive Summary

The Municipality of Anchorage (MOA) retained Intus Road Safety Engineering Inc. to undertake a safety review of the following intersections:

- *Lake Otis Parkway (LOP) at Tudor Road*
- *New Seward Highway (NSH) at Fireweed Lane*
- *Old Seward Highway (OSH) at Dimond Boulevard*
- *New Seward Highway (NSH) at 36<sup>th</sup> Avenue*
- *Northern Lights Boulevard (NLB) at Boniface Parkway*

These five intersections were identified by the State Farm Mutual Automobile Insurance Company (State Farm) as the five most dangerous intersections in Alaska. State Farm compiled the list of intersections based on motor vehicles crashes that resulted in insurance claims by its policyholders in 1999 and 2000. The list takes into account the number of crashes at various intersections, how many of those crashes involved injury, and the proportion of vehicles insured by State Farm in areas where the intersections are located.

The goals of the intersection safety reviews are to analyse the subject intersections, identify traffic safety problems (if any), develop strategic solutions to the identified problems, evaluate the technically feasible solutions, and recommend appropriate actions. The study method followed a systematic process to review physical, traffic, collision and conflict characteristics, and to generate and evaluate improvement options.

The safety performances of the intersections were reviewed using three sources of data: historical motor vehicle collision data, auto insurance claim records, and observed traffic conflicts. The collision and conflict data were used to establish predominate *safety problems* at the subject intersections. The problems were then combined with the physical and operating conditions of the intersection to determine which (if any) infrastructure elements were causing these safety problems. Technically feasible solutions to the identified problems

were developed, and underwent an economic evaluation to assist in prioritizing remedial measures, and making recommendations on mitigating measures.

The conflict data was also combined with the field observations to identify any dormant collision risks. In other words, elements of the roadway that are known to elevate collision risk but have yet to produce collisions at the subject intersection were identified and recorded. To distinguish these elements from those that are currently precipitating collisions, they will be termed *safety issues*.

The safety problems, solutions, and economic analysis for each of the study intersections are presented in the following sections.

### **LOP at Tudor Road Intersection**

The majority of collisions occurring at this intersection are rear-end collisions. The operational analysis and site observations indicate that congestion, delay, and aggressive driving are the likely contributing factors. Signal visibility is not considered to be a contributing factor as there are long views of several LED signal heads per approach. Detailed analysis also indicates that the rear-end collision problem is not associated with eastbound vehicles in the morning sunrise.

The rear-end collisions are primarily on the westbound and northbound approaches, and are more prominent during the daylight and on dry pavement. Despite warning signs to yield the right-of-way, northbound motorists are frequently in conflict with pedestrians in the east crosswalk. This is likely contributing to the rear-end collision problem in the northbound approach. Site observations indicate that the westbound left-turn conflicts with the eastbound motorists turning “right on red”. This may be precipitating some of the westbound rear-end collisions.

Signing that conveys the information to the motorist that dual turn lanes are available at the intersection, are provided on the far-side of the intersection. While these signs are situated

well within the motorists forward field-of-view, they are likely inadequate to provide advance warning of the dual turn. This may be leading to last minute lane changes, and in turn sideswipe and rear-end collisions.

The pavement condition on the intersection approaches appears to be somewhat worn and rutted. The preponderance of collisions during the wet weather may be attributed to a less than desirable coefficient of friction. A more in-depth investigation of the pavement condition would be required to determine if this is the case.

Safety issues that were noted, but are not reflected by the collision record are as follows:

- *Location of Sign Post: The sign post located in the westbound approach median were observed to cause a number of conflicts.*
- *Vulnerable Road Users: Due to the long cycle length to accommodate the vehicular movements, vulnerable road users such as pedestrians and cyclists had to wait for an extended period to cross the intersection. This led to non-compliance and jaywalking, further increasing the collision risks for these road users.*

The potential solutions for the LOP at Tudor intersection are geared towards the rear-end (and sideswipe) collision problem. The excellent visibility of the signal displays suggests that focusing on congestion reducing measures, and better guidance through improved signing is appropriate. The feasible solutions are:

- *Reduce the “green extension” times to improve operations and reduce congestion.*
- *Shorten the cycle times to improve operations.*
- *Provide a WBND right-turn lane to improve operations on this approach, and to reduce the probability of rear-end collisions.*

- *Provide R3-8 signing upstream of the intersection on all approaches to forewarn motorists of dual turn lanes, and reduce last minute lane changes leading to sideswipe and rear-end collisions.*
- *Provide a skid resistant pavement to shorten stopping distances and reduce collision occurrence.*

The conflicts created by motorists turning right-on-red are adequately addressed through a no-right-on-red regulation. However, such a regulation would also cause an increase in delay. As the delay is also contributing to the collision risk at this location, it is likely that the safety benefits provided by the no-right-on-red regulation would be offset by the safety disbenefits of increased delay. Therefore, no-right-on-red regulations are not recommended as a potential solution.

Based on the identified safety issues at the study intersection, the suggested safety improvements are:

- *Relocate the Keep Right sign and hazard marker on westbound approach to east of the crosswalk, and remove the median tip west of the crosswalk.*

The economic analyses of the LOP at Tudor intersection solutions are shown in TABLE ES.1.

TABLE ES.1: Economic Evaluation of LOP and Tudor

IMPROVEMENT	CRF	COST (\$1,000)	B/C RATIO
<i>Shorten cycle times &amp; reduce green extension times</i>	17%	120	9:1
<i>Install a WBND right-turn lane</i>	15%	900	1:3
<i>Place R3-8 on all approaches</i>	5%	5	58:1
<i>Resurface with a skid resistant pavement</i>	20%	200	13:1

Only the westbound right-turn lane is not economically attractive. Therefore, although it would likely improve the safety performance of the intersection it is dropped from consideration as the resources required to implement the westbound right-turn lane are more effectively allocated elsewhere.

### **NSH at Fireweed Lane**

The majority of collisions occurring at this intersection are rear-end collisions. A more detailed analysis of the rear-end collisions indicate that the majority of the collisions occur on NSH, and many of those in the southbound direction. There are several factors that are thought to contribute to the rear-end collisions at this location. They are:

- *Heavy traffic flows and peak period congestion causing risky driving behavior;*
- *Last minute lane changes on the eastbound approach from the right-turn lane to the middle lane;*
- *High approach speeds both northbound and southbound on NSH;*
- *Absence of right-turn lanes and the right-turn radius for northbound to eastbound traffic is such that vehicles might be slowing excessively on NSH before making the turn;*
- *A large proportion of commercial vehicles on NSH that are restricting visibility for passenger cars (this is exacerbated by the vertical alignment of the road which presents a crest vertical curve upstream of the intersection);*
- *The lack of an advance street name sign for northbound Fireweed Lane (which is inconsistent with the upstream signalized intersections); and*
- *Worn and rutted pavement that may not be providing adequate friction.*

Signal visibility is not considered to be a contributing factor as there are long views of several LED signal heads per approach.

The safety issues identified that are not precipitating collisions at this intersection are:

- *The “Keep Right” (R4-7) sign on the east leg of the intersection presents a graphical island configuration (longitudinal island) that is much different from the physical island configuration (triangular/channelizing island); and*
- *There is potential confusion over right-of-way between the westbound motorists (who are controlled by a YIELD sign), and the pedestrians crossing in the east crosswalk (who are controlled by pedestrian signal heads).*

Based on the identified safety problems at the study intersection, the suggested safety improvements are:

- *Adjust vertical alignment on SBND approach to improve visibility of signals;*
- *Place near-side signals on the southbound approach;*
- *Provide active advance warning signs for southbound approach;*
- *Provide a southbound right turn lane;*
- *Increase turning radius for northbound right turns;*
- *Provide a northbound advance street name sign for “Fireweed Lane”; and*
- *Provide a skid resistant pavement to shorten stopping distances and reduce collision occurrence.*

It is our understanding that Fireweed Lane is to be reconfigured as a three lane cross section – eliminating the lane trap for westbound traffic. This should bring about some safety benefits to this approach, but will not be discussed further as this is a pre-approved countermeasure.

The adjustment of the vertical alignment is a costly endeavor that, in consultation with MOA and DOT staff, is probably cost prohibitive. Also the currently visibility afforded to the motorist on the southbound approach well exceeds the accepted minimum as specified by current standards.

Based on the identified safety issues at the study intersection, the suggested safety improvements are:

- *Replace the R4-7 “Keep Right” sign with either a R4-7b (a worded “keep right sign) or a W1-6 (“One direction large arrow” sign) which are more consistent with the intersection approach geometry; and*
- *Reconsider the pedestrian signal heads and yield sign on the east crosswalk as it crosses the westbound to northbound right turn channel to eliminate the potential for confusion over right-of-way.*

The economic analyses of the NSH and Fireweed Lane intersection solutions are shown in TABLE ES.2.

TABLE ES.2: Economic Evaluation of HSH and Fireweed

IMPROVEMENT	CRF	COST (\$1,000)	B/C RATIO
<i>Add SBND Near-side signal heads</i>	25%	20	69:1
<i>SBND Active advance warning signs</i>	13%	500	2:1
<i>SBND right-turn lane</i>	25%	900	3:1
<i>Advance street name sign for NBND</i>	15%	6	19:1
<i>Increase NBND right turn radius</i>	15%	450	1:2
<i>Skid resistant pavement</i>	20%	200	11:1

The improvement to the northbound right-turn radius is not economically attractive and will be eliminated from further consideration as these resources could be better used elsewhere. All of the remaining countermeasures have positive B/C ratios and are candidates for implementation.

## OSH at Dimond Boulevard

The majority of collisions occurring at this intersection are rear-end collisions. The operational analysis and site observations indicate that congestion, delay, and aggressive driving are the likely contributing factors. Signal visibility is not considered to be a contributing factor as there are long views of several LED signal heads per approach. However, there is only one overhead far side signal head provided for the through and right-turn movements at the northbound and southbound approaches along OSH. The limited signal visibility may contribute to rear-end and angle collisions at the study intersection.

The rear-end collisions risk is pronounced on the southbound approach, although the collision frequency is relatively evenly distributed among all approaches. Collisions are more prominent during the daylight.

Although left-turns to and from driveways are well controlled, there is a relatively high density of driveways proximate to the intersection. The turbulence created in the traffic stream by vicinal driveways is known to increase collision risk, particularly rear-end collisions.

The pavement condition on the intersection approaches appears to be somewhat worn and rutted. A more in-depth investigation of the pavement condition would be required to determine if this is the case.

The safety issues identified at this intersection are:

- *Right-turn-on-red: Right-turn-on-red vehicles were observed to be in conflict with left-turn vehicles turning from the dual left-turn lanes. The conflicts are indicative of potential rear-end, sideswipe and angle type incidents.*

Based on the identified safety issues at the study intersection, the suggested safety improvements are:

- *Add right-turn lanes for NBND, SBND, and WBND approaches*
- *Add second NBND and SBND primary signal heads*
- *Reduce “green extension” times to improve operations*
- *Reduce cycle times to improve operations*
- *Replace the R3-8 signs with R3-5L signs and relocate them to over the lanes for EBND and WBND approaches*
- *Add R3-8 signs upstream of the intersection on all approaches*
- *Skid resistant pavement*

Upon preliminary investigation of the requirements for the right turn lanes, the southbound and westbound right turn lanes appear to require substantial property acquisition. The land taking would be significant and it is very likely that these options would be cost prohibitive. They will not be carried forward to the economic analysis.

Another potential solution is to prohibit U-turns or provide a WBND to SBND loop ramp from Dimond Boulevard to NSH to get rid of U-turning vehicles. It is not mentioned as a viable countermeasure because the operational effects of the change on the NSH and Dimond intersection are unknown, and given the land use in the north-west quadrant of the NSH and Dimond intersection, it is cost prohibitive.

The economic analyses of the OSH and Dimond Boulevard intersection solutions are shown in TABLE ES.3.

Only the northbound right-turn lane is not economically attractive. However, it is our understanding that the Alaska HSIP program has already identified this intersection as a HAL, and implementation of a northbound right-turn lane is being considered regardless of the unfavorable economic analysis. This turn lane will improve the safety performance of this intersection, but as it is already under consideration, and it does not appear to be economically attractive, it will not be considered further in this study. Of the remaining three countermeasures, the combined CRF (if all remaining options are implemented) is -42%, which yields an overall B/C ratio of 13:1. The -42% CRF would decrease the collision rate,

but not below the statewide average for signalized intersections, and is therefore a reasonable estimate.

TABLE ES.3: Economic Evaluation of OSH and Dimond

IMPROVEMENT	CRF	COST (\$1,000)	B/C RATIO
<i>NBND right turn lane</i>	25%	300	1:2
<i>Add NBND and SBND primary signal heads</i>	25%	70	8:1
<i>Reduce green extensions</i>	17%	15	97:1
<i>Replace and relocate R3-8 signs &amp; add R3-8 signs in all directions</i>	5%	5	66:1
<i>Skid resistant pavement</i>	20%	200	8:1

### NSH at 36<sup>th</sup> Avenue

The safety problems identified at the intersection of NSH and 36<sup>th</sup> Avenue are manifested in rear-end collisions on dry roads. The high approach speeds on NSH and the relatively congested operations are elevating the rear-end collision risk. In addition, on the northbound approach, where the rear-end collision risk is more pronounced, the transition from the freeway segment of the NSH to the arterial segment is not well defined visually, and creates an expectancy violation when the signal is encountered by northbound traffic.

Rear-end and sideswipe collisions are likely being produced on the southbound exit from the intersection by westbound left-turn vehicles that are forced to turn into the southbound curb and center lanes, and eastbound right-turning vehicles turning into the curb lane. The southbound curb lane is a “must exit” from NSH to Tudor Road, and motorists who have just completed the turn onto NSH from 36<sup>th</sup> Avenue who are not destined for Tudor Road will perform last minute lane changes and braking, creating sideswipes and rear-end collisions.

The left-turns being completed by eastbound and westbound traffic is made more difficult by the intersection skew. A significant intersection skew is generally an unexpected condition, and the greater than 90 degree turns increase the complexity of lane tracking and position. This unexpected increase in mental workload, would be compensated by slowing which in turn increases the propensity for rear-end collisions.

The safety issues associated with this intersection are:

- *The chevron signs placed on the median island for eastbound and westbound traffic are used in a non-standard manner and may be causing confusion and rear-end collisions.*

Based on the identified safety issues at the study intersection, the suggested safety improvements are:

- *Add a guide sign on the WBND approach for the dual turn lanes.*
- *Replace and relocate the YIELD signs in the NBND and SBND right-turn channels*
- *Reduce the “green extension” times and cycle times to improve operations*
- *Add R3-8 signs upstream on all approaches*
- *Replace the R3-8 signs with R3-5L signs on the NBND and SBND approach, and relocate them over the lanes*
- *Post rectangular black on yellow warning signs for northbound traffic indicating “Freeway Ends XX miles”*
- *Skid resistant pavement*

Intersections that are not right-angle intersections have an increased collision risk because of a variety of human factors concerns. Reconstructing the intersection to provide a right-angle of intersection is always a solution but in this instance it is not feasible because of property and other concerns.

In the longer term, as NSH is a freeway south of the 36<sup>th</sup> Avenue intersection it may be desirable to continue the freeway northward, and grade separate 36<sup>th</sup> Avenue. The decision to grade separate 36<sup>th</sup> Avenue is a long-range planning decision and it is not appropriate to do anything more than mention it in this study.

The chevron signs on the NSH median that are facing eastbound and westbound traffic on 36<sup>th</sup> Avenue should be removed as they are being used in a non-standard application. If the presence of the median island tip requires additional delineation, then it is suggested that delineators be used as a replacement.

The economic analyses of the NSH at 36<sup>th</sup> Avenue intersection solutions are shown in TABLE ES.4.

TABLE ES.4: Economic Evaluation of NSH and 36<sup>th</sup> Avenue

IMPROVEMENT	CRF	COST (\$1,000)	B/C RATIO
Add a guide sign on WBND approach for dual turn	15%	60	2:1
Replace and relocate YIELD signs in NBND and SBND right-turn channel	5%	5	40:1
Reduce cycle time and green extension	17%	120	7:1
Add R3-8 signs on all approaches and replace R3-8 signs on N/S approaches with R3-5L signs	5%	100	5:1
Skid resistant pavement	20%	200	9:1

All of the proposed countermeasures are economically attractive. However, the five countermeasures combine to produce a CRF that would reduce the collision rate to less than the average rate for Alaskan signalized intersections. This is statistically an unreliable

prediction and a better estimate of the collision reduction potential is -33% (which reduces the collision rate to the state-wide average). The -33% CRF yields an overall B/C ratio of 5:1.

The posting of northbound freeway ends signs (either a single sign after the Tudor road interchange) or a series of three signs at the termination, one mile upstream and two miles upstream are expected to compensate somewhat for the lack of a dramatic visual change in the drivers view at the transition. The active advance warning of the traffic signal at 36<sup>th</sup> Avenue is a key safety device, however, the static freeway ends signs should serve a priming function, and reinforce the need to slow down to arterial speeds. The freeway ends signs are recommended, but are not included in the economic evaluation because there is no significant research on the collision reduction abilities of these types of signs.

### **NLB at Boniface Parkway**

Angle and rear-end collisions are being caused by risk taking due to delay and congestion. All approaches are provided with protected-permissive left turn phasing where drivers proceeding during the permissive phase are accepting inadequate gaps leading to both left-turn-opposing-through collisions, and rear-end collisions.

Collisions are more prominent during darkness, and the roadway lighting is the probable causative factor.

All nearside right-hand-side signal displays are obstructed by landscaping, vegetation or commercial signs at the intersection, and the driveways located in close proximity to the intersection were observed to cause numerous conflicts involving right-turn vehicles.

Based on the identified safety issues at the study intersection, the suggested safety improvements are:

- *Relocate or otherwise improve the visibility of the near-side signal heads*

- *Implement protected-only left-turn phases for the EBND and WBND approaches*
- *Provide NBND and SBND right turn lanes*
- *Upgrade/improve street lighting*
- *Skid resistant pavement*

For the medium term, consider relocating or consolidating the driveways at the intersection during redevelopment of the adjacent properties. The local HSIP program has already pinpointed the west approach on NLB as being a potential candidate from improved “access management”, and the MOA and State DOT are already pursuing this option.

The economic analyses of the NLB and Boniface Parkway intersection solutions are shown in TABLE ES.5.

TABLE ES.5: Economic Evaluation of NLB and Boniface Parkway

IMPROVEMENT	CRF	COST (\$1,000)	B/C RATIO
<i>Improve visibility of near-side signal heads</i>	10%	10	70:1
<i>Convert to E/W Protected only phasing</i>	30%	50	6:1
<i>Add N/S right turn lanes</i>	15%	2400	1:10
<i>Improve lighting</i>	50%	1500	1:1
<i>Skid resistant pavement</i>	20%	200	7:1

The north and south right turn lanes are not economically attractive. This countermeasure has been given a relatively high capital cost because of known soil contamination in the area. Nevertheless, in order to produce even a 1:1 B/C ratio, the capital cost would have to be reduced to \$130,000. Despite the economic analysis a failure to provide right-turn lanes at a signalized intersection such as this is contrary to the MOA design guidelines. This has been recognized by the MOA and the Alaska DOT. Through their HSIP program, this intersection

has also been identified as needing safety improvements, and the provision of north and south right-turn lanes is being pursued through the HSIP initiative.

Improved lighting at the subject intersection is produces a B/C ratio of 1:1. Traditionally, safety improvement projects have focused on improvements that yield ratios of 2:1 or higher in order to expend resources on the most beneficial projects. The decision to proceed with the lighting countermeasure will reside with the MOA. It is perhaps prudent to undertake further analysis of the current illumination and determine if improvements are feasible. At that point, a refined cost estimate can be made, and a more accurate B/C ratio developed.

The provision of protected-only turn phasing for the east and west approaches is an economically attractive option but is not warranted according to the requirements of the MOA Office of Planning, Development and Public Works. While the protected-only phasing will certainly make the intersection safer, it will increase intersection delay (which in itself will counteract some of the safety gains), and is against local policy. The decision to pursue this option resides with the MOA.

The remaining two countermeasures (skid resistant pavement, and improving the visibility of the near-side signal heads) are economically attractive. These two measures combine to produce a CRF of -28% and a B/C ratio of 10:1. The resultant collision rate is above the state-wide average for signalized intersections and is considered a reasonable estimate.

### **Global Safety Issues**

During the site inspection and conflict observations, a number of global or network related safety issues were identified that were considered to have a significant impact on the safety performance of the study intersections. These issues are provided in this report for discussion, and may require further investigation. However, it may provide the initial momentum to start the process of addressing these issues that may result in policy changes in engineering, education and enforcement.

All intersections could benefit from the following countermeasures:

- *More frequent refreshing of pavement markings (15% reduction in all collision types)*
- *Increased police enforcement of aggressive driving (up to a 20% reduction of all collision types – but variable depending on level of enforcement and ability to sustain effort)*
- *Speed zoning rationalization*
- *Improved network connectivity*
- *System-wide adaptive signal control (i.e., SCOOT, SCATS, etc.)*

With respect to the network connectivity, the land use pattern and the street system in Anchorage are such that the north-south movements in the urban area place an enormous burden on the LOP, NSH, and OSH. Specifically, the area east of NSH is generally bisected by several open spaces that interrupt north-south traffic flow east of NSH. Motorists east of NSH that are traveling north-south and must traverse the green belt are required to use either LOP, NSH, or OSH as the most convenient and continuous north-south facilities. Global safety benefits are likely to incur if the north-south street system were more complete in the east end of Anchorage.

Many of the study intersections recommended shorter cycle times. The ability to change the cycle times requires input from the MOA signals staff. The MOA operates a closed-loop signal system and has relatively good coordination between adjacent signals. Changing the signal timing is a system-wide consideration.

### **Claims Data**

The MOA expressed a desire to explore the long-term use of claims data as a supplement to collision data. Specifically, the MOA requested that Intus conduct an analysis of claims and collision data to determine if a stable correlation existed between the two safety indicators.

The data that has been collected for this individual project is considered small or limited in statistical terms. The limited dataset is subject to random variations (i.e., noise) and it is not

possible to draw any significant conclusions respecting a correlation between claims and collision data.

Nevertheless, regression analysis was undertaken for linear, logarithmic, exponential, and power functions, with the linear regression yielding the best fit. The linear function demonstrates that about 24% of all intersection collisions are reported as insurance claims to State Farm. However, the goodness-of-fit is not very promising. The regression also indicates that five to six claims are made each year to State Farm that do not generate a collision report. This is likely due to a damage caused by a noncollision (such as a stone chip on a windshield), damage incurred in a motor vehicle collision that was not attended by the police, etc.

Apart from the regression analysis there is some concern with using claims data in engineering analysis. The insurance companies maintain databases to track client claims and not to identify high hazard locations. Since identifying an exact location of the incident is not of primary concern to the insurer, there is a justifiable concern respecting the accuracy of location reporting.

In the end, the use of claims data as a surrogate for collision data is not recommended.

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## 1.0 Introduction

The Municipality of Anchorage (MOA) retained Intus Road Safety Engineering Inc. to undertake a safety review of the following intersections:

- *Lake Otis Parkway (LOP) at Tudor Road*
- *New Seward Highway (NSH) at Fireweed Lane*
- *Old Seward Highway (OSH) at Dimond Boulevard*
- *New Seward Highway (NSH) at 36<sup>th</sup> Avenue*
- *Northern Lights Boulevard (NLB) at Boniface Parkway*

These five intersections were identified by the State Farm Mutual Automobile Insurance Company (State Farm) as the five most dangerous intersections in Alaska. State Farm compiled the list of intersections based on motor vehicles crashes that resulted in insurance claims by its policyholders in 1999 and 2000. The list takes into account the number of crashes at various intersections, how many of those crashes involved injury, and the proportion of vehicles insured by State Farm in areas where the intersections are located.

As part of State Farm's Prevention and Safety Program, funding was offered to the MOA for in-depth safety studies that could lead to actual road improvements with the goal of reducing the collision risk at the study intersections.

These intersections have also been identified by local government, through the State Highway Safety Improvement Program, as locations with an elevated crash risk. This being the case, the MOA is taking advantage of State Farm funding to conduct safety reviews for the above-mentioned intersections.

### 1.1 Study Areas

The study intersections are located in the Municipality of Anchorage, Alaska (see FIGURE 1.1). All of the intersections are signalized and fall within the boundaries of the East Anchorage Transportation Study.

Each of the individual study intersections are as follows:

- *The LOP at Tudor Road intersection is located in a commercial area in the southeastern part of the city. LOP is a major north-south arterial road, while Tudor Road is a major east-west arterial road.*
- *The NSH at Fireweed Lane intersection is located in a semi-residential and commercial area. A residential neighborhood is located east of NSH, and a commercial area is located west of the Highway. NSH is classified as a freeway and is the major north-south link in the MOA. Fireweed Lane is an arterial road that connects the western part of the municipality to the NSH.*
- *The OSH at Dimond Boulevard intersection is located in a “big-box” commercial area. OSH is a major north-south arterial road, while Dimond Boulevard is a major east-west arterial road. The intersection is located one block west of an interchange with NSH.*
- *The NSH at 36th Avenue intersection is located in a commercial area, just south of the split between NSH and OSH. 36th Avenue is minor east-west arterial road.*
- *The NLB at Boniface Parkway intersection is located in the eastern suburban area of the municipality. Boniface Parkway is a major north-south arterial road, while NLB is a major east-west arterial road.*

It is interesting to note that all of the study intersections with the exception of NSH at Fireweed Lane are considered to be congested intersections (operating at levels of service “D” or “E”) at all times of the day (i.e., AM, midday, and PM peak periods).<sup>1</sup>

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<sup>1</sup> Anchorage Congestion Management System “Status of the System Report”, Final Report, prepared by the Municipality of Anchorage’s Transportation Planning Division with Cambridge Systematics Inc. and Rader Econometrics & Engineering., December 2000.

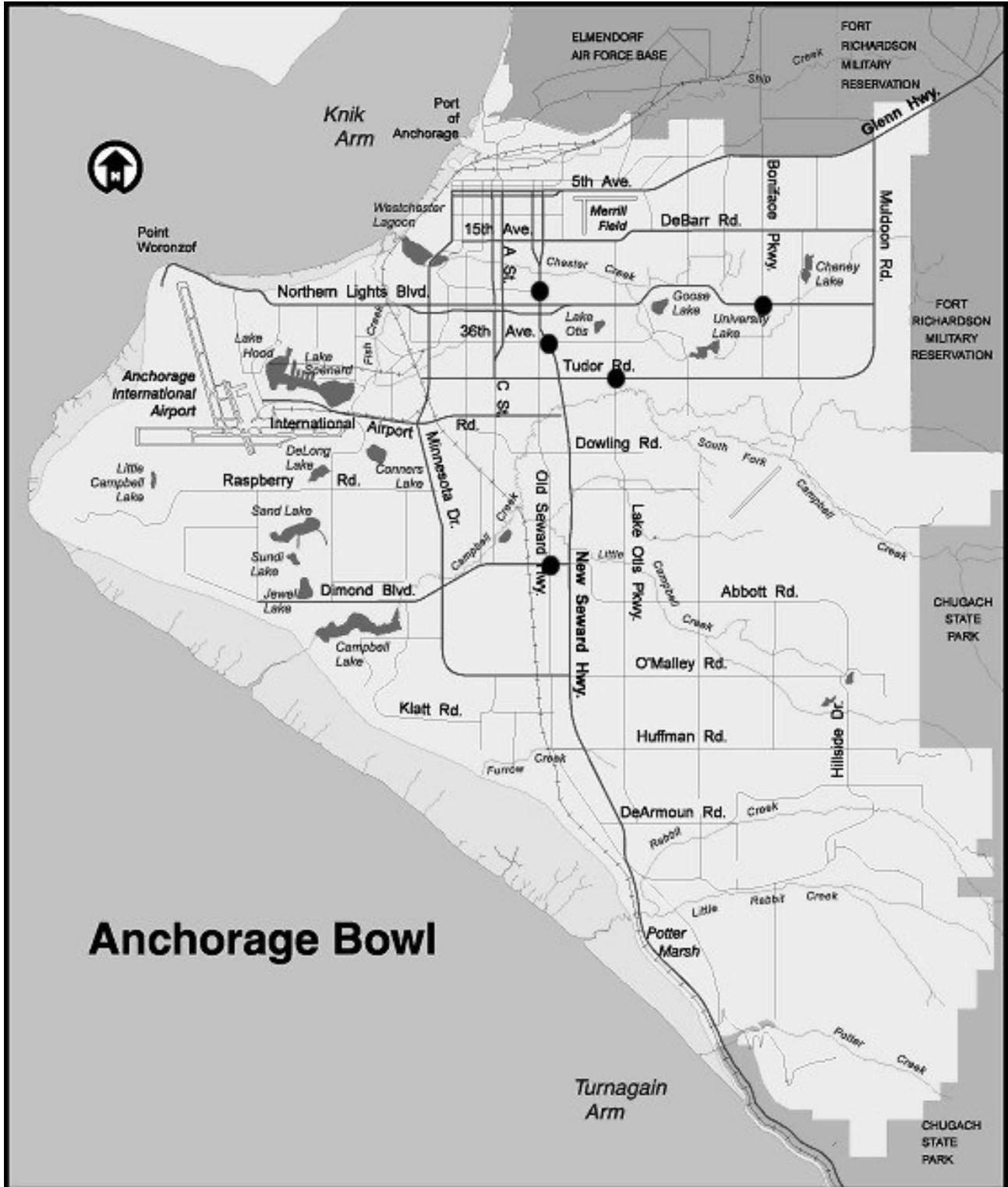


FIGURE 1.1: Study Intersections

## 1.2 Study Goal

The goals of the intersection safety reviews are to analyse the subject intersections, identify traffic safety problems (if any), develop strategic solutions to the identified problems, evaluate the technically feasible solutions, and recommend appropriate actions.

## 1.3 Method

The study method followed a systematic process to review physical, traffic, collision and conflict characteristics, and to generate and evaluate improvement options. The method is shown schematically in FIGURE 1.2.

The physical characteristics were reviewed by conducting on-site inspections of road geometry, land use, and intersection traffic control at the intersections. Additionally, a positive guidance review was conducted to determine if the information needs of the driver are satisfied and if there are any driver expectancy violations.

The analysis of human factors focuses on the ease with which the driver can traverse the intersection, given the existing physical and engineering characteristics. This analysis includes an assessment of the predictability and complexity offered to the driver, and the judgment required on the part of the driver. In analyzing human factors, we observed driver behaviour at the intersection, and the relationship between the existing geometric characteristics and driver perceptions of the intersection. It includes reviewing the visual environment (including directional and regulatory signing, landscaping, land use, and background distractions) from the perspective of the driver.

Positive Guidance is an approach to enhance the safety and operational efficiency of problem locations. It marries the transportation engineering and human factors technologies to produce a technique for identifying high-payoff, low-cost, short-range solutions to safety problems. A positive guidance review was conducted using the techniques described in the second edition of A Users' Guide to Positive Guidance (FHWA, 1981). The steps in this procedure are: identify hazards, assess hazard visibility, determine driver expectancy violations, analyse information loads, identify the information needs, and evaluate the current information system.

A positive guidance review was undertaken to assist in determining causes of collisions and to identify safety issues at the subject intersections.

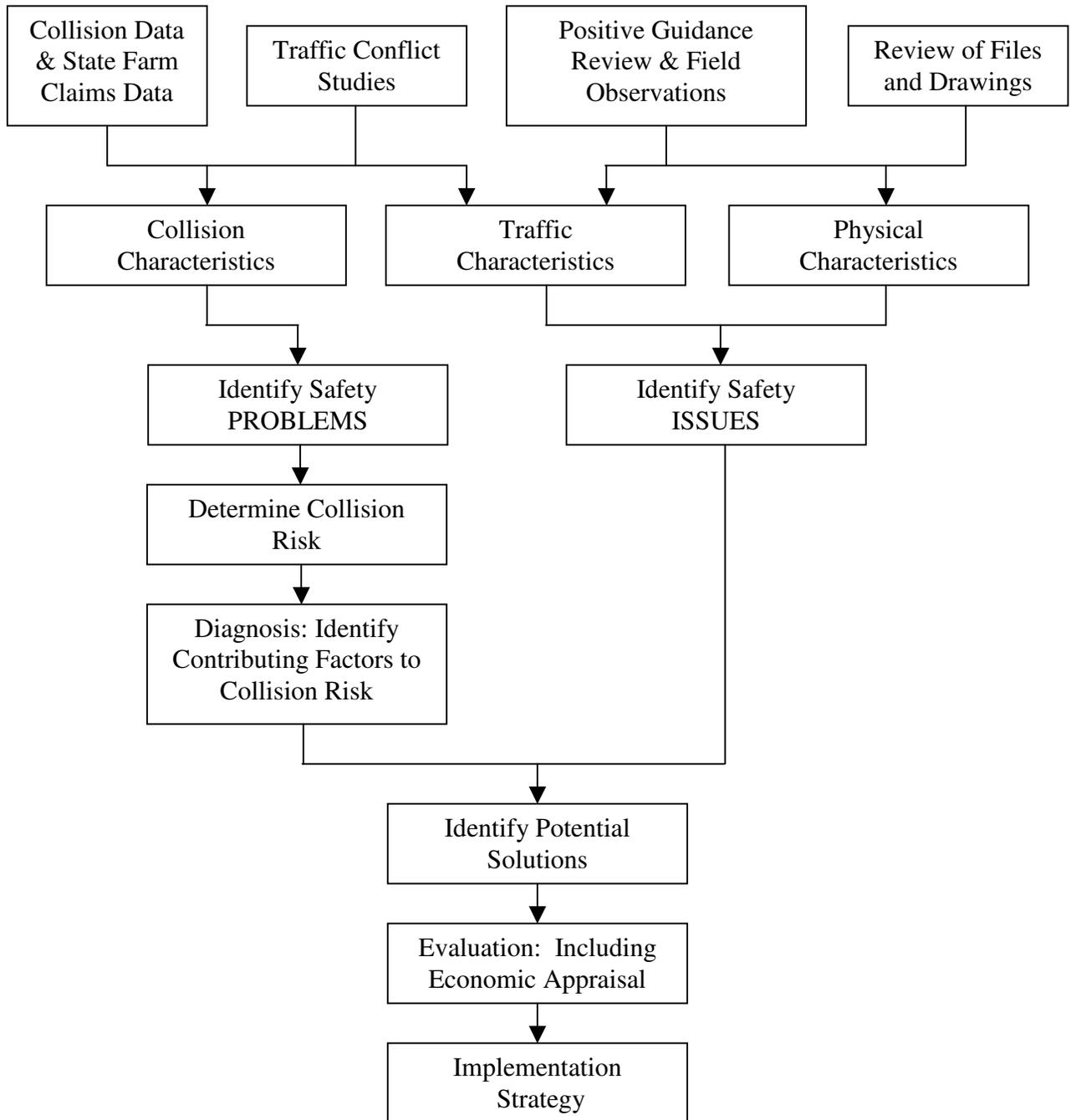


FIGURE 1.2: Study Methodology

The traffic characteristics were reviewed through field observations and an examination of intersection turning movement counts provided by the MOA. The dates that traffic was counted are shown in TABLE 1.1.

TABLE 1.1: Date of Turning Movement Counts

INTERSECTION	COUNT DATE
<i>LOP at Tudor</i>	<i>October 4, 2001</i>
<i>NSH at 36</i>	<i>June 14, 2000</i>
<i>NSH at Fireweed</i>	<i>April 4, 2001</i>
<i>NLB at Boniface</i>	<i>April 17, 2002</i>
<i>OSH at Dimond</i>	<i>November 11, 2000</i>

The safety performances of the intersections were reviewed using three sources of data: historical motor vehicle collision data, auto insurance claim records, and observed traffic conflicts. The details of each source are:

- *Collision Data: Summaries of motor vehicle collisions reported at the five intersections between January 1, 1998 and December 31, 2000 (three years) were extracted and provided by the Alaska Department of Transportation (DOT).*
- *Claims Data: Summaries of motor vehicle collision claims reported at the five intersections to the State Farm Mutual Automobile Insurance Company between January 1, 1999 and December 31, 2000 (two years) were extracted and provided by the Strategic Resources Department of State Farm.*
- *Conflict Data: The motor vehicle collision propensity was further evaluated by conducting comprehensive traffic conflict studies at the five intersections. A description of the traffic conflict technique and its application at the study intersections is included in APPENDIX A.*

The collision and conflict data were used to establish predominate **safety problems** at the subject intersections. The problems were then combined with the physical and operating conditions of the

intersection to determine which (if any) infrastructure elements were causing these safety problems. Technically feasible solutions to the identified problems were developed, and underwent an economic evaluation to assist in prioritizing remedial measures, and making recommendations on mitigating measures.

The conflict data was also combined with the field observations to identify any dormant collision risks. In other words, elements of the roadway that are known to elevate collision risk but have yet to produce collisions at the subject intersection were identified and recorded. To distinguish these elements from those that are currently precipitating collisions, they will be termed *safety issues*.

#### A. Collision Analysis

The collision records for each of the study intersections was examined as follows:

- *Number of collisions;*
- *Collision rate, and critical collision rate;*
- *Severity distribution;*
- *Hourly, daily, and monthly temporal distribution;*
- *Road condition;*
- *Light condition;*
- *Collision type; and*
- *Collision contributing cause/police citation.*

Appropriate statistical tests were used with a 95% level of confidence (see APPENDIX B) to determine if certain collision characteristics were aberrant. Rather than doggedly repeating the individual collision characteristics for each intersection, only those that were found to be aberrant are mentioned in this report.

Overall, all five intersections had a significant number of collisions over the three year analysis period, and collision rates that were above the critical rates for similar intersections (see TABLE 1.2).

TABLE 1.2: Overall Collision Statistics for the Study Intersections

INTERSECTION	NO. OF CRASHES	CRASH RATE (/MEV)	CRITICAL RATE <sup>+</sup> (/MEV)
<i>LOP at Tudor</i>	202	2.4	1.4
<i>NSH at Fireweed</i>	159	2.3	1.4
<i>OSH at Dimond</i>	136	2.1	1.4
<i>NSH at 36<sup>th</sup></i>	153	1.8	1.4
<i>NLB at Boniface</i>	104	2.1	1.4

+ - 95% level of confidence

Angle collisions, as contained in the Alaska DOT collision database, are an amalgam of different collision types. Sideswipe, turning, and right-angle collisions are all categorized as angle collisions, although the mechanism that causes each of these collisions types is vastly different. If angle collisions are identified as a potential safety problem, either through an elevated frequency or over-representation in the distribution of collision types, then the diagnosis of the problem required further classification of the angle collisions.

The claims database contains limited fields, namely: intersection, date, time, severity and facts of loss. Thus, the claims data provides limited analysis opportunities.

### B. Claims Data

The claims data made available by State Farm is limited. The generalized data is included in TABLE 1.3.

TABLE 1.3: Overall Claims Statistics for the Study Intersections

INTERSECTION	NO. OF CLAIMS	CLAIMS: COLLISION RATIO (%)	NO. OF CLAIMS THAT MATCHED COLLISION REPORTS	PROPORTION OF INJURY CLAIMS (%)
<i>LOP at Tudor</i>	47	35	19	36
<i>NSH at Fireweed</i>	29	27	20	41
<i>OSH at Dimond</i>	40	44	18	30
<i>NSH at 36<sup>th</sup></i>	29	28	19	41
<i>NLB at Boniface</i>	28	40	18	50

+ - 95% level of confidence

It is apparent from the claims:collision ratio that collisions at the study intersections generate claims to State Farm less than 45% of the time. The claims data is of limited usefulness in identifying specific collision causes and will not be carried through to the remainder of the analysis.

Nonetheless, an examination of the correlation between claims and collision data, as required by the terms of reference for this study is included in Section 8.

### *C. Conflict Data*

Traffic conflict studies were conducted at each of the study intersections as required by the study terms of reference. The traffic conflicts were measured in accordance with the procedures outlined in the Traffic Conflict Procedures Manual 2<sup>nd</sup> edition produced by Hamilton Associates, 1997. The results for each intersection are summarized herein.

### *D. Solutions*

Mitigating measures identified to help minimize the safety problems at the study intersections were engineering/infrastructure-based solutions wherever practical. It is understood that a problem usually has several solutions, with varying benefits and disbenefits. However, this study recognizes but omits extensive discussion of the following:

- *Measures that are considered to be prohibitively expensive,*
- *Measures that have been shown to be ineffective, and*
- *Measures that are incompatible with the classification of the roadway.*

Each of the remaining mitigating measures is evaluated for its collision reduction potential using existing literature (if available). It should be noted that these numbers are compiled from numerous data, and are indicative of collision reductions from a breadth of applications, that may not accurately reflect the conditions that are occurring at the study intersections. Therefore the collision reduction estimates are presented with the sole purpose of providing a ranking of collision reduction potential relative to the other proposed mitigating measures.

If more than one countermeasure is applied to a location to address the same collision type, the collective effect is not simply the sum of the CRFs. The resulting CRF was calculated as follows:

$$CRF = 1 - (1 - CRF_1) (1 - CRF_2) \dots (1 - CRF_n)$$

In addition, collisions at signalized intersections are inevitable and it is not reasonable to expect that the collision rate can be reduced significantly below the average for signalized intersections. In Alaska signalized intersections with four approaches are expected to have 1.17 collisions per million entering vehicles. Therefore, the collision rates for the subject intersections after the countermeasures are applied, should not be expected to be less than this average. In the absence of actual “after” data the most optimistic prediction of an “after” collision rate is the system-wide average for that type of facility.

Identified safety issues, which are not amenable to a benefit-cost analysis are addressed through a recommendation for either a low cost remedial treatment, or “watchful waiting” coupled with treatment during the next regularly scheduled rehabilitation of the intersection.

#### *E. Economic Evaluation*

A standard benefit-cost analysis is used to assist in evaluating the viable solutions to the identified intersection safety problems. The Alaska DOT Project Ranking Worksheet for the Highway Safety Improvement Program was used to conduct the economic analysis.

The cost estimates do not consider the economies of scale that may be realized if the countermeasures are implemented as part of a larger road reconstruction project. They do however, attempt to include costs for property acquisition. Overall the cost estimates are fairly coarse and should be reviewed in detail by the MOA and the Alaska DOT to improve on the accuracy before deciding to implement.

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## 2.0 Lake Otis Parkway at Tudor Road

### 2.1 Site Characteristics

LOP is a north-south arterial running from Huffman Road to 15<sup>th</sup> Avenue. As it crosses Tudor Road it is classified as a major urban, divided, arterial road with two basic lanes in each direction. The speed limit south of Tudor Road is 45 mph; the speed limit north of Tudor Road is 40 mph. Tudor Road is an east-west major arterial running from Minnesota Drive to Muldoon Road. As it crosses LOP, it is an urban, divided, arterial with two basic lanes in each direction. The speed limit is 45 mph.

The basic lanes on both streets are supplemented with turning lanes at the subject intersection. All approaches have been provided with an exclusive left-turn lane (the westbound direction has dual left-turn lanes); the southbound and eastbound approaches have right-turn lanes; and the northbound approach has dual right-turn lanes. The eastbound right-turn lane has an exceptionally long storage length.

The north-east and south-east corners of the intersection are occupied by gas/service stations, the north-west corner is a retail store (donut and coffee shop), and the south-west corner is owned by a church but appears to be relatively open space.

According to the 2001 Anchorage Traffic Map produced by the Alaska DOT, the average daily traffic volumes on LOP and Tudor Road are in the order of 24,600, 33,500, 49,600, and 45,700 for the north, south, east, and west legs, respectively.

The LOP at Tudor Road intersection is signalized with an eight-phase operation. The signal is traffic-actuated and coordinated with adjacent signals, except during low traffic-demand periods when the signal is operated as an isolated intersection. For coordination purposes the midday cycle time is 140 seconds, and the AM and PM peak cycle times are 160 seconds during weekdays. Each approach to the intersection is provided with five separate signal heads; three primary heads

suspended over the intersection, one far-side head on the left, and one far-side head on the right. All signal heads are LED displays.

Under the existing signal timing and traffic volumes, the LOP at Tudor Road intersection is busy at all times of the day. The levels of service to traffic are as shown in FIGURE 2.1.

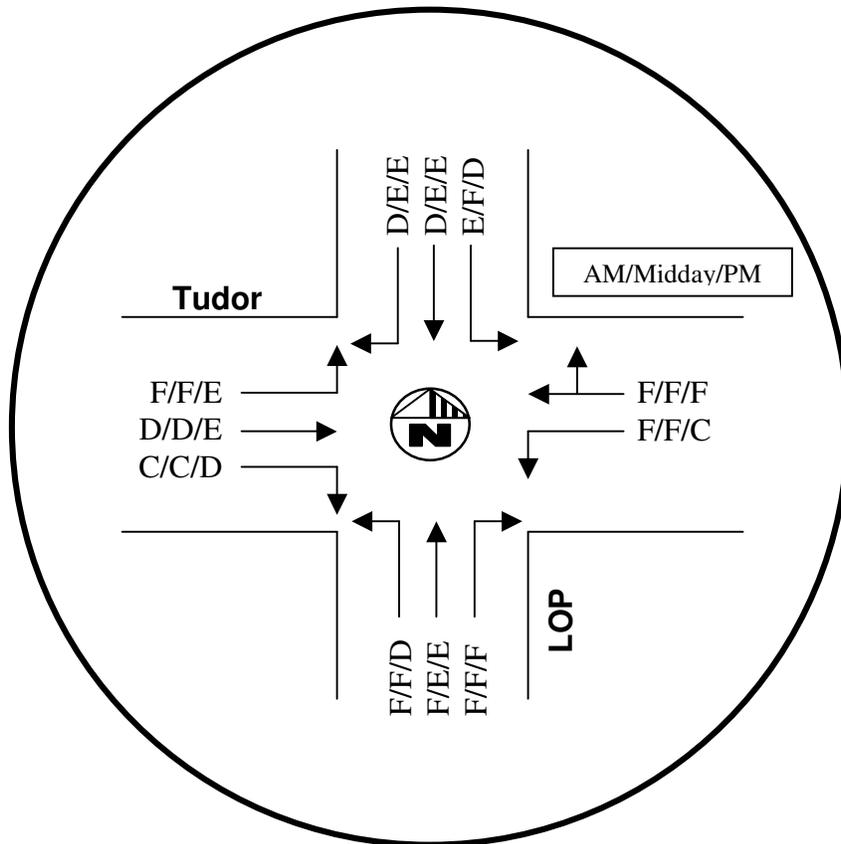


FIGURE 2.1: Traffic Operations at LOP and Tudor Road

## 2.2 Collision Analysis

The collision diagram for LOP at Tudor Road is shown in FIGURE 2.2. The aberrant collision characteristics were found to be:

- *Collisions on wet and dry pavement were both over-represented with proportions of 53% and 16%, respectively;*
- *Sixty-two percent of all collisions occurred during daylight and were over-represented;*
- *Rear-end collisions are over-represented at 52%; and*
- *Collisions with signposts are over-represented, although they only account for eight collisions over the three years.*

Given the rather large proportion of rear-end collisions a more in-depth examination of these collisions was undertaken, and yielded the following information:

- *Approximately 37% of the rear-end collisions involved westbound vehicles, while 32% involved northbound vehicles. In contrast, only 34% of the traffic enters from the westbound approach, and 22% of the intersection traffic enters from the northbound approach.*
- *While wet pavement collisions are over-represented at 16% of all collisions, only 12% of rear-end collisions occurred on wet pavement.*
- *Daylight collisions are over-represented at 62% of all collisions, and 68% of rear-end collisions occurred during daylight.*

The frequency of angle collisions is “as expected” for an Alaskan signalized intersection. However, angle collisions are the second most prominent collision type (39%), and are worthy of some consideration. A breakdown of the angle collisions indicates that:

- *49% of the angle collisions are between vehicles traveling in the same direction (sideswipes);*
- *41% of the angle collisions are between conflicting vehicles (usually right-turn vehicles); and*
- *4% of the angle collisions are between opposing vehicles (ex., left-turn with opposing through).*

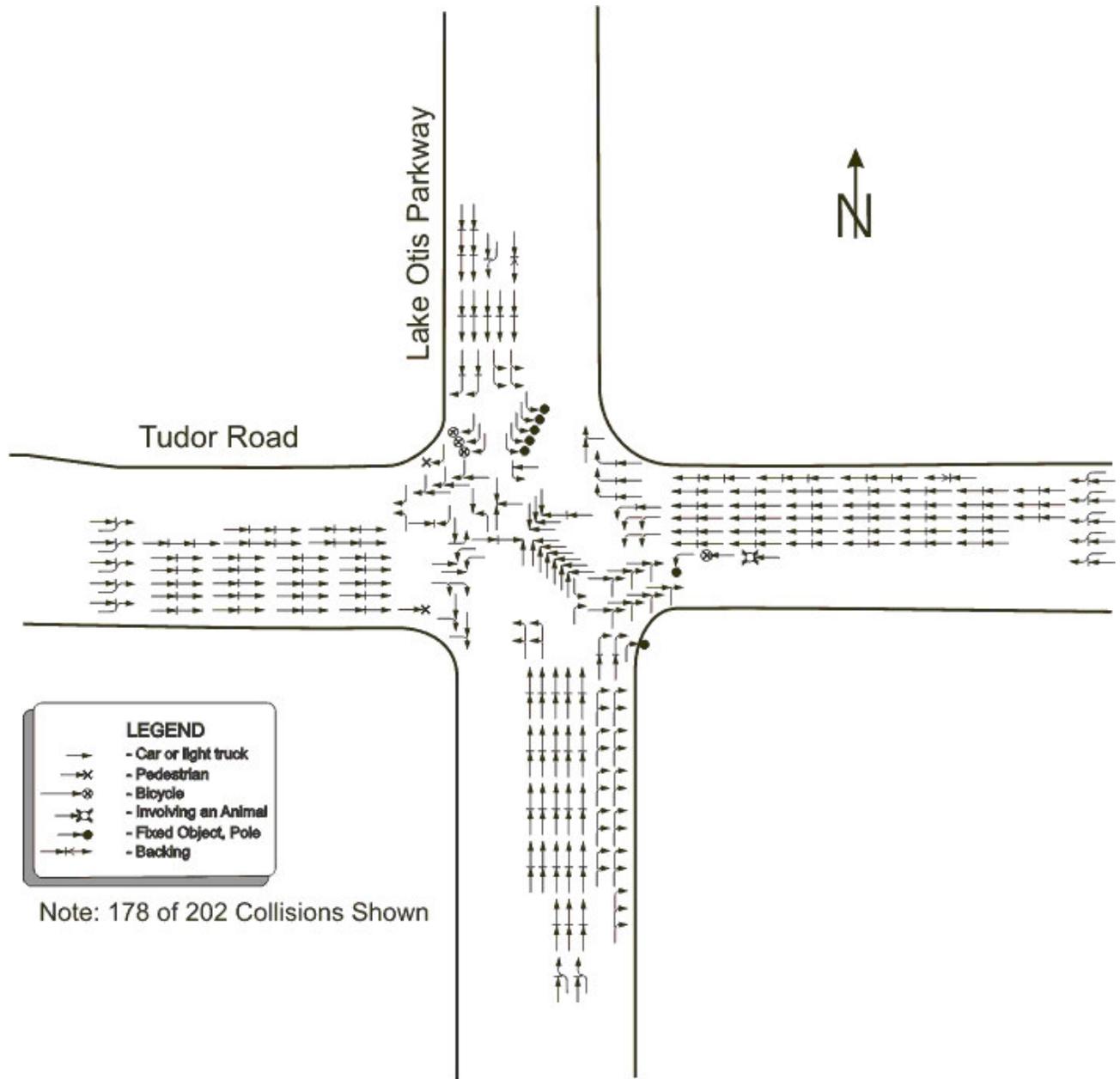


FIGURE 2.2: Collision Diagram for LOP at Tudor Road

### 2.3 Traffic Conflict Analysis

The conflict data for the LOP at Tudor intersection is shown in TABLE 2.1. The conflict rate is 1.3 conflicts per thousand entering vehicles (TEV), which is considered average when compared to other intersections studied by the Intus team.

TABLE 2.1: Traffic Conflict Summary

CONFLICT TYPE	CONFLICT FREQUENCY	AVERAGE CONFLICT SCORE	SEVERITY SCORE EQUAL OR GREATER THAN 4.0
<i>Rear-end</i>	38	3.3	32%
<i>Cyclist</i>	10	3.4	30%
<i>Pedestrian</i>	6	3.3	17%
<i>Right-turn</i>	4	3.5	50%
<i>Left-turn Opposing</i>	3	3.3	33%
<i>Others</i>	4	4.3	50%
<b>OVERALL</b>	65	3.5	35%

The overall average severity score of all the conflicts is considered high.

The spatial distribution of traffic conflicts is summarized in FIGURE 2.3. The results indicated that rear-end conflicts accounted for 58% of all observed conflicts. In addition, approximately 16% of the conflicts involved pedestrians or cyclists.

The majority of the rear-end conflicts were observed at the northbound and eastbound exit legs. The pedestrian and cyclist conflicts were mainly associated with the northbound right-turn movements on LOP.

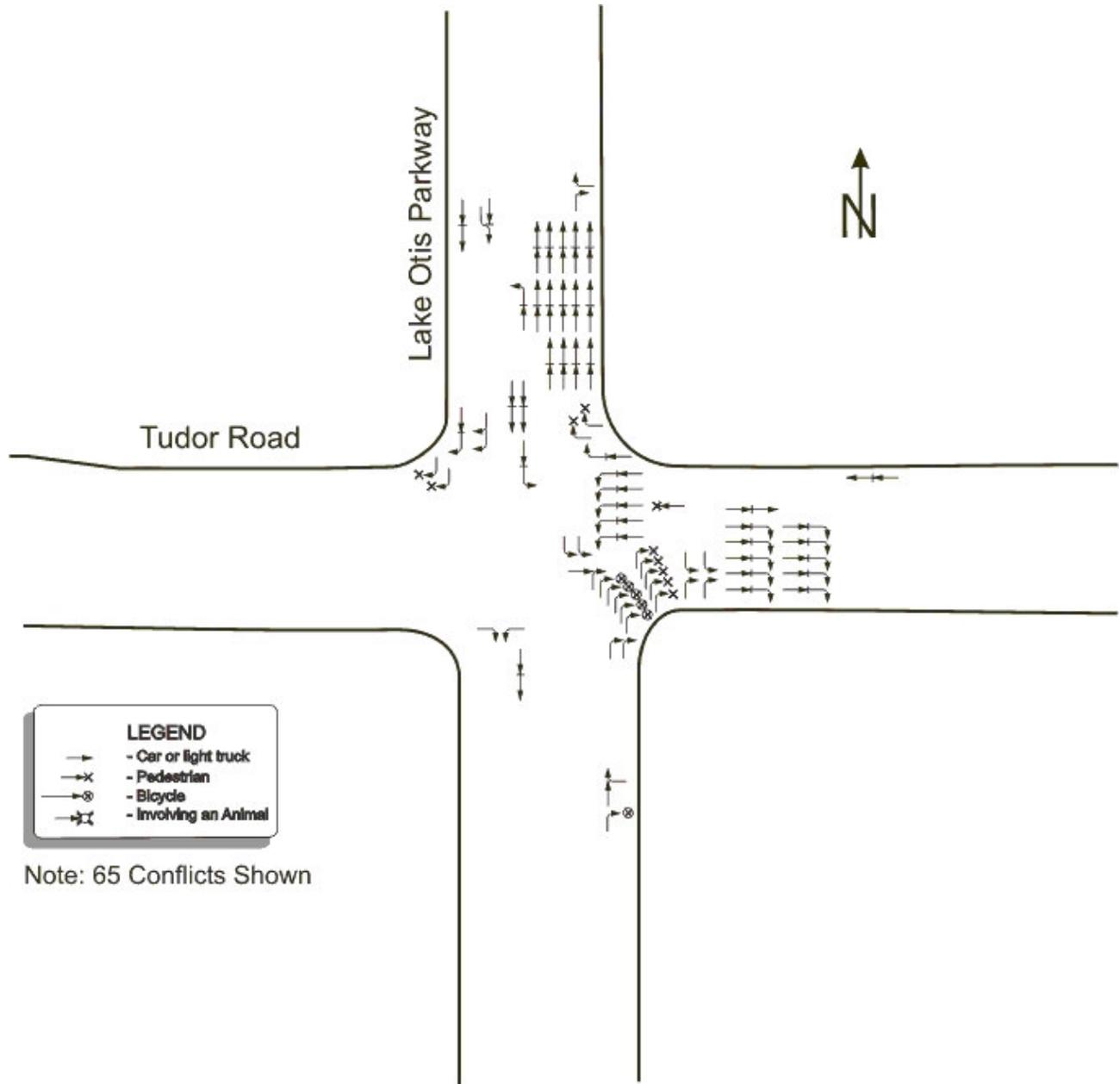


FIGURE 2.2: Traffic Conflict Diagram for LOP at Tudor Road

## 2.4 On-site Observations

The following safety issues were identified during the on-site inspection and during the traffic conflict observations:

- *A number of red-light running incidents were observed, as well as vehicles accelerating to “beat” the amber phase.*
- *Travel speeds were observed to be higher than the 45 mph speed limit.*
- *Long cycle times resulting in long waits for pedestrians and cyclists. Some pedestrians were observed to ignore traffic control devices or jaywalk through the intersection.*
- *The “Walk” phase of the signal appears to be very short, further exacerbating the delays for pedestrians and cyclists.*
- *Left-turn vehicles turning from the dual left-turn lanes were observed to be in conflict with right-turn-on-red vehicles.*
- *Vehicles were generally not yielding to pedestrians during the “walk” phases, in particular for the northbound right-turn vehicles although signing is provided to remind motorists to yield to pedestrians using the crosswalks.*
- *The northbound and southbound right-turn-on-red vehicles were observed to conflict with pedestrians crossing the south crosswalk. Site observations indicated that the drivers were focusing on accepting adequate gaps in the eastbound traffic stream, and were not aware of the presence of pedestrians.*
- *There are no signs providing upstream, advance warning of the dual turn lanes.*
- *It appears that the sign located on the westbound approach median may be impeding the southbound left-turn movement (please refer to PHOTO 2.1).*



PHOTO 2.1: Sign Post at Westbound Approach

## 2.5 Identified Safety Problems and Issues

The majority of collisions occurring at this intersection are rear-end collisions. The operational analysis and site observations indicate that congestion, delay, and aggressive driving are the likely contributing factors. Signal visibility is not considered to be a contributing factor as there are long views of several LED signal heads per approach. Detailed analysis also indicates that the rear-end collision problem is not associated with eastbound vehicles in the morning sunrise.

The rear-end collisions are primarily on the westbound and northbound approaches, and are more prominent during the daylight and on dry pavement. Despite warning signs to yield the right-of-way, northbound motorists were frequently in conflict with pedestrians in the east crosswalk. This is likely contributing to the rear-end collision problem in the northbound approach. Site observations indicate that the westbound left-turn conflicts with the eastbound motorists turning “right on red”. This may be precipitating some of the westbound rear-end collisions.

Signing that conveys the information to the motorist that dual turn lanes are available at the intersection, are provided on the far-side of the intersection. While these signs are situated well within the motorists forward field-of-view, they are likely inadequate to provide advance warning of the dual turn. This may be leading to last minute lane changes, and in turn sideswipe and rear-end collisions.

The pavement condition on the intersection approaches appears to be somewhat worn and rutted. The preponderance of collisions during the wet weather may be attributed to a less than desirable coefficient of friction. A more in-depth investigation of the pavement condition would be required to determine if this is the case.

Safety issues that were noted, but are not reflected by the collision record are as follows:

- *Location of Sign Post: The sign post located in the westbound approach median were observed to cause a number of conflicts.*
- *Vulnerable Road Users: Due to the long cycle length to accommodate the vehicular movements, vulnerable road users such as pedestrians and cyclists had to wait for an*

*extended period to cross the intersection. This led to non-compliance and jaywalking, further increasing the collision risks for these road users.*

## 2.6 Improvement Strategy

The potential solutions for the LOP at Tudor intersection are geared towards the rear-end (and sideswipe) collision problem. The excellent visibility of the signal displays suggests that focusing on congestion reducing measures, and better guidance through improved signing is appropriate. The feasible solutions are:

- *Reduce the “green extension” times to improve operations and reduce congestion.*
- *Shorten the cycle times to improve operations.*
- *Provide a WBND right-turn lane to improve operations on this approach, and to reduce the probability of rear-end collisions.*
- *Provide R3-8 signing upstream of the intersection on all approaches to forewarn motorists of dual turn lanes, and reduce last minute lane changes leading to sideswipe and rear-end collisions.*
- *Provide a skid resistant pavement to shorten stopping distances and reduce collision occurrence.*

The conflicts created by motorists turning right-on-red are adequately addressed through a no-right-on-red regulation. However, such a regulation would also cause an increase in delay. As the delay is also contributing to the collision risk at this location, it is likely that the safety benefits provided by the no-right-on-red regulation would be offset by the safety disbenefits of increased delay. Therefore, no-right-on-red regulations are not recommended as a potential solution.

More systemic solutions that may improve this (and other) intersection safety performance, are included in Section 7.

Based on the identified safety issues at the study intersection, the suggested safety improvements are:

- *Relocate the Keep Right sign and hazard marker on westbound approach to east of the crosswalk, and remove the median tip west of the crosswalk.*

## 2.7 Economic Evaluation

The economic analyses of the LOP at Tudor intersection solutions are shown in TABLE 2.2. The economic analysis sheet is included in Appendix C.

TABLE 2.2: Economic Evaluation of LOP and Tudor

IMPROVEMENT	CRF	COST (\$1,000)	B/C RATIO
<i>Shorten cycle times &amp; reduce green extension times</i>	17%	120	9:1
<i>Install a WBND right-turn lane</i>	15%	900	1:3
<i>Place R3-8 on all approaches</i>	5%	5	58:1
<i>Resurface with a skid resistant pavement</i>	20%	200	13:1

Only the westbound right-turn lane is not economically attractive. Therefore, although it would likely improve the safety performance of the intersection it is dropped from consideration as the resources required to implement the westbound right-turn lane are more effectively allocated elsewhere. Of the remaining three countermeasures, the combined CRF (if all three options are implemented) is -37%, which yields an overall B/C ratio of 12:1. The -37% CRF would decrease the collision rate, but not below the statewide average for signalized intersections, and is therefore a reasonable estimate.

The ability to change the cycle times requires input from the MOA signals staff. The MOA operates a closed-loop signal system and has relatively good coordination between adjacent signals. Changing the signal timing is a system-wide consideration. Pending confirmation from the MOA on the cycle times, it is recommended that the signal timing changes, the additional signing, and the skid resistant pavement be implemented at the LOP and Tudor Road intersection.

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## 3.0 New Seward Highway at Fireweed Lane

### 3.1 Site Characteristics

According to the Official Streets and Highways Plan of the MOA, the NSH is a north-south freeway running from Rabbit Creek Road to about 20<sup>th</sup> Avenue. For practical purposes, the freeway portion of NSH ends north of Tudor Road, where the NSH becomes an arterial road with at-grade, signalized intersections. As it crosses Fireweed Lane, NSH is a major urban, divided, arterial road with three basic lanes in each direction. The speed limit of NSH is 45 mph. Fireweed Lane is an east-west street that is classified as a minor arterial west of NSH and a neighborhood collector east of NSH. West of NSH, Fireweed Lane continues to Spenard Road. As it crosses NSH, Fireweed Lane has one basic lane in each direction. The speed limit west of NSH is 35 mph.

The collector portion of Fireweed Lane (to the east of NSH) although it intersects with NSH, is not signalized. Rather the westbound lane is channelized so that only right turns are permitted, and the right turns are channelized into an added northbound lane.

The basic lanes on both approaches of the NSH and the eastbound approach of Fireweed Lane are supplemented with turning lanes at the subject intersection. All approaches have been provided with an exclusive left-turn lane; the eastbound approach has also been provided with a right turn lane.

The east side of the intersection is occupied by low density residential properties without direct access to NSH, the west side of the intersection is occupied by retail establishments. The south-west corner is occupied by a gas/service station.

The NSH at Fireweed Lane intersection is signalized (except for the westbound approach as discussed above) with a four-phase operation. The signal is traffic-actuated and coordinated with adjacent signals. For coordination purposes the midday cycle time is 120 seconds, the AM peak cycle time varies between 120 and 140 seconds, and the PM peak cycle time is 160 seconds during weekdays. The northbound approach is provided with two primary signal heads suspended over the intersection, a secondary head on the far-left side of the intersection, a far-right side signal head, and

a post mounted signal head on the median. The southbound approach is provided with three primary signal heads suspended over the intersection, and far-right and far-left signal heads. The eastbound approach has two primary signal heads suspended over the intersection, and far-right and near-right side signal heads. All signal heads are LED displays.

Under the existing signal timing and traffic volumes, the NSH at Fireweed Lane intersection is moderately busy at all times of the day. The levels of service to traffic are as shown in FIGURE 3.1.

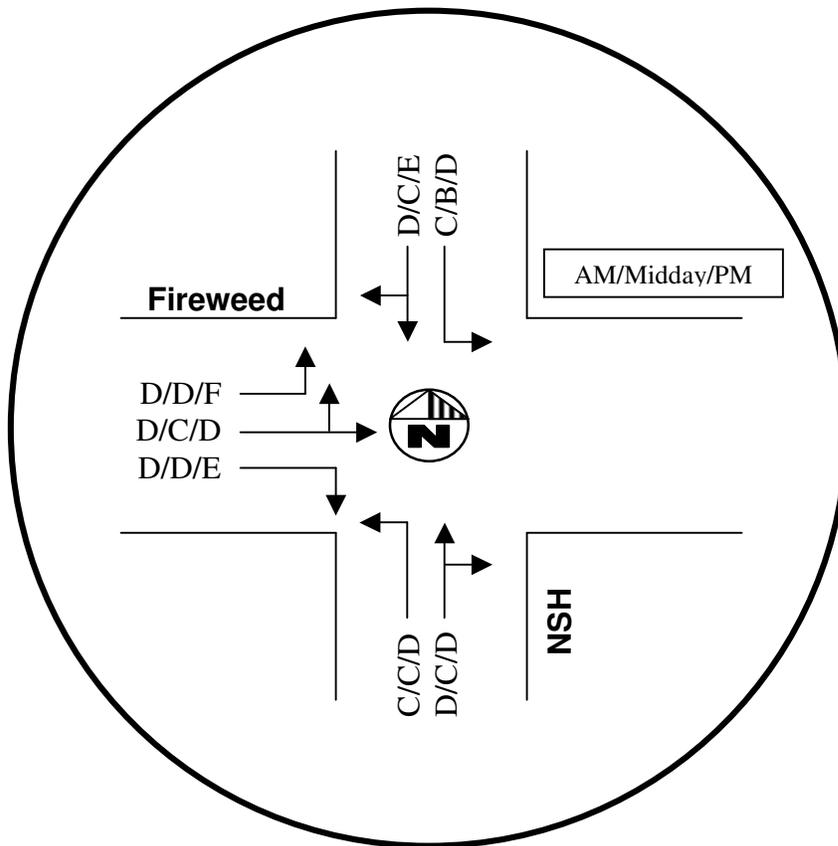


FIGURE 3.1: Traffic Operations at NSH and Fireweed Lane

According to the 2001 Anchorage Traffic Map produced by the Alaska DOT, the average daily traffic volumes on NSH at Fireweed Lane are in the order of 52996, and 48046 for the north, and south legs, respectively.

Fireweed Lane west of NSH is expected to be converted from a four-lane facility to a facility with one lane in each direction and a center-turn lane. This conversion is being undertaken as a safety improvement strategy.

### 3.2 Collision Analysis

The collision diagram for NSH at Fireweed Lane is shown in FIGURE 3.2. The aberrant collision characteristics were found to be:

- *The annual collision frequency appears to be decreasing;*
- *Collisions on wet and dry pavement were both over-represented with proportions of 18% and 48%, respectively;*
- *Sixty-five percent of all collisions occurred during daylight and were over-represented; and*
- *Rear-end collisions are over-represented at 75%.*

Given the rather large proportion of rear-end collisions a more in-depth examination of these collisions was undertaken, and yielded the following information:

- *Approximately 90% of the rear-end collisions involve northbound or southbound vehicles.*
- *The southbound direction accounted for 70% of all rear-end collisions, although only 43% of the intersection traffic enters from this direction.*

The frequency of angle collisions is “as expected” for an Alaskan signalized intersection. However, angle collisions are the second most prominent collision type (20%), and are worthy of some consideration. A breakdown of the angle collisions indicates that:

- *The majority of the angle collisions involve northbound and southbound vehicles and are sideswipes between vehicles traveling in the same direction;*
- *For southbound travel the angle collisions are due to right-turns, lost control, or changing lanes; and*
- *For northbound travel the angle collisions have lane changes and improper overtaking as contributing factors.*

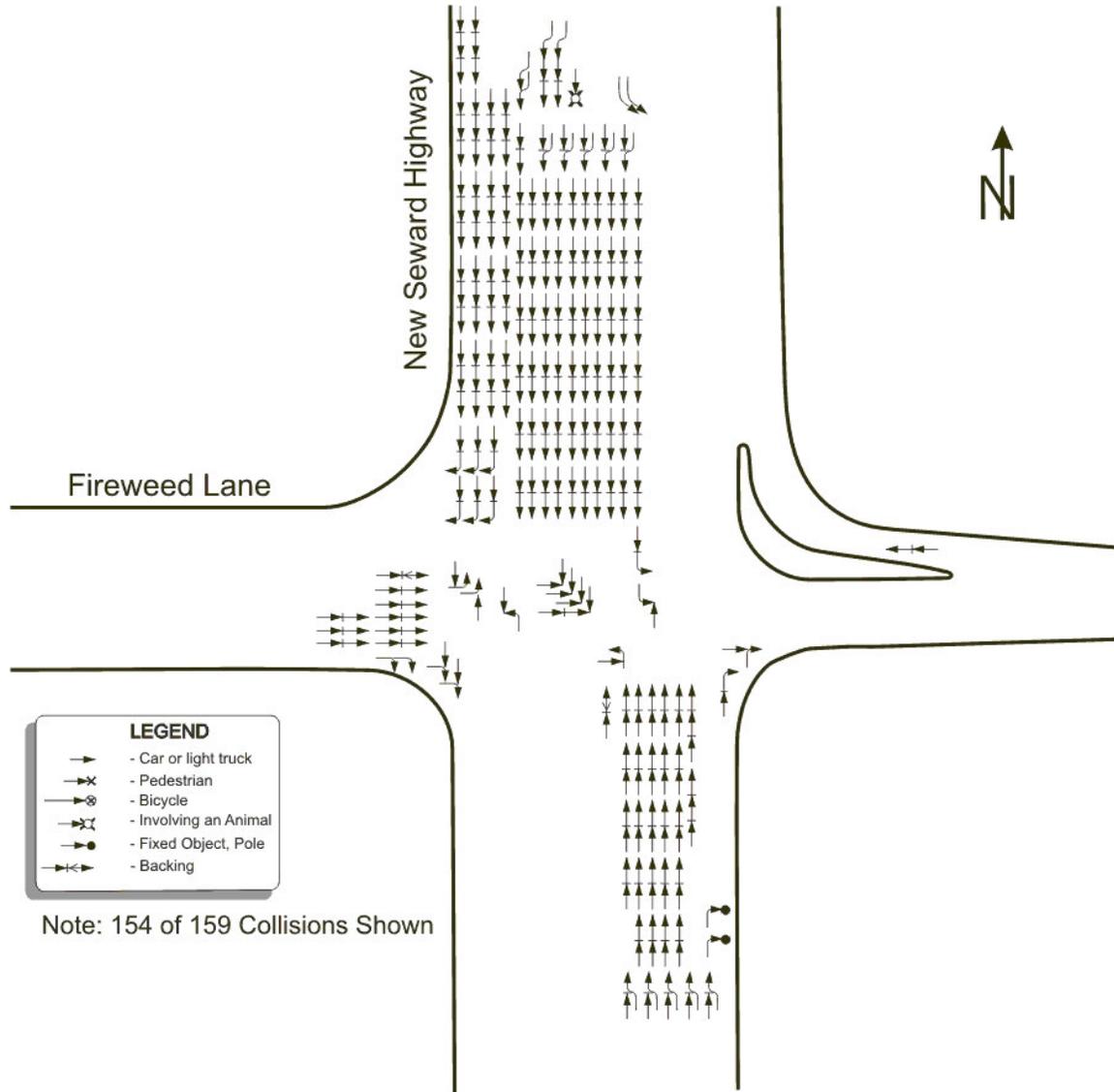


FIGURE 3.2: Collision Diagram for NSH at Fireweed Lane

### 3.3 Traffic Conflict Data

The conflict data for the NSH at Fireweed intersection is shown in TABLE 3.1. The conflict rate is 1.9 conflicts per TEV, which is considered average when compared to other intersections studied by the Intus team.

TABLE 3.1: Traffic Conflict Summary

CONFLICT TYPE	CONFLICT FREQUENCY	AVERAGE CONFLICT SCORE	SEVERITY SCORE EQUAL OR GREATER THAN 4.0
<i>Rear-end</i>	61	3.3	23%
<i>Cyclist</i>	2	3.5	50%
<i>Pedestrian</i>	2	4.5	100%
<i>Right-turn</i>	2	4.5	100%
<i>Others</i>	8	3.25	25%
<b>TOTAL</b>	75	3.8	60%

The overall average severity score of all the conflicts is considered high.

The spatial distribution of traffic conflicts is summarized in FIGURE 3.3. The results indicated that rear-end conflicts accounted for 81% of all observed conflicts. The majority of the rear-end conflicts were observed at the southbound approach and the exit leg, and were associated with the right-turn movements.

### 3.4 On-site Observations

The following safety issues were identified during the on-site inspection and during the traffic conflict observations:

- *The eastbound curb lane on Fireweed Lane becomes an exclusive right-turn lane at the intersection. Vehicles were observed to change lanes (to the middle lane) late, causing rear-end conflicts.*
- *Travel speeds along NSH were observed to be higher than the 45 mph speed limit. For the southbound direction, this may be related to the long spacing with the upstream signal, and the anticipation that the freeway section of NSH is downstream. For the northbound direction the high speeds may be motorists who are acclimatized to the freeway speeds of NSH.*

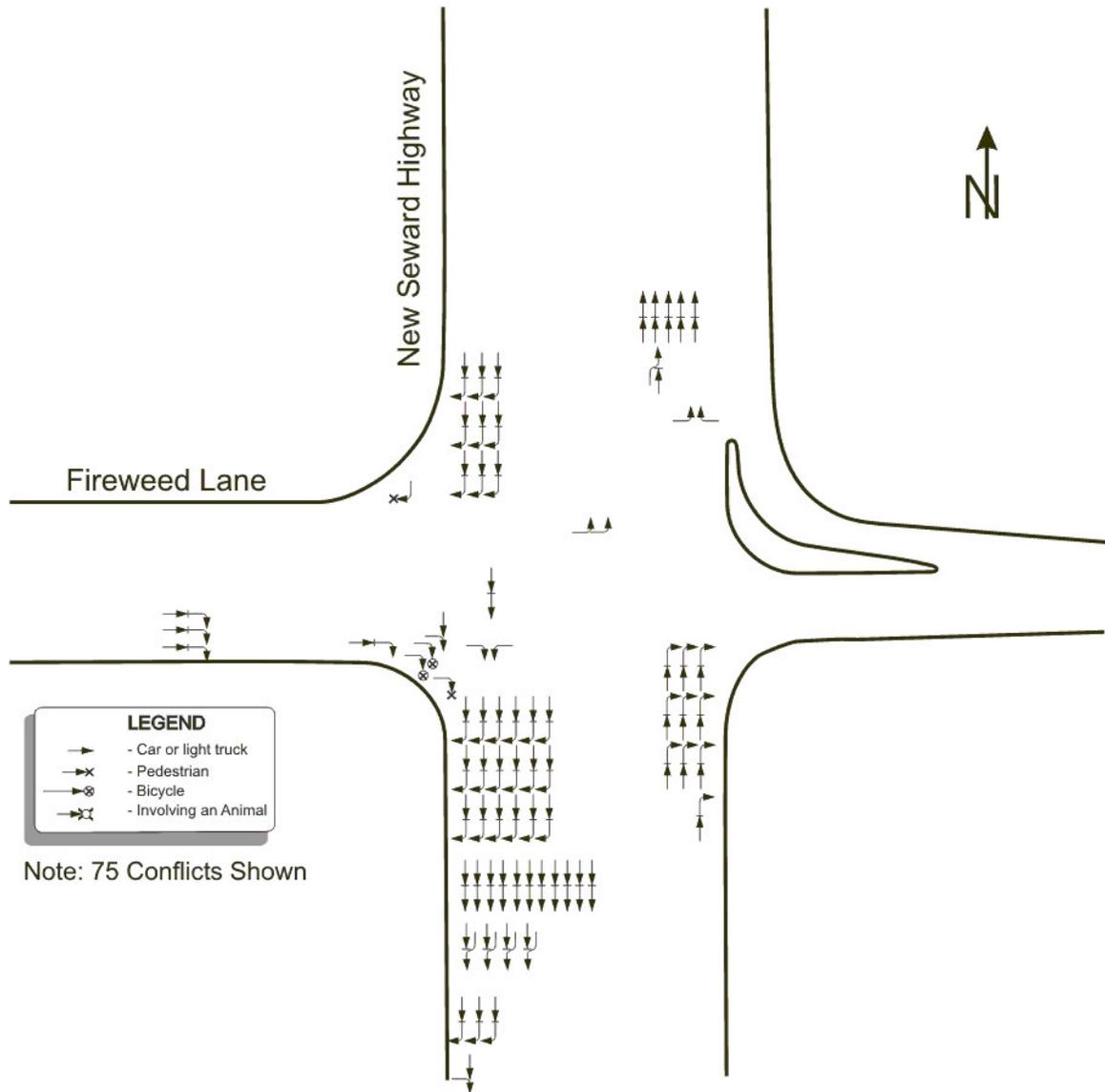


FIGURE 3.3: Traffic Conflict Diagram for NSH at Fireweed Lane

- The turning radius for the northbound right-turn appears to be tight for the operating speed on NSH, and may lead to rear-end incidents involving right-turn and through vehicles.
- The visibility of the traffic signals for the southbound approach appears to be limited due to the presence of a vertical crest curve (Please refer to PHOTO 3.1). This safety issue is



PHOTO 3.1: Southbound Signal Visibility

*further compounded by the high proportion of commercial vehicles that also limit the signal visibility for passenger vehicles.*

- *As one travels westbound toward the intersection, the island tip is equipped with a “Keep Right”(R4-7) sign and an object marker (OMI-1). The “Keep Right” sign displays a particular island configuration that is not representative of the actual island shape. In particular, the sign denotes a thin island that the motorist must keep right of, but may travel beside in an essentially straight path. The actual island shape is such that a right-turn is required.*
- *As one travels northbound on NSH, advance street name signs are provided for Benson and Northern Lights Boulevards. Fireweed Lane does not have a northbound advance street name sign.*
- *The crosswalk on the unsignalized westbound leg of the intersection is provided with pedestrian signal heads. The pedestrian signal heads provide a clear indication to pedestrians as to when they have the right-of-way to cross Fireweed Lane. However, the westbound vehicles are uncontrolled and a potential conflict exists as to who has the right-of-way.*

### 3.5 Identified Safety Problems and Issues

The majority of collisions occurring at this intersection are rear-end collisions. A more detailed analysis of the rear-end collisions indicate that the majority of the collisions occur on NSH, and many of those in the southbound direction. There are several factors that are thought to contribute to the rear-end collisions at this location. They are:

- *Heavy traffic flows and peak period congestion causing risky driving behavior;*

- *Last minute lane changes on the eastbound approach from the right-turn lane to the middle lane;*
- *High approach speeds both northbound and southbound on NSH;*
- *Absence of right-turn lanes and the right-turn radius for northbound to eastbound traffic is such that vehicles might be slowing excessively on NSH before making the turn;*
- *A large proportion of commercial vehicles on NSH that are restricting visibility for passenger cars (this is exacerbated by the vertical alignment of the road which presents a crest vertical curve upstream of the intersection);*
- *The lack of an advance street name sign for northbound Fireweed Lane (which is inconsistent with the upstream signalized intersections); and*
- *Worn and rutted pavement that may not be providing adequate friction.*

Signal visibility is not considered to be a contributing factor as there are long views of several LED signal heads per approach.

The safety issues identified that are not precipitating collisions at this intersection are:

- *The “Keep Right” (R4-7) sign on the east leg of the intersection presents a graphical island configuration (longitudinal island) that is much different from the physical island configuration (triangular/channelizing island); and*
- *There is potential confusion over right-of-way between the westbound motorists (who are controlled by a YIELD sign), and the pedestrians crossing in the east crosswalk (who are controlled by pedestrian signal heads).*

### 3.6 Improvement Strategy

Based on the identified safety problems at the study intersection, the suggested safety improvements are:

- *Adjust vertical alignment on SBND approach to improve visibility of signals;*
- *Place near-side signals on the southbound approach;*
- *Provide active advance warning signs for southbound approach;*
- *Provide a southbound right turn lane;*

- *Increase turning radius for northbound right turns;*
- *Provide a northbound advance street name sign for “Fireweed Lane”; and*
- *Provide a skid resistant pavement to shorten stopping distances and reduce collision occurrence.*

It is our understanding that Fireweed Lane is to be reconfigured as a three lane cross section – eliminating the lane trap for westbound traffic. This should bring about some safety benefits to this approach, but will not be discussed further as this is a pre-approved countermeasure.

The adjustment of the vertical alignment is a costly endeavor that, in consultation with MOA and DOT staff, is probably cost prohibitive. Also the currently visibility afforded to the motorist on the southbound approach well exceeds the accepted minimum as specified by current standards.

Other more systemic measures are discussed in the Section 7.

Based on the identified safety issues at the study intersection, the suggested safety improvements are:

- *Replace the R4-7 “Keep Right” sign with either a R4-7b (a worded “keep right sign) or a W1-6 (“One direction large arrow” sign) which are more consistent with the intersection approach geometry; and*
- *Reconsider the pedestrian signal heads and yield sign on the east crosswalk as it crosses the westbound to northbound right turn channel to eliminate the potential for confusion over right-of-way.*

### 3.7 Economic Evaluation

The economic analyses of the NSH and Fireweed Lane intersection solutions are shown in TABLE 3.2. The economic analysis sheet is included in Appendix C.

TABLE 3.2: Economic Evaluation of HSH and Fireweed

IMPROVEMENT	CRF	COST (\$1,000)	B/C RATIO
<i>Add SBND Near-side signal heads</i>	25%	20	69:1
<i>SBND Active advance warning signs</i>	13%	500	2:1
<i>SBND right-turn lane</i>	25%	900	3:1
<i>Advance street name sign for NBND</i>	15%	6	19:1
<i>Increase NBND right turn radius</i>	15%	450	1:2
<i>Skid resistant pavement</i>	20%	200	11:1

The improvement to the northbound right-turn radius is not economically attractive and will be eliminated from further consideration as these resources could be better used elsewhere. All of the remaining countermeasures have positive B/C ratios and are candidates for implementation.

Of the remaining five countermeasures, the combined CRF (if all five options are implemented) is -52%. The -52% CRF would decrease the collision rate below the statewide average for signalized intersections, and is therefore not a reasonable estimate. In order to reduce the collision rate for NSH and Fireweed Lane to the statewide average for signalized intersections with four approaches, a CRF of -49% would be required. Using the maximum expected CRF of -49%, the B/C ratio of implementing all five options is 3:1.

The ability to change the cycle times requires input from the MOA signals staff. The MOA operates a closed-loop signal system and has relatively good coordination between adjacent signals. Changing the signal timing is a system-wide consideration.

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## 4.0 Old Seward Highway at Dimond Boulevard

### 4.1 Site Characteristics

OSH is a north-south arterial running from parallel to and immediately west of the NSH. It roughly bisects the MOA street system and runs from around Rabbit Creek Road to just north of 36<sup>th</sup> Avenue. As it crosses Dimond Boulevard it is classified as a major urban, divided, arterial road with two basic lanes in each direction. The speed limit is 45 mph. Dimond Boulevard is an east-west major arterial running from Sand Lake Road to east of NSH where it becomes Abbott Road. As it crosses OSH, it is an urban, divided, arterial with three basic lanes in each direction. The speed limit is 40 mph.

The basic lanes on both streets are supplemented with turning lanes at the subject intersection. All approaches have been provided with dual left-turn lanes; and the eastbound approach also has a right-turn lane.

The north-west corner of the intersection is occupied by a gas/service station, the south-east corner is a bank/office building, and the remaining corners are retail developments.

The LOP at Tudor Road intersection is signalized with an eight-phase operation. The signal is traffic-actuated and coordinated with adjacent signals, except during low traffic-demand periods when the signal is operated as an isolated intersection, and in the weekday PM peak period when the signal is operated on a fixed time basis. For coordination purposes the midday cycle time is 150 seconds, and the AM and PM peak cycle times are 110 and 160 seconds during weekdays, respectively. Each approach to the intersection is provided with at least four separate signal heads; two primary heads suspended over the intersection, one far-side head on the left, and one far-side head on the right. The Dimond Boulevard approaches also have pole-mounted signal heads on the median. All signal heads are LED displays.

Complete turning movement counts for the OSH at Dimond intersection were not available, hence a capacity analysis could not be undertaken. Nonetheless, from site observations and through

consultation with MOA and DOT staff it is apparent that under the existing signal timing and traffic volumes, the OSH at Dimond Boulevard intersection is busy at all times of the day.

According to the 2001 Anchorage Traffic Map produced by the Alaska DOT, the average daily traffic volumes on OSH and Dimond Boulevard are in the order of 15990, 18932, 41170, and 37520 for the north, south, east, and west legs, respectively. During the field visit it was noted that the PM peak eastbound queue from the NSH at Dimond Boulevard intersection often extends into the subject intersection. Furthermore, it was noted that many westbound vehicles made “U”-turns at the intersection of OSH and Dimond. This movement is permitted, and is depicted in the lane use signing for the westbound left-turn lane closest to the median. Observations of the intersection of the southbound ramps from the NSH at Dimond Boulevard in the PM peak revealed a significant delay for westbound to southbound traffic. It is expected that the drivers making “U”-turns at the OSH and Dimond intersection are doing so to avoid the direct left-turn at NSH and Dimond.

## 4.2 Collision Analysis

The collision diagram for OSH at Dimond Boulevard is shown in FIGURE 4.1. The aberrant collision characteristics were found to be:

- *Sixty-three percent of all collisions occurred during daylight and were over-represented; and*
- *Rear-end collisions are over-represented at 63%.*

Given the rather large proportion of rear-end collisions a more in-depth examination of these collisions was undertaken, and yielded the following information:

- *The rear-end collisions are fairly evenly distributed to all intersection approaches. However, the southbound direction which produces 16% of the entering volume, also produces 30% of the rear-end collisions.*

The frequency of angle collisions is “as expected” for an Alaskan signalized intersection. However, angle collisions are the second most prominent collision type (29%), and are worthy of some consideration. A breakdown of the angle collisions indicates that:

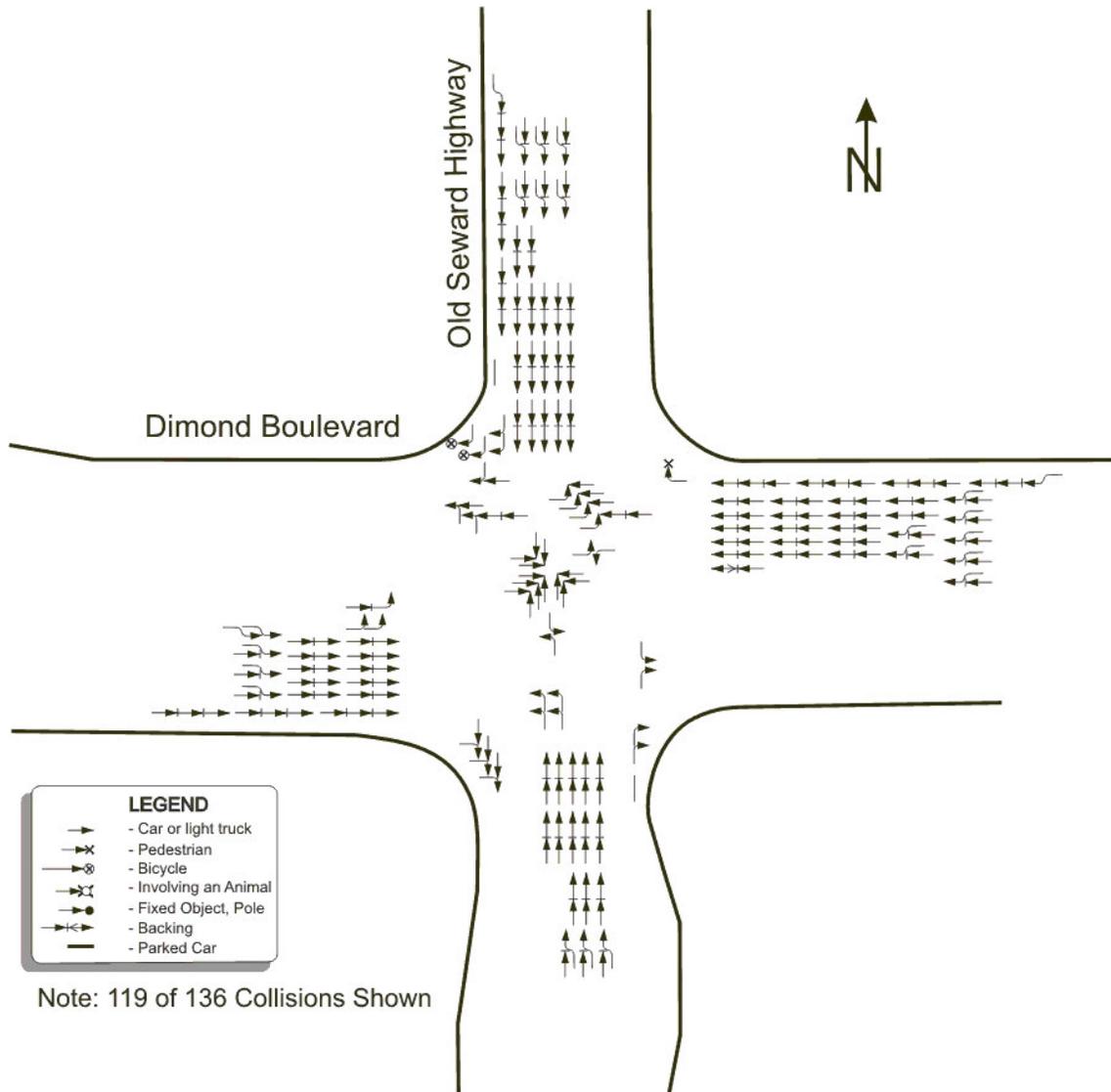


FIGURE 4.1: Collision Diagram for OSH at Dimond Boulevard

- At least 40% of the angle collisions were between vehicles moving in the same direction (i.e., sideswipe type collisions).
- The angle collisions are more prevalent in the dark; 38% of angle collisions occur in the dark, whereas 24% of all collisions occurred in the dark.

### 4.3 Traffic Conflict Data

The conflict data for the OSH at Dimond intersection is shown in TABLE 4.1. The conflict rate is 4.2 conflicts per TEV, which is considered high when compared to other intersections studied by the Intus team.

TABLE 4.1: Traffic Conflict Summary

CONFLICT TYPE	CONFLICT FREQUENCY	AVERAGE CONFLICT SCORE	SEVERITY SCORE EQUAL OR GREATER THAN 4.0
<i>Rear-end</i>	120	3.3	27%
<i>Weaving</i>	16	3.4	44%
<i>Right-turn</i>	15	3.3	33%
<i>Cyclist</i>	4	3.0	0%
<i>Pedestrian</i>	4	3.5	25%
<i>TOTAL</i>	159	3.3	26%

The overall average severity score of all the conflicts was found to be 3.3 and is considered high.

The spatial distribution of traffic conflicts is summarized in FIGURE 4.2. The results indicated that rear-end conflicts accounted for 75% of all observed conflicts. The majority of the rear-end conflicts were observed at the southbound and eastbound exit legs, and were associated with the right-turn movements.

### 4.4 On-site Observations

The following safety issues were identified during the on-site inspection and during the traffic conflict observations:

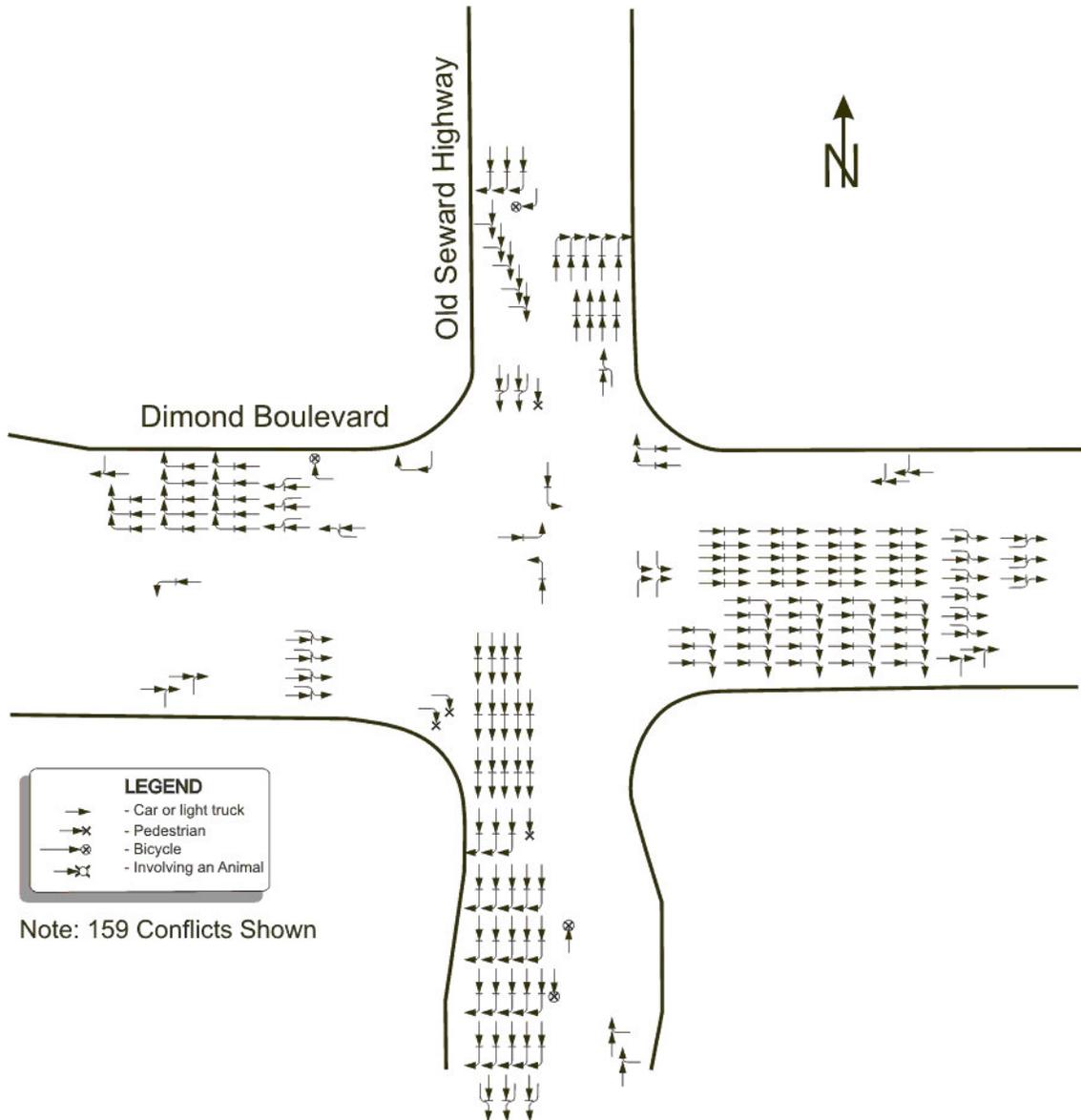


FIGURE 4.2: Traffic Conflict Diagram for OSH at Dimond Boulevard

- *The relatively high driveway density resulted in incidents involving vehicles changing lanes at the last minute, causing numerous rear-end, right-turn and weaving type conflicts.*

- *A number of pedestrians were observed to jaywalk across the north and south legs of the intersection.*
- *A number of weaving maneuvers were observed at the eastbound exit leg to access NSH causing a number of rear-end or weaving type conflicts.*
- *U-turns are allowed from the westbound left-turn lanes. However, a number of conflicts were observed as a result of left-turn movements conflicting with northbound right-turn-on-red vehicles.*
- *Traffic conditions were generally observed to be congested during the afternoon peak hours, in particular at the approach to the NSH interchange. As a result of the congestion and queue spill back at the eastbound exit leg, the protected southbound left-turn movement (lead phase) was often observed to be stuck in the intersection, or resulted in rear-end type conflicts.*
- *Only one overhead far side signal head is provided for the through and right-turn movements at the northbound and southbound approaches along OSH.*
- *Left-turn vehicles turning from the dual left-turn lanes were observed to be in conflicts with right-turn-on-red vehicles.*
- *Currently an empty bus bay is provided at the northbound approach. It appears that some drivers may use the bus bay as a right-turn lane, particularly in the winter time when the pavement and the curb and gutter is covered by snow (please refer to PHOTO 4.1).*



PHOTO 4.1: Northbound Approach

#### 4.5 Identified Safety Problems and Issues

The majority of collisions occurring at this intersection are rear-end collisions. The operational analysis and site observations indicate that congestion, delay, and aggressive driving are the likely contributing factors. Signal visibility is not considered to be a contributing factor as there are long views of several LED signal heads per approach. However, there is only one overhead far side signal head provided for the through and right-turn movements at the northbound and southbound approaches along OSH. The limited signal visibility may contribute to rear-end and angle collisions at the study intersection.

The rear-end collisions risk is pronounced on the southbound approach, although the collision frequency is relatively evenly distributed among all approaches. Collisions are more prominent during the daylight.

Although left-turns to and from driveways are well controlled, there is a relatively high density of driveways proximate to the intersection.. The turbulence created in the traffic stream by vicinal driveways is known to increase collision risk, particularly rear-end collisions.

The pavement condition on the intersection approaches appears to be somewhat worn and rutted. A more in-depth investigation of the pavement condition would be required to determine if this is the case.

The safety issues identified at this intersection are:

- *Right-turn-on-red: Right-turn-on-red vehicles were observed to be in conflict with left-turn vehicles turning from the dual left-turn lanes. The conflicts are indicative of potential rear-end, sideswipe and angle type incidents.*

#### 4.6 Improvement Strategy

Based on the identified safety issues at the study intersection, the suggested safety improvements are:

- *Add right-turn lanes for NBND, SBND, and WBND approaches*

- *Add second NBND and SBND primary signal heads*
- *Reduce “green extension” times to improve operations*
- *Reduce cycle times to improve operations*
- *Replace the R3-8 signs with R3-5L signs and relocate them to over the lanes for EBND and WBND approaches*
- *Add R3-8 signs upstream of the intersection on all approaches*
- *Skid resistant pavement*

Upon preliminary investigation of the requirements for the right turn lanes, the southbound and westbound right turn lanes appear to require substantial property acquisition. The land taking would be significant and it is very likely that these options would be cost prohibitive. They will not be carried forward to the economic analysis.

Another potential solution is to prohibit U-turns or provide a WBND to SBND loop ramp from Dimond Boulevard to NSH to get rid of U-turning vehicles. It is not mentioned as a viable countermeasure because the operational effects of the change on the NSH and Dimond intersection are unknown, and given the land use in the north-west quadrant of the NSH and Dimond intersection, it is cost prohibitive.

#### **4.7 Economic Evaluation**

The economic analyses of the OSH and Dimond Boulevard intersection solutions are shown in TABLE 4.2.

Only the northbound right-turn lane is not economically attractive. However, it is our understanding that the Alaska HSIP program has already identified this intersection as a HAL, and implementation of a northbound right-turn lane is being considered regardless of the unfavorable economic analysis. This turn lane will improve the safety performance of this intersection, but as it is already under consideration, and it does not appear to be economically attractive, it will not be considered further in this study. Of the remaining three countermeasures, the combined CRF (if all remaining options are implemented) is -42%, which yields an overall B/C ratio of 13:1. The -42% CRF would decrease the collision rate, but not below the statewide average for signalized intersections, and is therefore a reasonable estimate.

The ability to change the cycle times requires input from the MOA signals staff. The MOA operates a closed-loop signal system and has relatively good coordination between adjacent signals. Changing the signal timing is a system-wide consideration.

TABLE 4.2: Economic Evaluation of OSH and Dimond

IMPROVEMENT	CRF	COST (\$1,000)	B/C RATIO
<i>NBND right turn lane</i>	25%	300	1:2
<i>Add NBND and SBND primary signal heads</i>	25%	70	8:1
<i>Reduce green extensions</i>	17%	15	97:1
<i>Replace and relocate R3-8 signs &amp; add R3-8 signs in all directions</i>	5%	5	66:1
<i>Skid resistant pavement</i>	20%	200	8:1

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## 5.0 New Seward Highway at 36<sup>th</sup> Avenue

### 5.1 Site Characteristics

According to the Official Streets and Highways Plan of the MOA, the NSH is a north-south freeway running from Rabbit Creek Road to about 20<sup>th</sup> Avenue. For practical purposes, the freeway portion of NSH ends north of Tudor Road, where the NSH becomes an arterial road with at-grade, signalized intersections. As it crosses 36<sup>th</sup> Avenue NSH is a major urban, divided, arterial road with three basic lanes in each direction. The speed limit of NSH is 55 mph south of 36<sup>th</sup> Avenue and 45 mph north of 36<sup>th</sup> Avenue. 36<sup>th</sup> Avenue is an east-west minor arterial running from Spenard Road to Lake Otis Boulevard (where it continues as Providence). As it crosses NSH, it is an urban, divided, arterial with two basic lanes in each direction. The speed limit is 40 mph.

The basic lanes on both streets are supplemented with turning lanes at the subject intersection. All approaches have been provided with dual left-turn lanes; the northbound and southbound approaches have right turn lanes that are channelized by raised islands and are provided with YIELD signs; the eastbound and westbound approaches have exclusive right-turn lanes.

The north-east and south-east corners of the intersection are occupied by commercial enterprises (i.e., offices and a hotel), the north-west corner is a restaurant, and the south-west corner is a vacant commercial property. The NSH has been built as a controlled access facility to off-load the OSH of through traffic. The NSH is proximate to the OSH and at 36<sup>th</sup> Avenue, which intersects both roads, the distance between the OSH and NSH intersections is approximately 120 yards.

The NSH at 36<sup>th</sup> Avenue intersection is signalized with an eight-phase operation. The signal is traffic-actuated and coordinated with adjacent signals. For coordination purposes the midday cycle time is 120 seconds, the AM peak cycle time varies between 100 and 140 seconds, and the PM peak cycle time is 160 seconds during weekdays. Each approach to the intersection is provided with two primary signal heads suspended over the intersection, and one secondary head. All approaches except southbound are also provided with an additional signal head on the far-right side of the intersection. Finally, the northbound and southbound approaches have signal heads on the median islands. All signal heads are LED displays.

Under the existing signal timing and traffic volumes, the NSH at 36<sup>th</sup> Avenue intersection is busy at all times of the day. The levels of service to traffic are as shown in FIGURE 5.1.

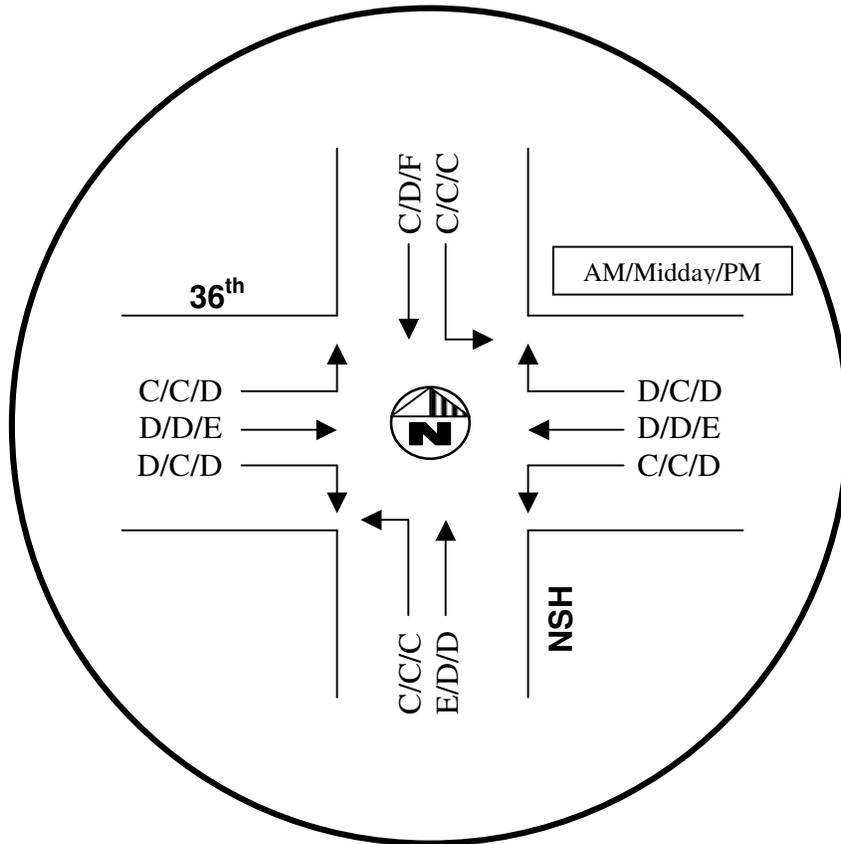


FIGURE 5.1: Traffic Operations at NSH and 36<sup>th</sup> Avenue

According to the 2001 Anchorage Traffic Map produced by the Alaska DOT, the average daily traffic volumes on NSH at 36<sup>th</sup> Avenue are in the order of 48046, 52195, 21094, and 24560 for the north, south, east, and west legs, respectively.

The NSH at 36<sup>th</sup> Avenue intersection is the first signalized intersection north of the end of the freeway portion of the NSH. It has been provided with an active advance warning sign (AAWS), the distance from the northbound stop line to the AAWS is approximately 160 yards.

The NSH from Rabbit Creek Road to 36<sup>th</sup> Avenue is currently undergoing a Major Investment Study with a view to improving traffic operations and safety in the NSH corridor. Several options being analysed, including transit alternatives, widening to six lanes, and the “do nothing” option.

## 5.2 Collision Analysis

The collision diagram for NSH at 36<sup>th</sup> Avenue is shown in FIGURE 5.2. The aberrant collision characteristics were found to be:

- *Almost one-half of the collisions occur on dry pavement and are over-represented; and*
- *Rear-end collisions are over-represented at 67%.*

Given the rather large proportion of rear-end collisions a more in-depth examination of these collisions was undertaken. The distribution of rear-end collisions and volume entering are shown in TABLE 5.1.

TABLE 5.1: Distribution of Rear-end Collisions at NSH and 36<sup>th</sup> Avenue

DIRECTION	PROPORTION (%)	
	VOLUME	REAR-END COLLISIONS*
N	41	44
S	35	23
E	13	19
W	11	12

\* Two percent of the rear-end collisions have direction marked as “unknown”

The frequency of angle collisions is “as expected” for an Alaskan signalized intersection. However, angle collisions are the second most prominent collision type (27%), and are worthy of some consideration. A breakdown of the angle collisions indicates that the majority of the angle collisions involve left-turning vehicles.

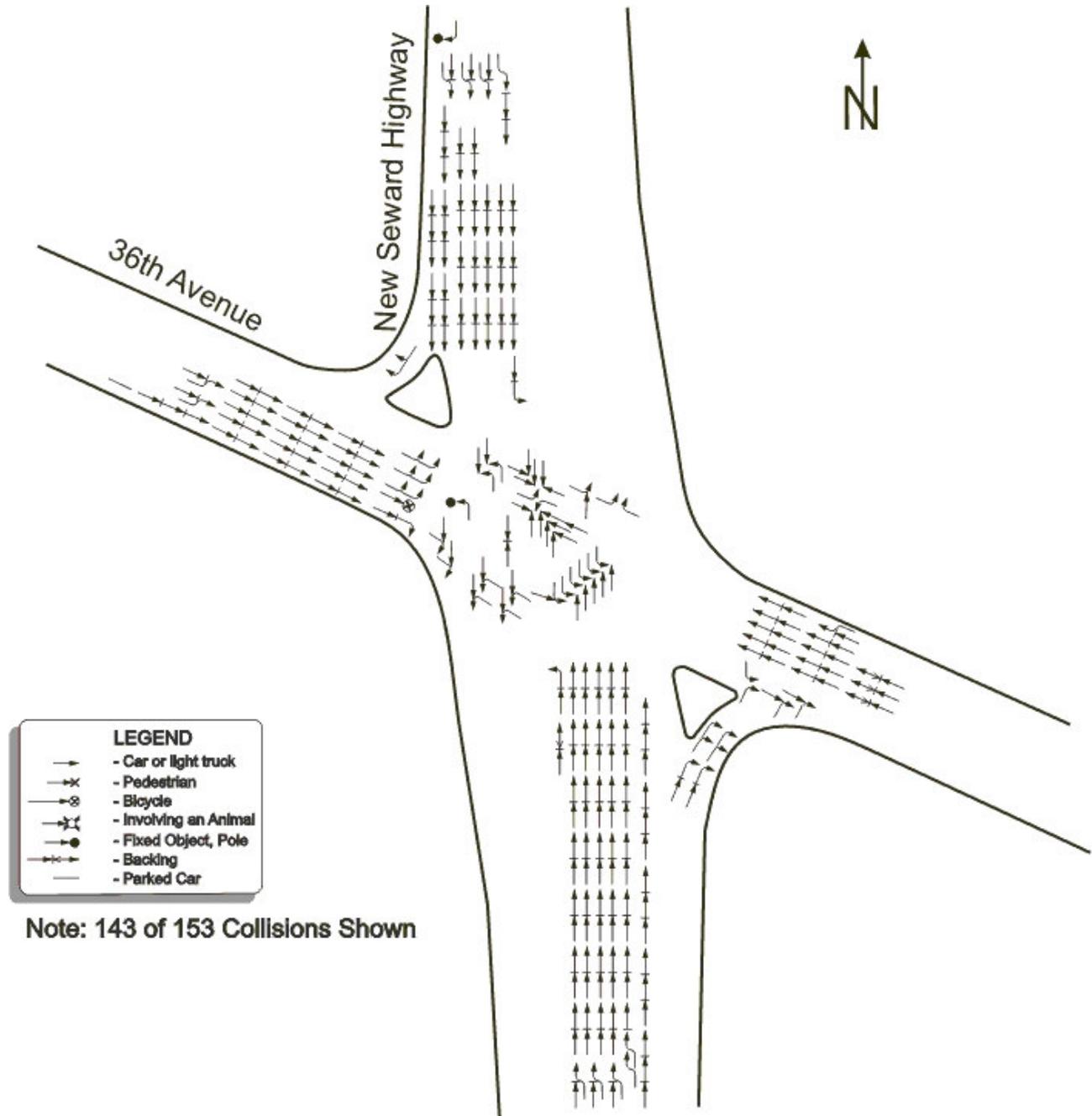


FIGURE 5.2: Collision Diagram for NSH at 36<sup>th</sup> Avenue

### 5.3 Traffic Conflict Data

The conflict data for the NSH at 36<sup>th</sup> Avenue intersection is shown in TABLE 5.2. The conflict rate is 3.6 conflicts per TEV, which is considered high when compared to other intersections studied by the Intus team.

TABLE 5.2: Traffic Conflict Summary

CONFLICT TYPE	CONFLICT FREQUENCY	AVERAGE CONFLICT SCORE	SEVERITY SCORE EQUAL OR GREATER THAN 4.0
<i>Rear-end</i>	147	3.2	20%
<i>Weaving</i>	20	3.3	25%
<i>Left-turn Opposing</i>	6	3.2	17%
<i>Right-turn</i>	6	3.2	17%
<i>Cyclist</i>	10	3.4	30%
<b>TOTAL</b>	182	3.5	36%

The overall average severity score of all the conflicts is considered high.

The spatial distribution of traffic conflicts is summarized in FIGURE 5.3. The results indicated that rear-end conflicts accounted for 81% of all observed conflicts. The majority of the rear-end conflicts were observed at the northbound and southbound exit legs, and were associated lane changing or drivers following too close.

### 5.4 On-site Observations

The following safety issues were identified during the on-site inspection and during the traffic conflict observations:

- *The Yield signs at the intersection appear to be worn out with little reflectivity. As well, the placement of the Yield signs may be less conspicuous to right-turn drivers (please refer to Photo 5.1). These safety issues may cause rear-end incidents involving right-turn vehicles along NSH.*

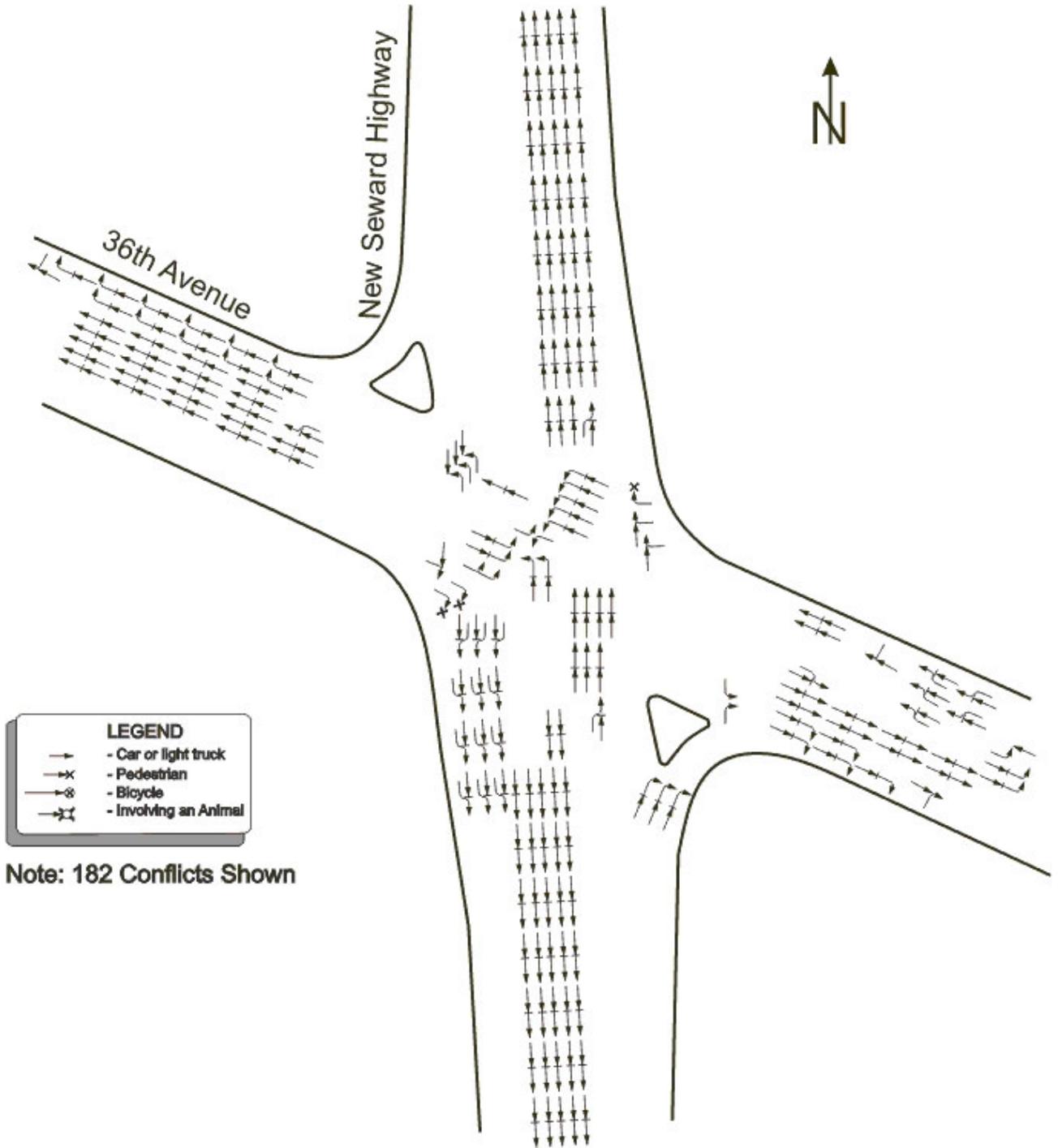


FIGURE 5.3: Traffic Conflict Diagram for NSH at 36<sup>th</sup> Avenue

- *The eastbound and westbound left-turn vehicles were observed to be slower in completing the left-turn movement due to the intersection skew.*
- *A large proportion of commercial vehicles were observed along NSH.*
- *The speed limit along NSH is posted at 55 mph south of 36<sup>th</sup> Avenue and 45 mph north of 36<sup>th</sup> Avenue. Vehicles were observed to be traveling at speeds significantly higher than the posted speeds along NSH.*



PHOTO 5.1: Yield Sign Placement

- *As a result of the speeding and the long cycle length, a number of vehicles were observed to be running the red signal.*
- *Eastbound left-turn vehicles were observed to spill back to OSH during the peak hours.*
- *Due to the intersection skew, westbound left-turn vehicles were forced to turn into the southbound curb and center lanes. However, the southbound curb lane becomes a drop or exit only lane to Tudor Road, causing a number of weaving conflicts or last minute lane changes. In addition, eastbound right-turn vehicles not destined to Tudor Road were also forced to change lanes causing a number of weaving incidents.*
- *The eastbound and westbound pedestrian clearance phases crossing NSH were designed to clear the pedestrian to the median refuge only.*
- *Chevrons have been placed on the median tip on the north leg of the intersection and facing eastbound traffic. The intent of the signs is undoubtedly to guide left-turning traffic to the correct side of the island tip. The additional guidance was likely deemed warranted because of the angle of intersection. The use of chevrons in this manner is atypical and may cause motorist confusion. It is recommended that the chevrons be removed, and that if additional*

*guidance is desirous that the directional dividing line on 36<sup>th</sup> Avenue be extended through the intersection with a yellow continuity line.*

There is concern over the fact that the NSH and 36<sup>th</sup> Avenue intersection is located at the terminus of the freeway segment of NSH. Northbound motorists, having traveled on a 55 mph controlled access facility come to expect uninterrupted traffic flow, and encountering a signalized intersection greatly increases the potential for rear-end collisions, sideswipe collisions, and disobeying the traffic control device. The MOA and DOT have addressed this concern with an active advance warning sign, and by using several LED signal heads in well placed locations.

From a human factors perspective as one travels northbound on NSH there is very little change in the visual scene as one transitions from the freeway segment of NSH to the arterial segment at 36<sup>th</sup> Avenue. The dominant features of the visual scene on the freeway portion of NSH are three lanes of travel, a depressed median, and adjacent land use that is essentially open space. Except for some sparse development adjacent to the NSH, this visual scene is carried through the 36<sup>th</sup> Avenue intersection.

## 5.5 Identified Safety Problems and Issues

The safety problems identified at the intersection of NSH and 36<sup>th</sup> Avenue are manifested in rear-end collisions on dry roads. The high approach speeds on NSH and the relatively congested operations are elevated the rear-end collision risk. In addition, on the northbound approach, where the rear-end collision risk is more pronounced, the transition from the freeway segment of the NSH to the arterial segment is not well defined visually, and create an expectancy violation when the signal is encountered by northbound traffic.

Rear-end and sideswipe collisions are likely being produced on the southbound exit from the intersection by westbound left-turn vehicles that are forced to turn into the southbound curb and center lanes, and eastbound right-turning vehicles turning into the curb lane. The southbound curb lane is a “must exit” from NSH to Tudor Road, and motorists who have just completed the turn onto NSH from 36<sup>th</sup> Avenue who are not destined for Tudor Road will perform last minute lane changes and braking, creating sideswipes and rear-end collisions.

The left-turns being completed by eastbound and westbound traffic is made more difficult by the intersection skew. A significant intersection skew is generally an unexpected condition, and the greater than 90 degree turns increase the complexity of lane tracking and position. This unexpected increase in mental workload, would be compensated by slowing which in turn increases the propensity for rear-end collisions.

The safety issues associated with this intersection are:

- *The chevron signs placed on the median island for eastbound and westbound traffic are used in a non-standard manner and may be causing confusion and rear-end collisions.*

## 5.6 Improvement Strategy

Based on the identified safety issues at the study intersection, the suggested safety improvements are:

- *Add a guide sign on the WBND approach for the dual turn lanes.*
- *Replace and relocate the YIELD signs in the NBND and SBND right-turn channels*
- *Reduce the “green extension” times and cycle times to improve operations*
- *Add R3-8 signs upstream on all approaches*
- *Replace the R3-8 signs with R3-5L signs on the NBND and SBND approach, and relocate them over the lanes*
- *Post rectangular black on yellow warning signs for northbound traffic indicating “Freeway Ends XX miles”*
- *Skid resistant pavement*

Intersections that are not right-angle intersections have an increased collision risk because of a variety of human factors concerns. Reconstructing the intersection to provide a right-angle of intersection is always a solution but in this instance it is not feasible because of property and other concerns.

In the longer term, as NSH is a freeway south of the 36<sup>th</sup> Avenue intersection it may be desirable to continue the freeway northward, and grade separate 36<sup>th</sup> Avenue. The decision to grade separate 36<sup>th</sup> Avenue is a long-range planning decision and it is not appropriate to do anything more than mention it in this study.

The chevron signs on the NSH median that are facing eastbound and westbound traffic on 36<sup>th</sup> Avenue should be removed as they are being used in a non-standard application. If the presence of the median island tip requires additional delineation, then it is suggested that delineators be used as a replacement.

## 5.7 Economic Evaluation

The economic analyses of the NSH at 36<sup>th</sup> Avenue intersection solutions are shown in TABLE 5.3.

TABLE 5.3: Economic Evaluation of NSH and 36<sup>th</sup> Avenue

IMPROVEMENT	CRF	COST (\$1,000)	B/C RATIO
<i>Add a guide sign on WBND approach for dual turn</i>	15%	60	2:1
<i>Replace and relocate YIELD signs in NBND and SBND right-turn channel</i>	5%	5	40:1
<i>Reduce cycle time and green extension</i>	17%	120	7:1
<i>Add R3-8 signs on all approaches and replace R3-8 signs on N/S approaches with R3-5L signs</i>	5%	100	5:1
<i>Skid resistant pavement</i>	20%	200	9:1

All of the proposed countermeasures are economically attractive. However, the five countermeasures combine to produce a CRF that would reduce the collision rate to less than the average rate for Alaskan signalized intersections. This is statistically an unreliable prediction and a

better estimate of the collision reduction potential is -33% (which reduces the collision rate to the state-wide average). The -33% CRF yields an overall B/C ratio of 5:1.

The posting of northbound freeway ends signs (either a single sign after the Tudor road interchange) or a series of three signs at the termination, one mile upstream and two miles upstream are expected to compensate somewhat for the lack of a dramatic visual change in the drivers view at the transition. The active advance warning of the traffic signal at 36<sup>th</sup> Avenue is a key safety device, however, the static freeway ends signs should serve a priming function, and reinforce the need to slow down to arterial speeds. The freeway ends signs are recommended, but are not included in the economic evaluation because there is no significant research on the collision reduction abilities of these types of signs.

The ability to change the cycle times requires input from the MOA signals staff. The MOA operates a closed-loop signal system and has relatively good coordination between adjacent signals. Changing the signal timing is a system-wide consideration.

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## 6.0 Northern Lights Boulevard & Boniface Parkway Intersection

### 6.1 Site Characteristics

NLB is an east-west arterial running the length of the urban area. As it crosses Boniface Parkway it is classified as a major urban, divided, arterial road with two basic lanes in each direction. The speed limit is 40 mph. Boniface Parkway is a north-south major arterial running from Tudor Road to the northern limits of the urban area. As it crosses NLB, it is an urban, divided, arterial with two basic lanes in each direction. The speed limit is 45 mph.

The basic lanes on both streets are supplemented with turning lanes at the subject intersection. All approaches have been provided with an exclusive left-turn lane; the eastbound and westbound approaches have also been provided with right-turn lanes.

The north-west and south-east corners of the intersection are occupied by gas/service stations, the north-east and south-west corners are retail establishments (a Burger King and a strip mall, respectively).

The NLB at Boniface Parkway intersection is signalized with an eight-phase operation. The signal is traffic-actuated and coordinated with adjacent signals, except during low traffic-demand periods when the signal is operated as an isolated intersection. For coordination purposes the midday cycle time is 120 seconds, the AM peak period cycle time is 140 seconds, and the PM peak cycle time is 160 seconds during weekdays. Each approach to the intersection is provided with five separate signal heads; two primary heads suspended over the intersection, one secondary signal head on the far-left, one far-side head on the right, and one near-side head on the right. The visibility of all of the near-side right signal heads were noted during the field observations as being either obscured or outside of the normal cone of vision. All signal heads are LED displays.

Under the existing signal timing and traffic volumes, the NLP at Boniface Parkway intersection is moderately busy at all times of the day. The levels of service to traffic are as shown in FIGURE 6.1.

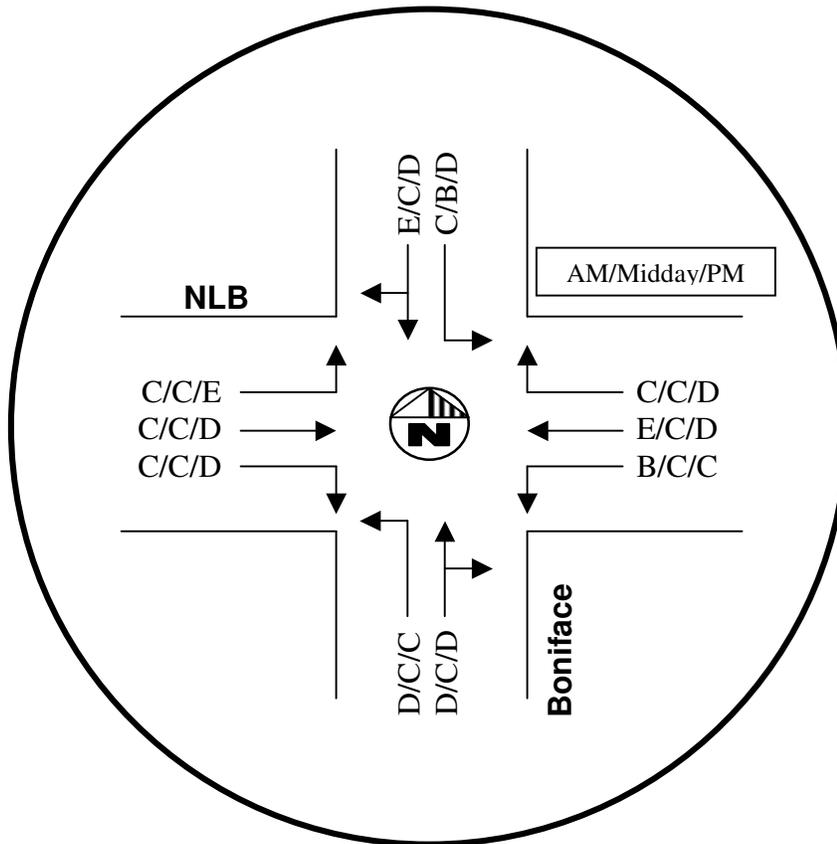


FIGURE 6.1: Traffic Operations at NLB and Boniface Parkway

According to the 2001 Anchorage Traffic Map produced by the Alaska DOT, the average daily traffic volumes on NLB and Boniface Parkway are in the order of 21890, 17740, 21900, and 24508 for the north, south, east, and west legs, respectively. It was noted during the field observations that some southbound to westbound motorists were shortcutting through the gas station driveway to avoid having to traverse the intersection.

## 6.2 Collision Analysis

The collision diagram for NLB at Boniface Parkway is shown in FIGURE 6.2. The aberrant collision characteristics were found to be:

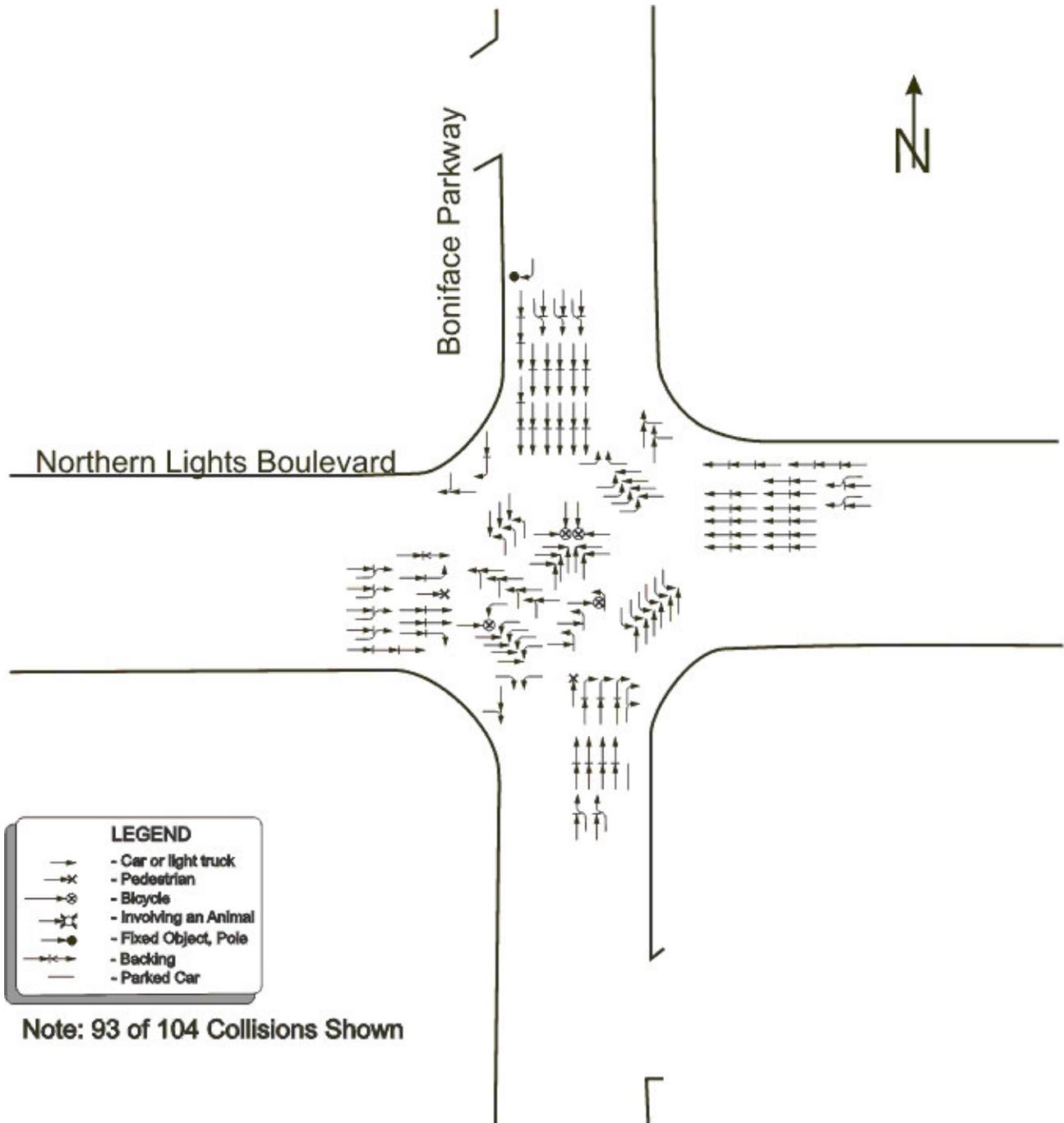


FIGURE 6.2: Collision Diagram for NLB at Boniface Parkway

- *The annual collision frequency appears to be increasing;*
- *Collisions occurring during darkness are over-represented;*
- *Angle collisions are the most frequent collisions and are over-represented at 52%;*
- *Rear-end collisions are the second most frequent collision type and are over-represented at 37%; and*
- *Cyclists collisions are over-represented although they constitute only five collisions over the three year study period.*

The angle collisions generally involve left-turning vehicles. The rear-end collisions tended to be most frequent on the southbound and westbound approaches.

### 6.3 Traffic Conflict Data

The conflict data for the NLB at Boniface intersection is shown in TABLE 6.1. The conflict rate is 3.1 conflicts per TEV, which is considered high when compared to other intersections studied by the Intus team.

TABLE 6.1: Traffic Conflict Summary

CONFLICT TYPE	CONFLICT FREQUENCY	AVERAGE CONFLICT SCORE	SEVERITY SCORE EQUAL OR GREATER THAN 4.0
<i>Rear-end</i>	70	3.4	37%
<i>Left-turn Opposing</i>	11	3.7	55%
<i>Weaving</i>	3	3.0	0%
<i>Right-turn</i>	2	3.5	50%
<i>Cyclist</i>	2	3.0	0%
<b>TOTAL</b>	88	3.3	28%

The overall average severity score of all the conflicts was found to be 3.3 and is considered high.

The spatial distribution of traffic conflicts is summarized in FIGURE 6.3. The results indicated that rear-end conflicts accounted for 80% of all observed conflicts, and 13% of the conflicts were found to be left-turn opposing conflicts. The majority of the rear-end conflicts were observed at the

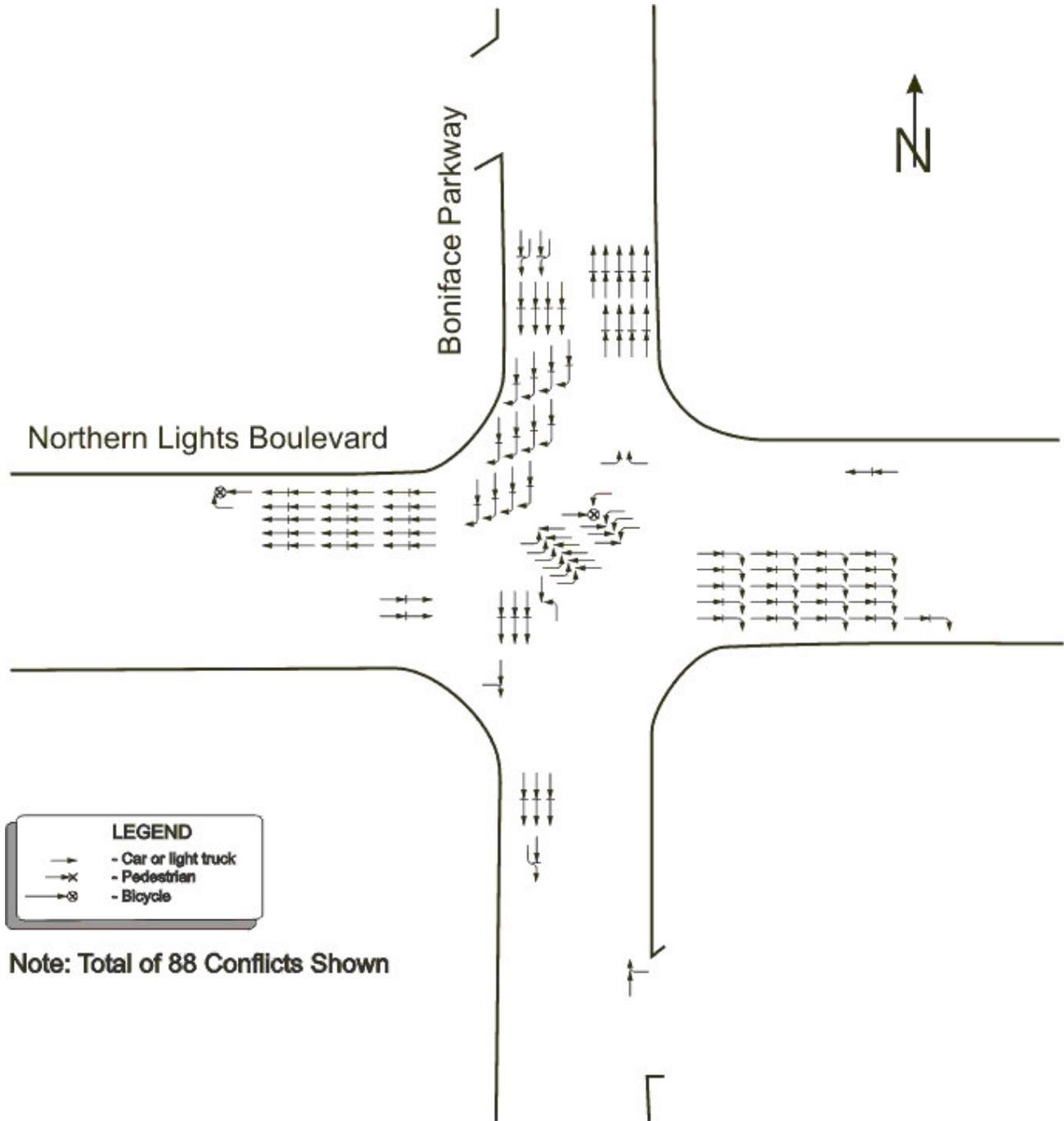


FIGURE 6.3: Traffic Conflict Diagram for NLB at Boniface Parkway

southbound approach, and at the eastbound and westbound exit legs, and were mostly associated with the right-turn movements into driveways. The majority of the left-turn opposing conflicts

involved eastbound and westbound vehicles traveling along NLB.

#### 6.4 Site Observations

- *Protected-permissive left-turn phasing is provided for all directions. Left-turn drivers were observed to accept inadequate gaps during the permissive phases causing left-turn opposing type conflicts.*
- *All nearside right-hand-side signal displays are obstructed by landscaping, vegetation or commercial signs at the intersection (please refer to Photo 6.1).*
- *A number of vehicles were observed to run the red light.*
- *The driveways located in close proximity to the intersection were observed to cause numerous conflicts involving right-turn vehicles.*
- *Southbound right-turn vehicles were often observed to be cutting through the gas station located at the northwest quadrant of the intersections. In addition, the lack of a curb and gutter along the west side of the southbound approach may create driver confusion due to the lack of delineation.*



PHOTO 6.1: Obstructed Nearside Signals

#### 6.5 Identified Safety Problems and Issues

Angle and rear-end collisions are being caused by risk taking due to delay and congestion. All approaches are provided with protected-permissive left turn phasing where drivers proceeding

during the permissive phase are accepting inadequate gaps leading to both left-turn-opposing-through collisions, and rear-end collisions.

Collisions are more prominent during darkness, and the roadway lighting is the probable causative factor.

All nearside right-hand-side signal displays are obstructed by landscaping, vegetation or commercial signs at the intersection.

The driveways located in close proximity to the intersection were observed to cause numerous conflicts involving right-turn vehicles.

## 6.6 Improvement Strategy

Based on the identified safety issues at the study intersection, the suggested safety improvements are:

- *Relocate or otherwise improve the visibility of the near-side signal heads*
- *Implement protected-only left-turn phases for the EBND and WBND approaches*
- *Provide NBND and SBND right turn lanes*
- *Upgrade/improve street lighting*
- *Skid resistant pavement*

For the medium term, consider relocating or consolidating the driveways at the intersection during redevelopment of the adjacent properties. The local HSIP program has already pinpointed the west approach on NLB as being a potential candidate from improved “access management”, and the MOA and State DOT are already pursuing this option.

## 6.7 Economic Evaluation

The economic analyses of the NLB and Boniface Parkway intersection solutions are shown in TABLE 6.2.

TABLE 6.2: Economic Evaluation of NLB and Boniface Parkway

IMPROVEMENT	CRF	COST (\$1,000)	B/C RATIO
<i>Improve visibility of near-side signal heads</i>	10%	10	70:1
<i>Convert to E/W Protected only phasing</i>	30%	50	6:1
<i>Add N/S right turn lanes</i>	15%	2400	1:10
<i>Improve lighting</i>	50%	1500	1:1
<i>Skid resistant pavement</i>	20%	200	7:1

The north and south right turn lanes are not economically attractive. This countermeasure has been given a relatively high capital cost because of known soil contamination in the area. Nevertheless, in order to produce even a 1:1 B/C ratio, the capital cost would have to be reduced to \$130,000. Despite the economic analysis a failure to provide right-turn lanes at a signalized intersection such as this is contrary to the MOA design guidelines. This has been recognized by the MOA and the Alaska DOT. Through their HSIP program, this intersection has also been identified as needing safety improvements, and the provision of north and south right-turn lanes is being pursued through the HSIP initiative.

Improved lighting at the subject intersection is produces a B/C ratio of 1:1. Traditionally, safety improvement projects have focused on improvements that yield ratios of 2:1 or higher in order to expend resources on the most beneficial projects. The decision to proceed with the lighting countermeasure will reside with the MOA. It is perhaps prudent to undertake further analysis of the current illumination and determine if improvements are feasible. At that point, a refined cost estimate can be made, and a more accurate B/C ratio developed.

The provision of protected-only turn phasing for the east and west approaches is an economically attractive option but is not warranted according to the requirements of the MOA Office of Planning, Development and Public Works. While the protected-only phasing will certainly make the

intersection safer, it will increase intersection delay (which in itself will counteract some of the safety gains), and is against local policy. The decision to pursue this option resides with the MOA.

The remaining two countermeasures (skid resistant pavement, and improving the visibility of the near-side signal heads) are economically attractive. These two measures combine to produce a CRF of  $-28\%$  and a B/C ratio of 10:1. The resultant collision rate is above the state-wide average for signalized intersections and is considered a reasonable estimate.

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## 7.0 Global and Network Safety Issues

During the site inspection and conflict observations, a number of global or network related safety issues were identified that were considered to have a significant impact on the safety performance of the study intersections. These issues are provided in this report for discussion, and may require further investigation. However, it may provide the initial momentum to start the process of addressing these issues that may result in policy changes in engineering, education and enforcement.

All intersections could benefit from the following countermeasures:

- *More frequent refreshing of pavement markings (15% reduction in all collision types)*
- *Increased police enforcement of aggressive driving (up to a 20% reduction of all collision types – but variable depending on level of enforcement and ability to sustain effort)*
- *Speed zoning rationalization*
- *Improved network connectivity*
- *System-wide adaptive signal control (i.e., SCOOT, SCATS, etc.)*

These systemic countermeasures, and some comments on driver behavior and the Anchorage fleet, are discussed in more detail in the following subsections.

### 7.1 Street Network Connectivity

The land use pattern and the street system in Anchorage are such that the north-south movements in the urban area place an enormous burden on the LOP, NSH, and OSH. Specifically, the area east of NSH is generally bisected by several open spaces (i.e., Campbell Park, Alaska Botanical Garden, and Far North Bicentennial/Hillside Park). The three aforementioned parks essentially form a continuous green belt that interrupts north-south traffic flow east of NSH. Motorists east of NSH that are traveling north-south and must traverse the green belt are required to use either LOP, NSH, or OSH as the most convenient and continuous north-south facilities.

The NSH which goes through the center of the city is the major north-south arterial road in Anchorage. It carries high traffic volumes (in the range of 60,000 AADT) in both directions. Two

of the study intersections (36<sup>th</sup> Avenue and Fireweed Lane) intersect with the Highway. Part of the problem is the extremely high volume that the at-grade intersections have to accommodate. As a result of the high volume, along with other localized issues, these two intersections were high accident locations. The Dimond Boulevard and OSH intersection is located just west of the NSH interchange, and is also subjected to high traffic volumes and resulting in high collision rates.

Another network related issue is the present function of the highway. Because of its existing alignment, it is functioning as a regional route serving as an inter-city link, as well as being used as an “access” road for local travel within the City. Due to this mix of trip purposes and the less than homogeneous function of the Highway, “through” trip drivers who are subjected to the “speed adaptation” phenomena may be at a higher risk of causing rear-end collisions at at-grade intersections where local conditions may be less than ideal.

The safety performance at the LOP and Tudor Road intersection is also partially caused by network related issues. Currently, LOP is the first north-south arterial road serving the areas east of LOP. However, this area is separated by the Far North Bi-centennial Park. Thus, vehicles originated from and destined to these areas would likely use LOP, resulting in extremely high westbound left-turn and northbound right-turn volumes at the LOP and Tudor Road intersection. In addition, the intersection is located just upstream (east of) of the interchange with NSH, further exacerbating this problem.

The MOA and the DOT may wish to investigate the provision of feasible alternate routes to NSH and LOP along the east boundary of the urban area to alleviate the high traffic demand along the study intersections. However, this may be difficult due to the potential environmental impact of building a road through the Park. It is our understanding that an East Anchorage Transportation Study is underway and the safety impacts of changes to the street network should be carefully considered in that planning study.

## 7.2 Speed Zoning

It appears that the speed zoning is inconsistent in Anchorage. For example, most arterial roads have similar cross section width, but would have a range of posted speed limits between 35 mph and 55 mph. The inconsistent speed zoning may lead to driver non-compliance, and may result in higher

collision risks. In general, based on our observations in Anchorage, the operating speeds on arterial roads are in the range of 50mph to 60 mph, indicating a compliance problem. Although the literature is inconsistent whether the operating speeds had any effect on safety, however it is the law of physics that dictates that higher operating speeds will result in high collision severity.

It is suggested that the MOA and the DOT review the speed zoning practice, and provide a more consistent and homogeneous speed zoning policy. In addition, general speed enforcement would be desirable to improve the speed compliance rate in Anchorage.

### 7.3 Intersection Related Issues

It was generally observed that the cycle length used at the major signalized intersections are very long (in excess of 120 seconds) due to the intersection size and traffic volumes. It should be noted that pedestrians become impatient when cycle lengths are longer than 90 to 120 seconds. This may cause them to jaywalk and disobey traffic control devices, or chooses not to cross at marked crosswalks increasing the collision risks for these users. In addition, long cycle lengths typically causes long queues that further exacerbate stop-and-go conditions at intersections causing rear-end incidents. It should be noted that it typically takes longer to dissipate a queue than to form a queue. It is suggested that the MOA and the DOT review the signal design policy, and attempt to provide shorter cycle lengths at major intersections if possible.

Despite the turbulence created by more frequent phase changes, shorter cycle times are not expected to have any significant impact on the collision frequency for motor vehicles.<sup>2</sup>

As intersection delay is correlated with the safety performance of the intersection, the cycle time, which affects intersection delay, must also be considered with respect to whether it is minimizing delay (hence, improving safety). The state-of-the-art in vehicle-actuated signal timing is to use current traffic demand, as measured through a series of detector loops in each lane of travel, to determine the appropriate cycle time on a cycle-by-cycle basis. One such method for vehicle-

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<sup>2</sup> Ng JCN, Hauer H, and Lovell J (1987) "Are Longer Signal Cycles Safer?", Proceedings of the Canadian Multidisciplinary Road Safety Conference V, Calgary, Alberta; pp. 75-83.

actuated control is “Green Logic”, which applies the principles of fuzzy logic in determining cycle times and maximum green times per approach. In a simulation experiment, conventional signal technology was compared to Green Logic in a series of traffic demand environments (i.e., average rush hour, off-peak hours, over-saturated, etc.) and it was found that the Green Logic produced 20% less time-loss while using 10% shorter cycle times.<sup>3</sup> This is fairly strong evidence to suggest that shorter cycle times during all traffic conditions (and particularly during the peak hours) will reduce delay, and improve safety.

The transverse pavement markings were in many cases faded and difficult to see. In particular the turn arrows and the word “ONLY” were worn and in some cases almost completely removed. This is particularly troubling since the field work was completed near the end of the “painting season”. By the end of the winter, many of these markings will be completely obliterated. It is recommended that the turn lane markings be either:

- *Repainted near the end of the painting season; or*
- *Placed with permanent marking material.*

## 7.5 Driver Behavior

Aggressive driver behavior was generally observed during our site visits and driving around in Anchorage. Aggressive driver behaviors include speeding, tailgating, performing illegal turns and running red lights at intersections. Aggressive driver behaviors may lead to increased collision risks, and may be indicative of driver frustration due to the congestion and network issues discussed above. It is suggested that the MOA and the DOT consider publicity and education campaigns to discourage aggressive driver behavior.

## 7.6 Vehicle Fleet

It was observed that the proportion of commercial vehicles, SUV’s and pick up trucks may be high compared to other North American cities. This high mix of taller vehicles may be problematic for passenger car drivers where their visibility to the road ahead and traffic control devices (signals and

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<sup>3</sup> Jongenotter E and Monsma S (2002) “Green Logic and the Benefits for Traffic-actuated Control – The Dutch Experience”, Traffic Engineering + Control 43(9), pp. 351-353.

signs) may be limited. This may lead to higher collision risks for passenger car drivers since most information needed for safe driving is provided visually. In addition to the visibility problem, the SUV and pick ups were observed to cross over medians to complete U-turns, as well as driving along unpaved shoulder to bypass traffic stuck in congestion. It is suggested that the general placement and visibility of the traffic control devices may need to be enhanced for the passenger car drivers. As well, features such as median design may need to be changed to discourage U-turns by SUV's and pick up trucks.

## 7.7 Integrating Safety

Many of the intersections that have been identified as HALs are also congested locations and have been targeted for improvement on the basis of congestion-mitigation. It is recommended that safety become an important criterion in the planning and design process through explicit consideration. Adoption of safety conscious planning and Road Safety Audits of design drawings are strongly recommended.

## 8.0 Claims Data Analysis

As this was the MOA first project dealing with insurance claims data, the MOA expressed a desire to explore the use of claims data as a supplement to collision data. Specifically, the MOA requested that Intus conduct an analysis of claims and collision data to determine if a stable correlation existed between the two safety indicators.

The data that has been collected for this individual project is considered small or limited in statistical terms. The limited dataset is subject to random variations (i.e., noise) and it is not possible to draw any significant conclusions respecting a correlation between claims and collision data.

Nevertheless, the average annual number of collisions was plotted against the average annual number of claims for all intersections, as shown in FIGURE 8.1.

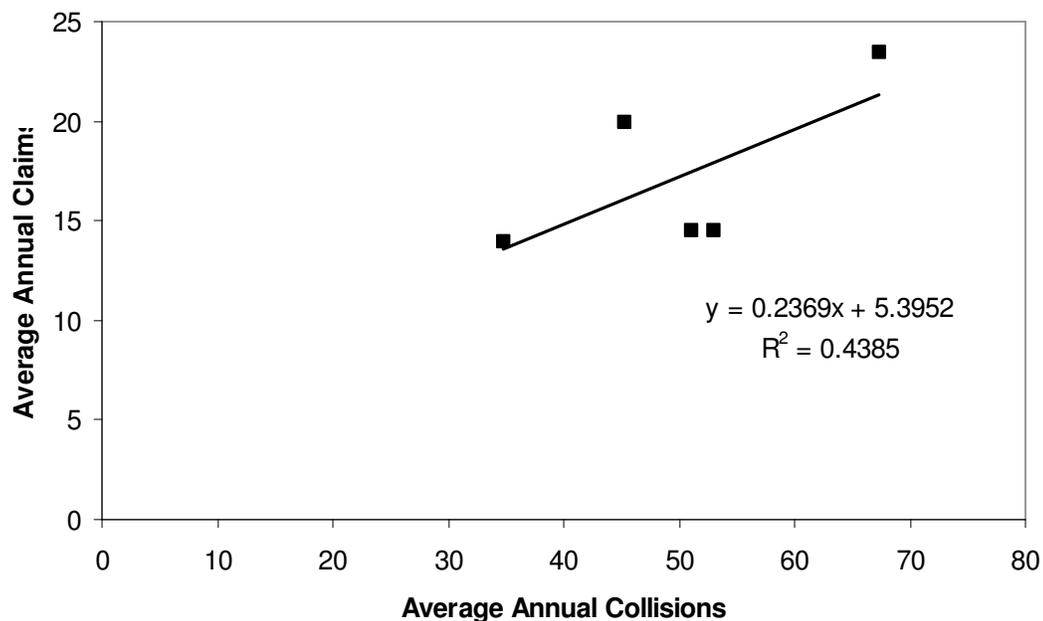


FIGURE 8.1: Correlation Between Claims and Collision Data

Regression was undertaken for linear, logarithmic, exponential, and power functions, with the linear regression yielding the best fit (as shown in FIGURE 8.1).

The linear function demonstrates that about 24% of all intersection collisions are reported as insurance claims to State Farm. However, the goodness-of-fit is not very promising. The regression also indicates that five to six claims are made each year to State Farm that do not generate a collision report. This is likely due to a damage caused by a noncollision (such as a stone chip on a windshield), damage incurred in a motor vehicle collision that was not attended by the police, etc.

Apart from the regression analysis there is some concern with using claims data in engineering analysis. The insurance companies maintain databases to track client claims and not to identify high hazard locations. Since identifying an exact location of the incident is not of primary concern to the insurer, there is a justifiable concern respecting the accuracy of location reporting.

In the end, the use of claims data as a surrogate for collision data is not recommended for the following reasons:

- *There does not appear to be a strong correlation between reported intersection collisions, and State Farm insurance claims data.*
- *The State Farm claims data is dependent on market share in the Anchorage area, which is unaccounted for in the above model. An increase in market share for State Farm should produce an increase in claims, while not producing an increase in reported collisions. In order to properly assess any relationship between future claims and collision data, it would be necessary to know the State Farm market share.*
- *The data collected by the insurance companies is limited and is not suitable for an engineering analysis of intersections.*

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## 9.0 Conclusions

State Farm Mutual Automobile Insurance Companies, using their claims database and analysis methodology, has identified the intersections of LOP and Tudor Road,, NSH and Fireweed Lane, OSH and Dimond Boulevard, NSH and 36<sup>th</sup> Avenue, and NLB and Boniface Parkway as hazardous locations. A review of the collision records for these five intersections confirm the State Farm findings that the safety performances of these intersections are statistically worse than is expected.

Implementing state-of-the-art intersection safety review techniques that included collision analysis, traffic conflict studies, and positive guidance reviews, Intus Road Safety Engineering Inc. undertook safety reviews of these five intersections with a goal of identifying the underlying safety problems and proposing cost-effective countermeasures.

Overall the intersections under study were found to be well designed, operated, ad maintained. Signal displays generally exceeded the minimum standards, and the existing geometric design is in most cases also exceeds the minimum requirements. Consequently, the recommendations for safety improvements at the study intersections are relatively minor improvements. The recommended improvements and their estimated benefit-cost ratios for all of the intersections are shown in TABLE 9.1.

At the intersection of LOP and Tudor Road it is also recommended that:

- *The Keep Right sign and hazard marker on westbound approach (facing eastbound traffic) be relocated to east of the crosswalk, and the median island tip be removed.*

At the intersection of NSH and Fireweed Lane it is also recommended that:

- *The westbound R4-7 “Keep right” sign be replaced with a r4-7b or a W1-6 sign, which are more consistent with the approach and island geometry; and*
- *The MOA reconsider the pedestrian signal heads and Yield sign on the east crosswalk as it crosses the westbound to northbound right turn channel to eliminate confusion between the conflicting devices.*

TABLE 9.1: Recommended Countermeasures

INTERSECTION	COUNTERMEASURE	B/C RATIO
LOP and Tudor	Shorten cycle times and reduce green extension times*	9:1
	Place R3-8 signs on all approaches	58:1
	Skid resistant pavement	13:1
NSH and Fireweed	Install a SBND near-side signal head	69:1
	Install a SBND active advance warning sign	2:1
	Construct a SBND right-turn lane	3:1
	Erect a NBND advance street name sign for Fireweed Lane	19:1
	Skid resistant pavement	11:1
OSH and Dimond	Add additional NBND and SBND primary signal heads	8:1
	Reduce the green extension and cycle times*	97:1
	Replace and relocate R3-8 signs and add R3-8 signs on all approaches	66:1
	Skid resistant pavement	8:1
NSH at 36 <sup>th</sup>	Erect a guide sign for WBND left turning traffic	2:1
	Replace and relocate the NBND and SBND Yield signs in the right turn channels	40:1
	Reduce the green extension and cycle times*	7:1
	Erect "Freeway Ends" signs on NBND NSH	Unknown
	Add R3-8 signs on all approaches and replace the R3-8 signs on the NBND and SBND approaches with R3-5L signs	5:1
	Skid resistant pavement	9:1
NLB and Boniface	Improve visibility of the near-side signal heads on all approaches	70:1
	Skid resistant pavement	7:1

\* Requires more input from the MOA traffic signals staff on the system-wide impacts

At the intersection of NSH at 36<sup>th</sup> Avenue it is also recommended that:

- The chevron warning signs on the NSH median islands be removed and replace with post mounted delineators; and
- Consideration be given to grade separating this intersection in the long-term.

At the intersection of NLB and Boniface Parkway two additional countermeasures were identified that require consideration by the MOA:

- *Conversion of the protected-permissive operation in the east-west direction to protected-only phasing will increase safety and provide a positive B/C ratio. However, the conditions at this location do not “warrant” protected-only phasing according to the MOA local policy. The MOA should consider whether breaching policy is acceptable.*
- *Collisions during times of darkness are over-represented and improved lighting produces an estimated B/C ratio of 1:1. It is recommended that the MOA review the current lighting system, determine if improvements can be made, and if so estimate a more refined cost for the upgrades so that the economic evaluation can be re-done.*

In the course of conducting the intersection safety reviews at these five intersections, it was noted that there were several systemic issues that may be effecting the safety performance of the study intersections. They are:

- *Faded pavement markings: Many of the turn arrows and “ONLY” markings were almost completely removed. This is particularly troubling as this was the end of the painting season, and by the end of winter these markings will in many cases be obliterated. A more frequent refreshing of the pavement markings can reduce collision occurrence by up to 15%.*
- *Street Network Connectivity: The north-south street system in the east part of Anchorage is generally bisected by a greenbelt. This severely hampers north-south movement and places a heavy burden on Lake Otis Parkway, New Seward Highway, and the Old Seward Highway (as these are the eastern-most continuous north-south routes). Not only is the incomplete network increasing collision risk by increasing congestion on these routes, it is also causing additional turning movements at intersections which is also increasing collision risk.*
- *Aggressive driving: Several instances of aggressive driving were observed during the field work. The collision risk brought about by aggressive driving may be mitigated by increased police enforcement, and/or publicity and education campaigns.*

- *Speed Zoning: It appears that the speed zoning in Anchorage is somewhat inconsistent. Roads of similar design and adjacent land use have different speed limits which may be leading to compliance problems. A review of the speed zoning policy may be beneficial.*
- *System-wide adaptive signal control: Many of the study intersections have an increased collision risk because they are congested during most times of the day. The congestion may be mitigated by system-wide adaptive signal control technology (i.e., SCOOT, SCATS, etc.). The MOA may want to consider implementing a new signal system control technology to improve operations and improve safety.*
- *Vehicle fleet: A significant proportion of the visible fleet was larger passenger vehicles such as pick-up trucks and Sport Utility Vehicles (SUVs). These vehicles can create visibility problems for other passenger vehicles. The MOA should consider the placement and visibility of traffic control devices inn light of the preponderance of SUVs and pick-up trucks.*
- *Integrating safety: Although not an issue with the current street system it is suggested that the MOA and the DOT consider implementing more proactive safety programs such as safety conscious planning and road safety audits. These programs will help prevent collision occurrence.*

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# Appendix A

## *Traffic Conflict Technique*

## Traffic Conflict Technique and Methodology

The motor vehicle collision propensity of the five study intersections was evaluated using the traffic conflict technique documented in the Traffic Conflict Procedures Manual, 2<sup>nd</sup> Edition. The Technique involves the systematic observation and reporting of traffic conflicts, or “near collisions” and the assessment of the degree of severity for each conflict.

A traffic conflict occurs when two or more road users approach the same point in time and space, and at least one road user takes successful evasive actions to avoid a collision within a predefined minimum time to collision. The severity and nature of traffic conflicts could be used to diagnose poor traffic control and geometric design at intersections. Furthermore, traffic conflicts provides supplemental information to collision data for safety studies, since observers were on-site to immediately identify and record near-misses. In addition, the more frequent occurrence of traffic conflicts allowed for a relatively large amount of safety related data to be collected in a limited amount of time.

There are four notable limitations to conducting traffic safety studies using the traffic conflict technique. First, traffic conflicts are a record of successful evasive actions, which are not a substitute for good quality collision information. Therefore, traffic conflicts and collisions should not be used interchangeably. Second, the technique is limited primarily to intersections. Effective methods for quantifying traffic conflicts along corridor sections through direct observation are unavailable or unproven. Since traffic conflicts could occur anywhere along a corridor, selecting specific sites within a corridor for observation would be impractical and economically infeasible. Third, the cost for conducting traffic safety studies using the traffic conflict technique is relatively high, and the existing methods require a total of 32 person-hours of survey time at each site. Finally, to ensure reliable and consistent results, teams of qualified, experienced traffic conflict observers should be maintained and retrained on an on-going basis. The technique therefore requires an investment in the training and maintenance of qualified observers.

An existing hazard is common to both a traffic conflict and a motor vehicle collision event. When two or more vehicles approach the same point in time and space, one or both road users may take evasive actions such as braking, accelerating or swerving to avoid a collision. Now, one of two things may occur. If the evasive action is successful, a primary traffic conflict occurs. If the evasive

action is unsuccessful or not taken, by definition a collision occurs. In general, the presence of a significant number of traffic conflicts is indicative of operational deficiencies and, possibly, collision propensity. Normal interaction between road users generally does not result in a traffic conflict. Precautionary measures to avoid a perceived dangerous situation are also not a conflict. A conflict only occurs when evasive action which is not part of normal driving is taken to avoid a real hazard.

The severity of a traffic conflict (a conflict score) is measured by the summation of two scale assigned and rated by an observer at the site:

- *Time-to-Collision (TTC): The Time-to-Collision (TTC) is a measure of the time elapsed before a collision would have occurred had the evasive action failed or no evasive action been taken.*
- *Risk-of-Collision (ROC): The Risk-of-Collision (ROC) is a subjective measure of the collision potential, and is dependent on the perceived control that the road user appears to have over the traffic conflict event.*

The range of time to collision and risk of collision scores is summarized in TABLE A1. The summation of these scores is known as the “overall severity score”, which ranges between 2 and 6. Research indicated that traffic conflicts which resulted in overall severity scores of 4 or more exhibited a correlation to motor vehicle collisions and are somewhat indicative of a more significant collision risk.

TABLE A1: Time to Collision and Risk of Collision Indices

TTC & ROC SCORES	TTC (SECONDS)	ROC(SECONDS)
1	Between 1.6 and 2.0	Low Risk
2	Between 1.0 and 1.5	Moderate Risk
3	Between 0.0 and 0.9	High Risk

In addition to the conflict score, the conflict types are recorded in the field and are generally divided into seven categories:

1. *Left Turn Opposing (LTO)*;
2. *Left Turn Crossing (LTC)*;
3. *Crossing (C)*;
4. *Rear-End (RE)*;
5. *Right Turn (RT)*;
6. *Weaving (W)*; and
7. *Pedestrian (P)*.

### **Traffic Conflict Observation Period**

Traffic conflicts were collected at the five study intersections using the techniques documented in the Traffic Conflict Procedures Manual, 2nd Edition. A two-person observation team trained in the traffic conflict technique was on-site for 32 person hours at each study intersection. The traffic conflict survey schedule is summarized in TABLE A2.

TABLE A2: Conflict Observation Schedule

INTERSECTION	DATES	TIMES OF DAY	DURATION	NO. OF OBSERVERS	NO. OF PERSON HOURS
<i>NLB at Boniface Parkway</i>	<i>Sep 30 &amp; Oct 1, 2002</i>	<i>0700-1000</i>	<i>3</i>	<i>2</i>	<i>12</i>
		<i>1100-1300</i>	<i>2</i>	<i>2</i>	<i>8</i>
		<i>1500-1800</i>	<i>3</i>	<i>2</i>	<i>12</i>
<i>LOP at Tudor Road</i>	<i>Oct 2 &amp; Oct 3, 2002</i>	<i>0700-1000</i>	<i>3</i>	<i>2</i>	<i>12</i>
		<i>1100-1300</i>	<i>2</i>	<i>2</i>	<i>8</i>
		<i>1500-1800</i>	<i>3</i>	<i>2</i>	<i>12</i>
<i>OSH at Dimond Boulevard</i>	<i>Oct 4 &amp; Oct 7, 2002</i>	<i>0700-1000</i>	<i>3</i>	<i>2</i>	<i>12</i>
		<i>1100-1300</i>	<i>2</i>	<i>2</i>	<i>8</i>
		<i>1500-1800</i>	<i>3</i>	<i>2</i>	<i>12</i>
<i>NSH at 36th Avenue</i>	<i>Oct 8 &amp; Oct 9, 2002</i>	<i>0700-1000</i>	<i>3</i>	<i>2</i>	<i>12</i>
		<i>1100-1300</i>	<i>2</i>	<i>2</i>	<i>8</i>
		<i>1500-1800</i>	<i>3</i>	<i>2</i>	<i>12</i>
					<i>32</i>
<i>NSH at Fireweed Lane</i>	<i>Oct 10 &amp; Oct 11, 2002</i>	<i>0700-1000</i>	<i>3</i>	<i>2</i>	<i>12</i>
		<i>1100-1300</i>	<i>2</i>	<i>2</i>	<i>8</i>
		<i>1500-1800</i>	<i>3</i>	<i>2</i>	<i>12</i>

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## Appendix B

### *Critical Collision Rate Comparison*

### Calculation of the Critical Collision Rate

The critical collision rate represents the expected tolerable collision rate of intersections with similar characteristics. If the actual collision rate is greater than the critical rate, the deviation is probably not due to chance but to the unfavorable characteristics of the intersection. The equation for the critical rate of the intersection is expressed as follows:

$$R_c = R_a + k \left( \sqrt{\frac{R_a}{M}} \right) + 0.5M$$

where:  $R_c$  = intersection critical collision rate  
 $R_a$  = average collision rate for similar intersections  
 $M$  = the annual number of vehicles entering the intersection in millions (Million Entering Vehicles – MEV)  
 $k$  = probability constant (A value of 1.65 is used to obtain a 95% confidence level)

Typically it is most useful to use a  $R_a$  value calculated from similar intersections (in this case urban signalized) within the same jurisdiction as the subject intersection. Given that system wide data of this nature was not available for the MOA, comparison data from the State of Alaska was utilized in the analysis [Reference here]. Therefore, this analysis cannot be considered definitive, but rather comparative, indicating whether or not a collision problem exists.

The rate quality control technique defines a location as a high accident location if the observed collision rate exceeds a critical collision rate. The main assumption of the technique is that the number of collisions occurring at a given location during a given time period can be approximated by the Poisson distribution. This assumption is widely accepted among safety researchers and turns out to be supported by a vast body of empirical evidence. The critical rate calculation was conducted using 95% confidence level and an average collision rate of 1.17 for signalized 4-leg intersections obtained from ADOT HSIP Handbook, Jan 25, 2002.

The critical rates were calculated by using:

$$C_i = \lambda + k \sqrt{\lambda / m} + 1 / 2 m$$

where:  $C_i$  = Intersection critical collision rate  
 $k$  = a constant related to the Level of Significance (95%,  $k = 1.645$ )  
 $\lambda$  = expected collision rate in collisions per million entering vehicles and  
 $m$  = number of million entering vehicles

### Chi-square Test

The Chi-square test is used when comparing a sample average to the population average. This test provides a level of confidence that the averages are significantly different and not due to statistical error resulting from a small sample size. For example, the level of confidence is high when both the sample size and the difference between the sample and the population is large. In this situation, the average is the frequency of occurrence of a specific type at the study intersection, while the population is the Anchorage or Alaska average for the same collision type at similar locations.

The Chi square test can be calculated using the following equation:

$$X^2 = \frac{(x - pn)^2}{pn} + \frac{[(n - x) - n(1 - p)]^2}{n(1 - p)}$$

where:  $X^2$  = chi-square test value  
 $p$  = the average ratio for the collision type being investigated  
 $x$  = the number of collision types being investigated, and  
 $n$  = the total number of collisions at the site.

The 95% confidence level was used, and corresponds to a chi-square test value of 3.84.

## Appendix C

*HSIP Economic Evaluation Print Outs*