C Street and West Klatt Road
Intersections Reconnaissance Study

Traffic Analysis Report

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Prepared for:

Municipality of Anchorage
Traffic Department

And

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Acronyms and Abbreviations

The following table presents acronyms and abbreviations that may be commonly used throughout this document.

ADT, AADT	Average Daily Traffic, Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ADOT/ (&)PF, or DOT/(&)PF	Alaska Department of Transportation and Public Facilities
AMATS	Anchorage Area Metropolitan Area Solutions
ASD	Anchorage School District
AWSC	All-way-stop-control (4-way stop signs)
CTWLTL	Continuous-two-way left turn lane
DCM	Design Criteria Manual
DD, DDHV	Direction al Distribution, DD Hourly Volume
EB, EBLT	Eastbound, eastbound left turn
Hwy	Highway
ITE	Institute of Transportation Engineers
K	% of AADT or ADT during peak hour
LOS	Level of Service (intersection performance grade)
LT	Left turn(s)
MOA	Municipality of Anchorage
Mph	Miles Per Hour
MUTCD	Manual of Uniform Traffic Control Devices
NB, NBLT	Northbound, northbound left turn
OSHP	MOA's Official Streets and Highways Plan
Ped	Pedestrian
Pkwy	Parkway
PTR	Permanent Traffic Recorder
PUD	Planned Unit Development
RIO	Right-in turns only
RIRO	Right-in, Right-out driveway
Rd	Road
RT	Right turn(s)
SB, SBLT	Southbound, southbound left turn
Sec	Second
Sf	Square feet
St	Street
Th, Thru	Through
ITE	ITE Trip Generation Manual
Veh	Vehicle
WB, WBLT	Westbound, westbound left turn

Introduction

Study Background

Hattenburg Dilley and Linnell (HDL) has been retained by the Municipality of Anchorage Traffic Department to evaluate the impacts of the C Street Extension on the C Street/Peninsula Circle, C Street/West Klatt Road and C Street/West Klatt Road/Timberlane Drive intersections; and prepare a reconnaissance study of feasible alternatives. This Traffic Analysis Report, prepared by Kinney Engineering in collaboration with HDL, primarily focuses on the higher traffic volume C Street/ West Klatt Road and West Klatt Road/Timberlane Drive intersections. Peninsula Circle is a low volume cul-de-sac which is evaluated under a separate cover for improved circulation and access.

In November 2006, the C Street Extension between O'Malley Road and Dimond Boulevard was opened to traffic. The C Street Extension is a 4-lane divided major arterial with and expressway-type controlled access so that no driveways or adjacent land has direct access and intersections are only at major street connections. There are pedestrian and bike walkways/pathways on both sides of the roadway. The northern terminus at Dimond Boulevard is signalized, and the southern terminus is the O'Malley Road diamond interchange that features modern roundabouts at the ramp intersections. Street intersections between Dimond and O'Malley will likely to be signalized in the future as warrants are satisfied.

The C Street expressway and A-C couplet is the third north-south corridor to span Anchorage and provide continuous route connectivity between the downtown and mid town employment centers and south Anchorage. Also, it is the only corridor with continuous pedestrian and bicycle facilities between downtown and south Anchorage. The other two major corridors between downtown and south Anchorage; the Minnesota Drive/O'Malley

Road corridor and the Seward Highway Corridor; are major arterials that transition into freeways.

One of the consequences of the C Street Extension will be the increased traffic on the segment of C Street to the south of the O'Malley Road. As such this report evaluates current and future operations and safety for the higher volume intersections at C Street/ West Klatt Road and C Street/West Klatt Road/Timberlane Drive.

The design (analysis) year for this study is 2017.

Study Area

Figure 1 presents the study area.

Aerial Photograph Source: Google Earth

Figure 1- Study Area

References

The following references and guidelines were used in this analysis.

- *Alaska Preconstruction Manual* (PCM) by DOT&PF
- American Association of State Highway and Transportation Officials (AASHTO) *A Policy on the Geometric Design of Highways and Streets*, (GDHS) 2001
- *Central Region Annual Traffic Volume Report* for the years between 1994 and 2004, published by DOT&PF
- *Alaska Traffic Manual (ATM)*, State of Alaska DOT&PF.
- *Manual on Uniform Traffic Control Devices (MUTCD)*, FHWA.
- *Official Streets and Highways Plan*, (OSHP) Municipality of Anchorage Community Planning and Development Transportation Planning Division, 2003.
- *Design Criteria Manual* (DCM) Municipality of Anchorage Project Management and Engineering, June 2005
- *Anchorage Annual Traffic Report* (misc. years), Municipality of Anchorage, Traffic Department.
- *Highway Safety Improvement Program Handbook* (HSIPHB) published by the State of Alaska, Department of Transportation and Public Facilities with supplement rates provide by Central Region Traffic and Safety.
- NCHRP Report 162, *Methods for Evaluating Highway Safety Improvements*, Laughland, *et. al*.
- Municipality of Anchorage websites for Planning and Zoning, Traffic, and Transit.
- *Highway Capacity Manual 2000* (HCM2000), TRB.
- *Traffic Engineering Handbook*, Fourth and Fifth editions, Institute of Transportation Engineers (ITE).
- *NCHRP Report 457, Engineering Study Guide for Evaluating Intersection Improvements*, TRB, 2001.
- *Roundabouts An Informational Guide*, June 2000, FHWA et. al.
- *Highway Capacity Software* 2000 (HCS), McTrans.
- Synchro and SimTraffic, Trafficware.
- *Victor Road Design Study Report*, Lounsbury and Associates, 2003.
- *Manual of Traffic Signal Design*, Second Edition, by James H. Kell and Iris J. Fullerton, Institute of Transportation Engineers
- *Alaska Traffic Accidents,* DOT&PF Statewide Planning
- *RODEL 1 Interactive Roundabout Design Software and Manual*, Rodel Software Ltd and Staffordshire County Council.

Project Area Conditions

Street Typical Sections

C Street is on a general north-south orientation and Klatt Road is on an east-west orientation. Timberlane Drive is the transition point between the two streets with C Street on east leg, and West Klatt Road on the west side of the intersection. The C Street and West Klatt Road corridor has a 4-lane divided urban section, with pedestrian and bicycle facilities on both sides.

West Klatt Road to the east of C street is a two-lane road with shoulders, and a pathway on the south side of the road. Timberlane Drive is a two lane street with pedestrian and bicycle facilities.

Functional Classification

Table 1 summarizes the MOA Official Streets and Highways Plan functional classes for the study area.

Street	Location	Functional Classification
C Street	Dimond Blvd. to O'Malley Road	Major Arterial, Class IIIA
C Street	O'Malley Road to Timberlane Drive	Minor Arterial, Class II
W. Klatt Road	C Street to Old Seward Highway	Minor Arterial, Class II
W. Klatt Road	Southport Drive to Timberlane Drive	Minor Arterial, Class II
Timberlane Drive	Klatt/C to Huffman	Neighborhood Collector, Class IC

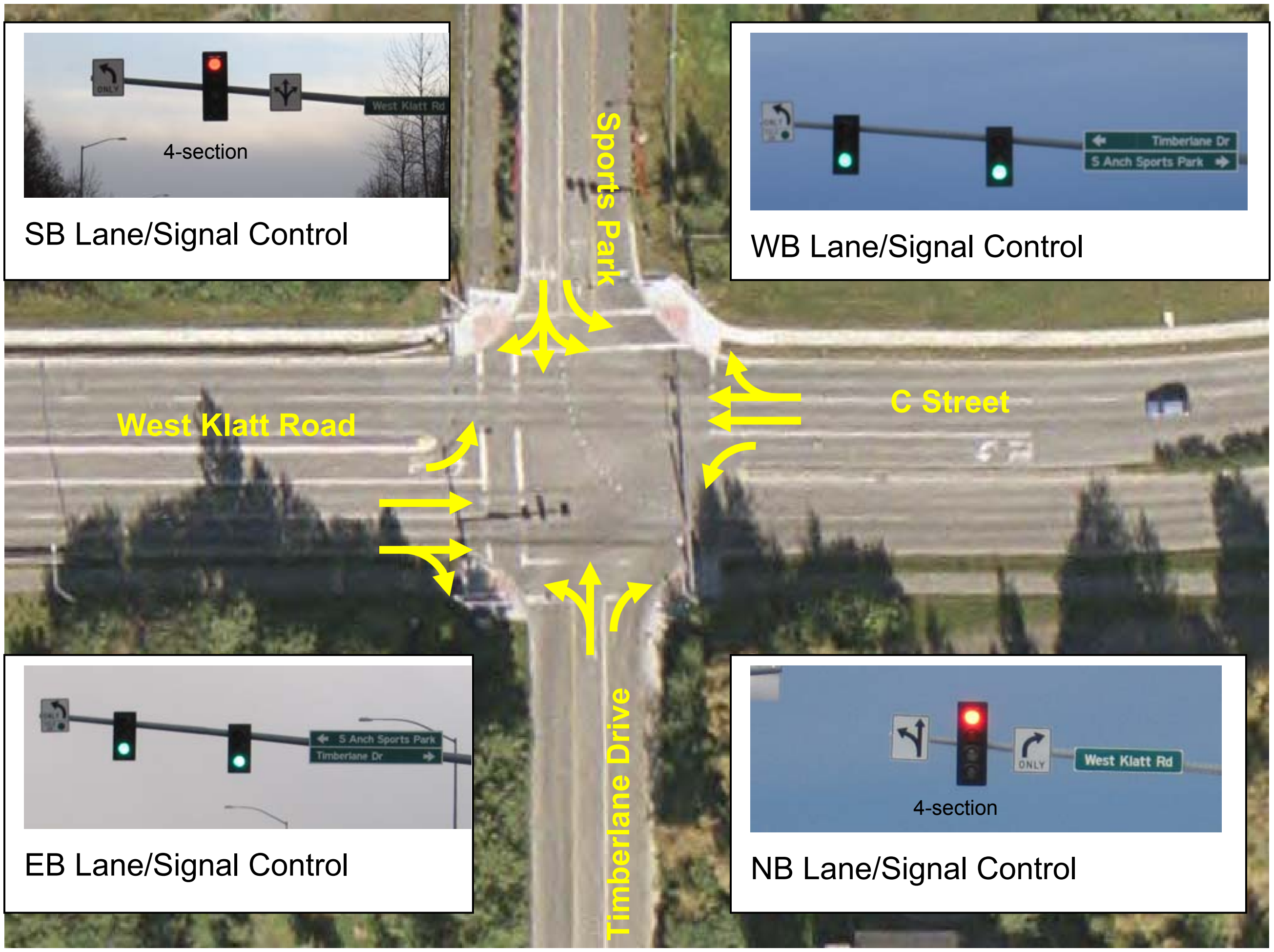
Table 1- Study Area Functional Classification

Intersections

C Street/ West Klatt Road/ Timberlane Drive Intersection

Figure 2 presents the lane configuration for the signalized C Street/West Klatt Road/Timberlane Drive intersection. The inset approach views indicate left-turn phasing.

North and south approaches are split-phased, (all movements from one approach proceed, then all movements from the opposing approach proceed). East and west approaches have permissive left-turn phasing.



Aerial Photograph Source: Google Earth

Figure 2- C Street/West Klatt Road/Timberlane Drive Intersection Approach Lane Configurations

The lane configurations required that the north-south approaches be split-phased. The north and south approach signals are a four-section signal faces, with a green circle and green left-turn arrow displayed simultaneously.

The signal is fully actuated with 105 second cycle throughout the day. Figure 7 presents phasing and timing information for the intersection. Pedestrian crossings are allowed across the north, south, and west approaches, but are prohibited across the east approach.

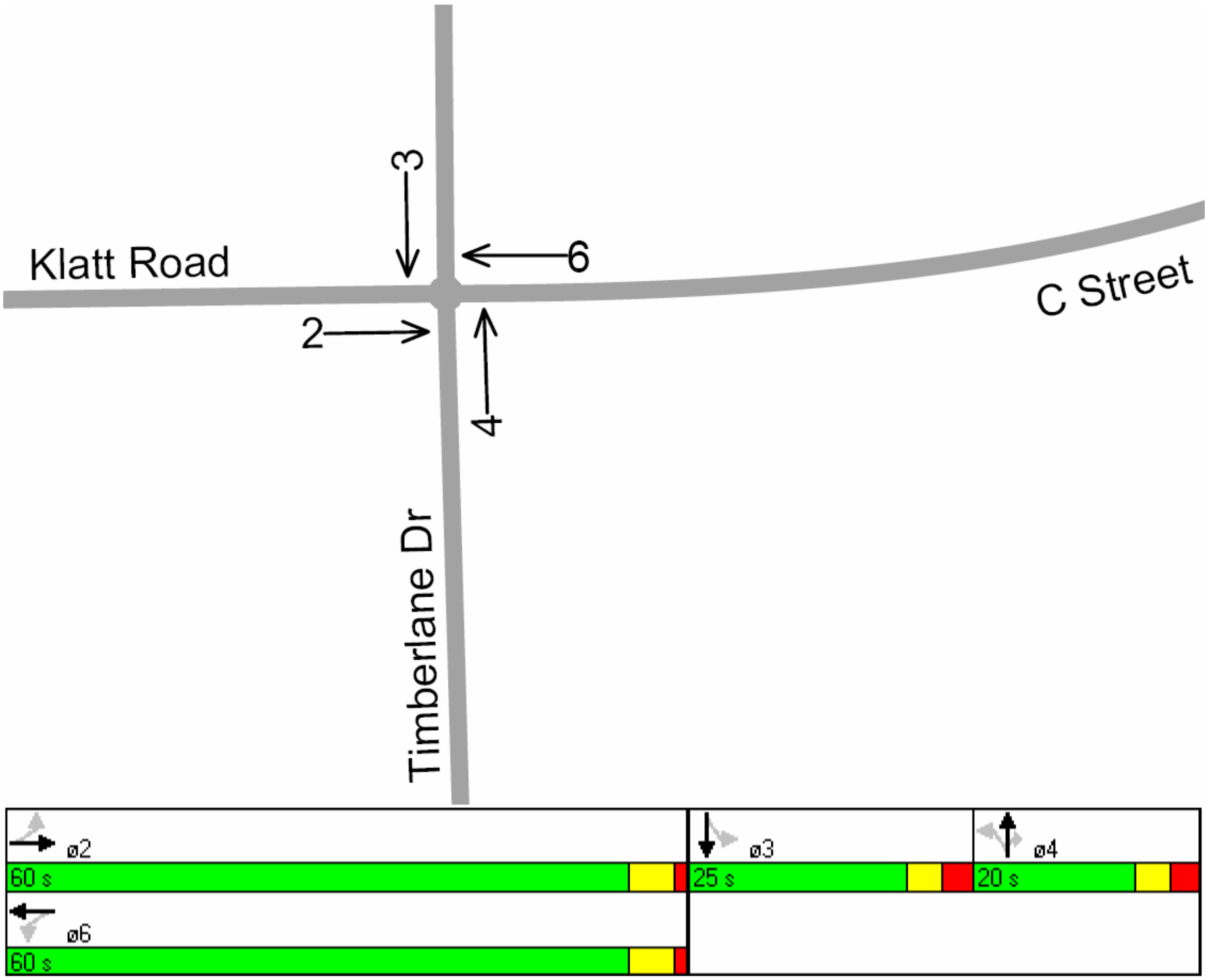
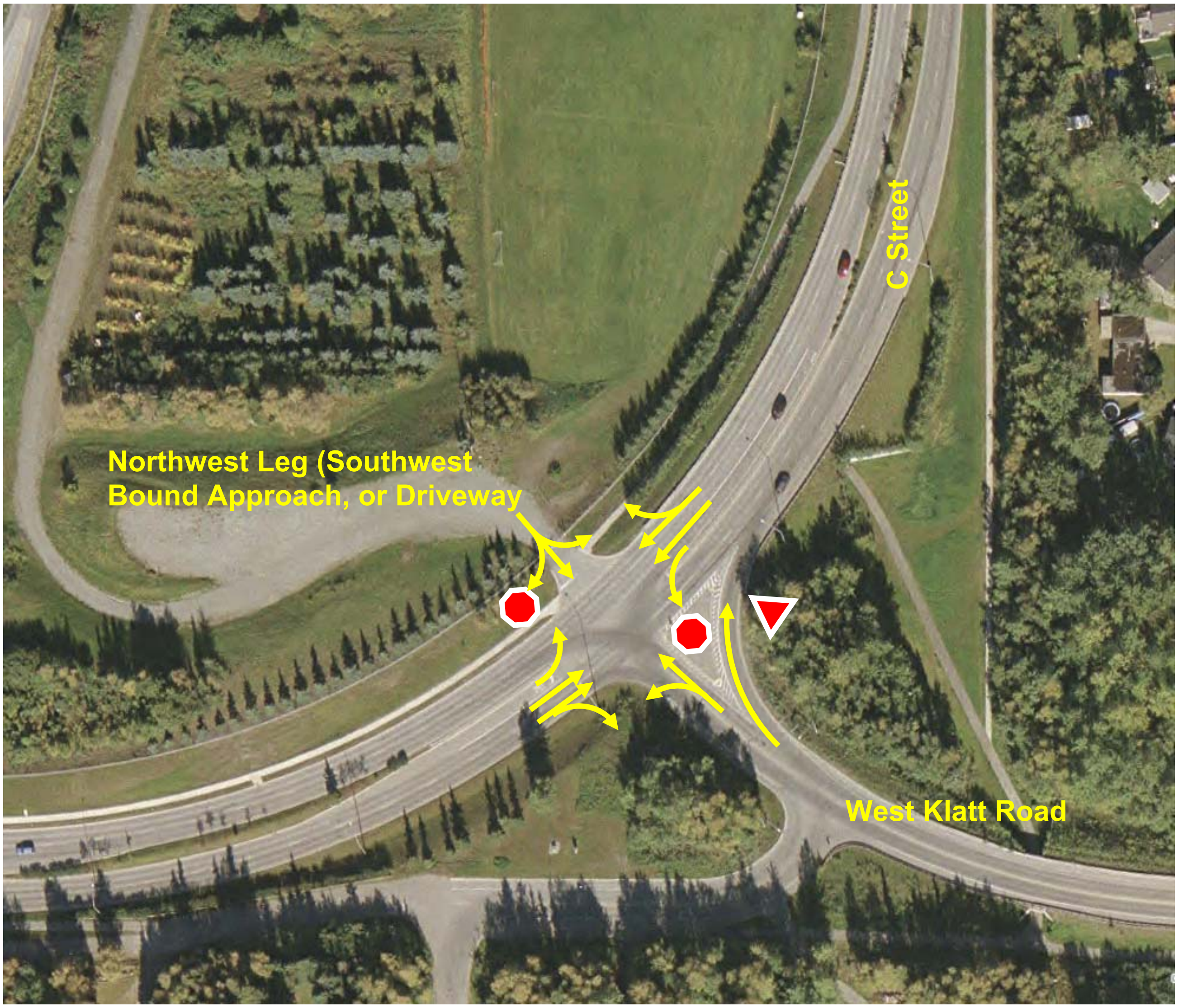


Figure 3- Phasing and Timing for C Street/West Klatt Road/Timberlane Drive Intersection

C Street/ West Klatt Road Intersection

Figure 4 presents lane configuration and intersection traffic control for the C Street/ West Klatt Road/ Timberlane Drive intersection.



Aerial Photograph Source: Google Earth

Figure 4- C Street/West Klatt Road Intersection Approach Lane Configurations

Traffic Conditions

Speeds

Posted speeds and locations of December 2006 speed studies are presented in the following figure.

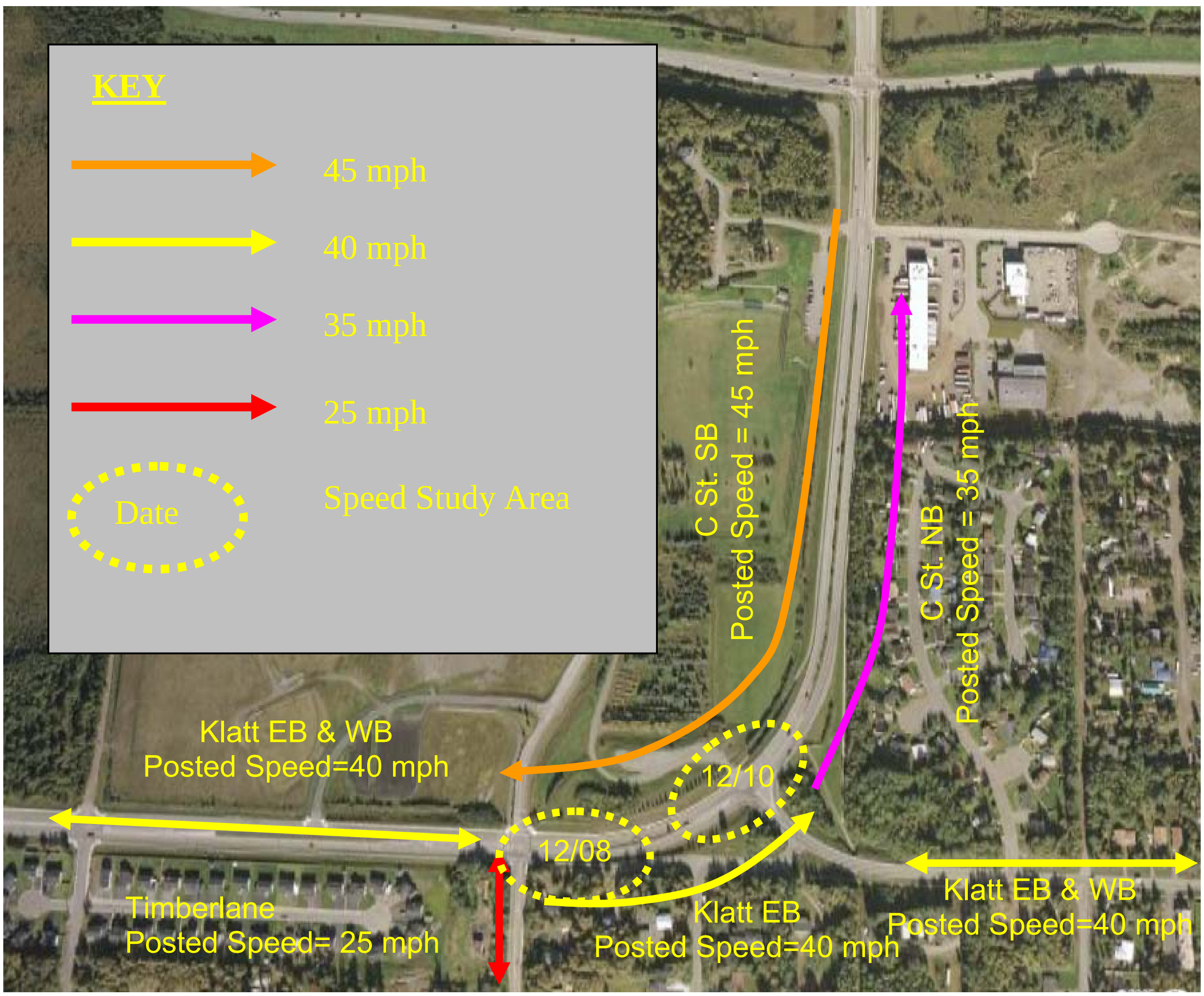


Figure 5- Posted Speeds and Speed Study Locations

	South to West Travel Direction	**East to North Travel Direction**
December 8, 2006 Speed Study (Kinney Engineering, Radar)		
Location of Study	Proximity of Timberlane Drive Intersection (Tangent)	
Posted	45 MPH	40 MPH
Mean	37.5 MPH	32.9 MPH
Standard Deviation	3.0 MPH	2.4 MPH
Median Speed	37.0 MPH	33.0 MPH
Maximum Speed	45.0 MPH	39.0 MPH
Minimum Speed	33.0 MPH	28.0 MPH
85^{th} Percentile Speed	40.0 MPH	34.0 MPH
December 10, 2006 Speed Studies (Kinney Engineering, Radar)		
Location of Study	Proximity of W. Klatt Road Intersection (Mid Curve)	
Posted	45 MPH➔40 MPH	40 MPH ➔ 35 MPH
Mean	33.3 MPH	29.0 MPH
Standard Deviation	3.0 MPH	2.7 MPH
Median Speed	33.0 MPH	28.0 MPH
Maximum Speed	41.0 MPH	36.0 MPH
Minimum Speed	27.0 MPH	26.0 MPH
85^{th} Percentile Speed	37.0 MPH	32.0 MPH

Table 2- Speed Study Summary

Since the speed studies were conducted during winter, the engineering analysis in this study uses the higher posted speed limits for the design speed, assuming that speeds are higher in the summer. As such, for the C Street-Klatt Road corridor, the southbound to westbound traffic flow design speed is 45 mph, and the eastbound to northbound speed is 40 mph.

Volumes

Average Annual Daily Traffic (AADT)

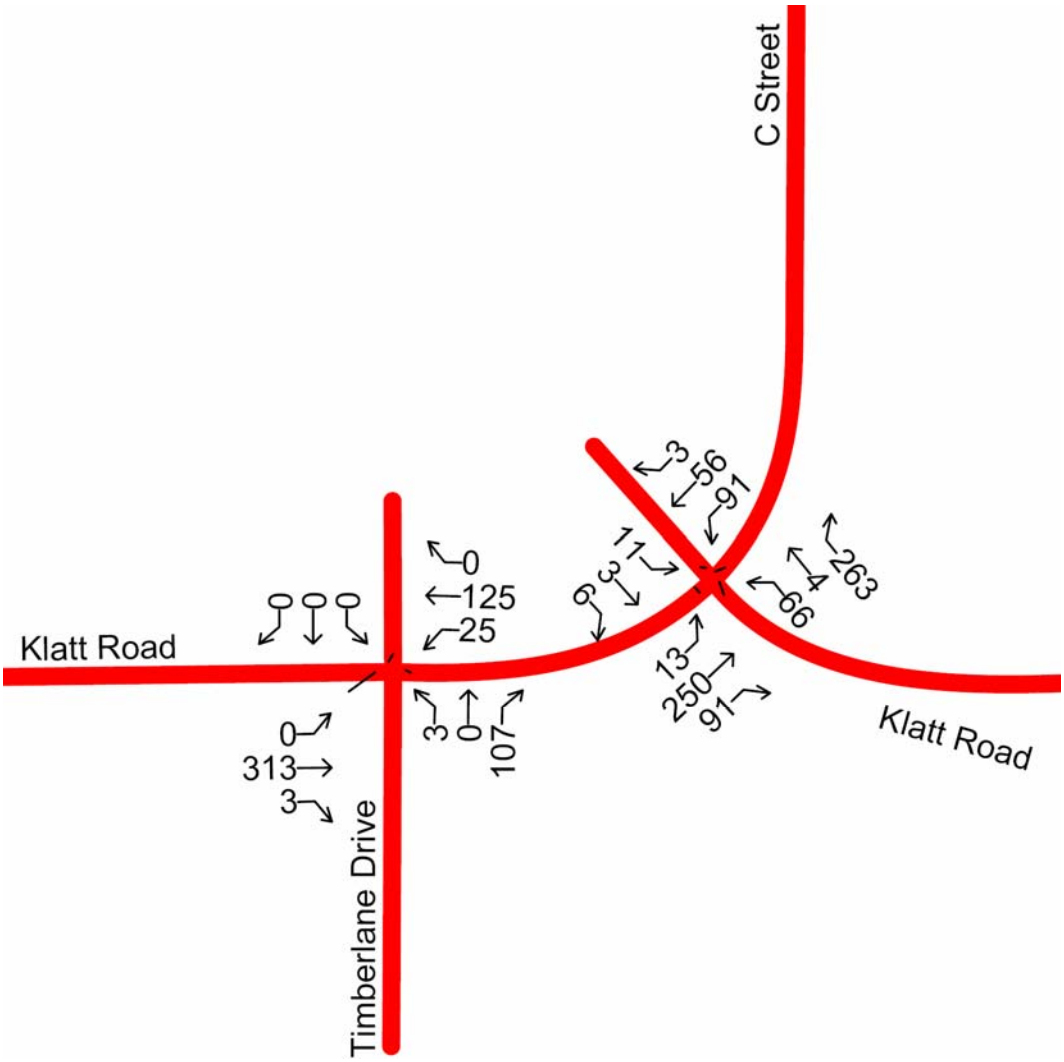
The following table presents 2005 AADT and the 10-year average AADT.

Begin	End	2005	10-Year AADT Average (1996 to 2005)
C STREET SOUTH			
Minnesota Drive	New Klatt Road	9,729	7,733
KLATT ROAD			
Johns Road	C Street	8,706	6,110
C Street	Timberline Drive	6,760	5,451
Timberline Drive	Victor Road	5,477	4,050
TIMBERLANE DRIVE			
West Klatt Road	Old Klatt Road	1,470	1,497

Table 3- AADT Summary

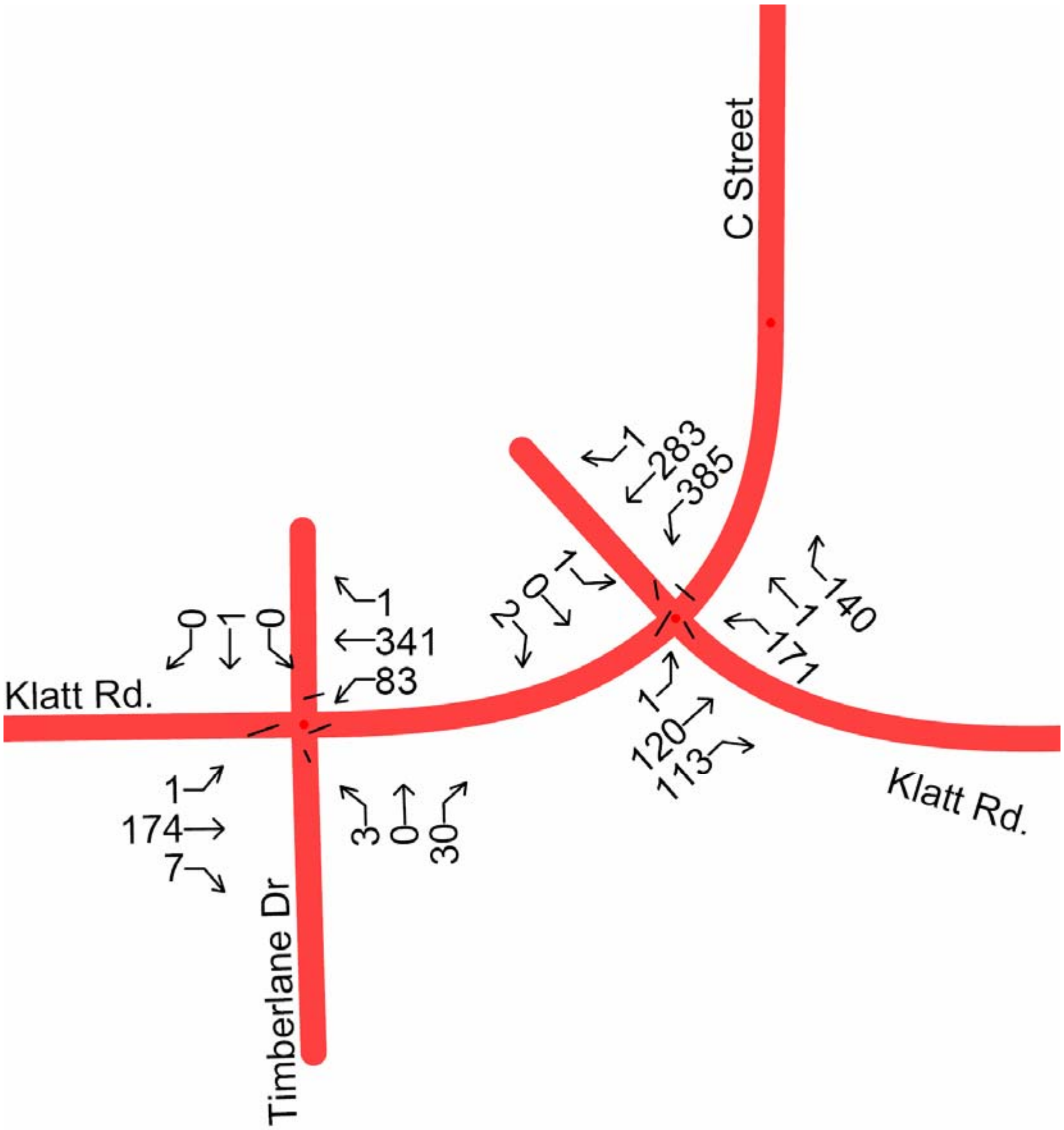
Turning Movements

Turning movement counts were conducted during peak commuting times (7:00 am to 9:00 am, 4:00 pm to 6:00 pm) during December 2006. The following figures depict morning and evening peak hours.



Note that intersections were counted on different days and the departure and approach volumes may not balance.

Figure 6- Morning Peak Hour Turning Movements (December 2006)



Note that intersections were counted on different days and the departure and approach volumes may not balance.

Figure 7- Evening Peak Hour Turning Movements (December 2006)

The peak hour factor for morning and evening commuting hours is about 0.91. About 2% of the traffic is trucks and buses.

Hourly Approach Volumes

Hourly approach volume counts were conducted in December 2006. These provided additional information that was primarily used to evaluate intersection control warrants. The turning percentages shown above in Figures 6 and 7 were applied to the approach volume for the warrant analysis.

Count Seasonal Adjustments

Within proximity of the project area, the Department of Transportation and Public Facilities maintains permanent traffic recorders (PTR) on Minnesota Drive north of Dimond Boulevard, on Dimond Boulevard west of Arctic Boulevard, and on O'Malley Road east of Seward Highway. Since the Dimond and Minnesota PTRs are likely to represent traffic patterns of this project area, the O'Malley information was not used in this analysis.

The PTR information indicates that December 2005 average daily traffic (ADT) counts are about 95% of the AADT for the respective locations. The design condition for Anchorage Roads is during the summer season for most major roads; and these PTRs show summer ADT to range from 103% to 110% AADT. If turning movement and approach counts follow ADT patterns, then an adjustment of 115% (100 x (1.1÷0.95)) should be applied to the collected December data to convert to a summer design traffic condition.

South Anchorage Sports Park Adjustment

The December counts did not include the sports traffic. There are 3 unpaved parking areas within the park that accommodate about 350 vehicles (derived by dividing 145,000 square feet of parking area by 400 square feet of stall-aisle area per vehicle). During events that fully utilize parking, it may be expected the parking turnover would be about 2 hours, which would be about 175 vehicles entering and 175 vehicles leaving. However, the peak hour of the facility would not likely occur during the peak hour of the roadway system. For purposes of this analysis, we assume that 175 would enter the main park entrance and 80 would exit during the evening peak hour.

Intersection Sight Distance

Intersection sight distance is not of significant concern for signals. However the C Street and Klatt Road intersection is a two-way stop sign control intersection and intersection sight distance affects the stopped driver's ability to select safe gaps to cross or turn onto the main road.

Minimum intersection sight distance is stopping sight distance. Minimum stopping sight distance for 40 MPH (eastbound to northbound speed) is 305 feet; and for 45 MPH (southbound to westbound speed) is 360 feet.

The following table summarizes required and available intersection sight distance.

Approach Under Stop Control		**Left Turn AASHTO Case B1**		**Through AASHTO Case B3**		**Right Turn Case B2**
Northwest Leg (parking area)	Sight Direction➔	South	North	South	North	North
	Critical Gap➔	8.5 seconds	7.5 seconds	7.5 seconds	6.5 seconds	6.5 seconds
	Approach Speed➔	40 MPH	45 MPH	40 MPH	45 MPH	45 MPH
	AASHTO Intersection Sight Distance➔	499 feet	495 feet	440 feet	429 feet	429 feet
	*Estimated Sight Distance➔	250 feet	350 feet	250 feet	350 feet	350 feet
Southeast Leg (connection to Klatt Road)	Sight Direction➔	North	South	North	South	South
	Critical Gap➔	8.5 seconds	7.5 seconds	7.5 seconds	6.5 seconds	6.5 seconds
	Approach Speed➔	45 MPH	40 MPH	45 MPH	40 MPH	40 MPH
	AASHTO Intersection Sight Distance➔	561 feet	440 feet	495 feet	381 feet	381 feet
	*Estimated Sight Distance➔	550 feet	400 feet	550 feet	400 feet	400 feet

**Estimated intersection sight distance was determined by measurements on an aerial photo. This assumes winter conditions, where snow accumulates on medians and restricts horizontal sight lines.*

Table 4- Intersection Sight Distance, C Street and West Klatt Road

Intersection sight distance may be less than AASHTO recommendations for this intersection in winter. In addition, the stopping sight distance may not be adequate in winter for the northwest leg.

Future Traffic Volumes

AMATS Demand Model

The following figure depicts MOA Long Range Transportation Plan 2015 AADT for the study area. Also shown are the 2005 recorded AADT (shaded values).

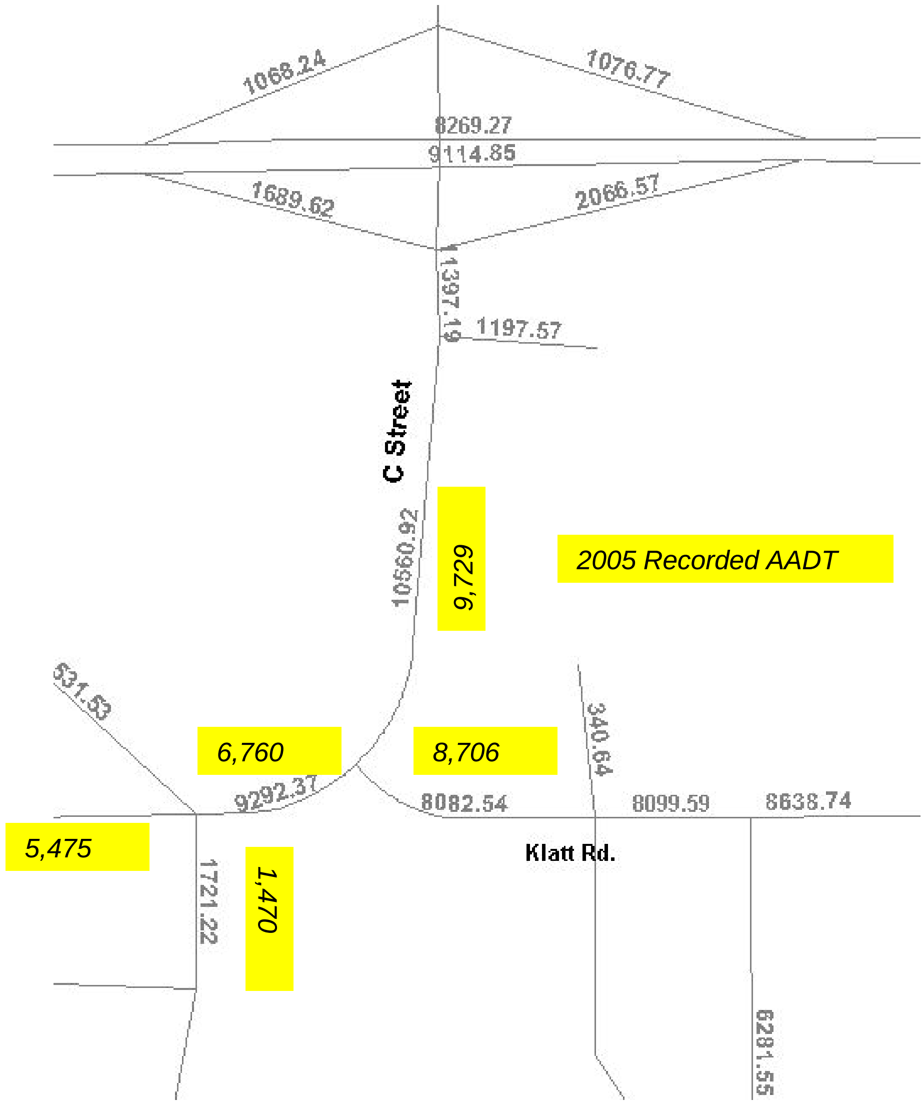


Figure 8- LRTP 2015 AADT

Future Intersection Design Turning Movement Volumes

Figure 8 depicts the 10-year AADT volume growth. Overall, the growth rate for the study area is about 1% per year. The maximum growth rate (segment between intersections) is about 3.2% per year. Future design volumes are forecasted with the overall growth rate of 1% per year. The morning and evening peak hour conditions, summer operations (15% higher than December counts shown in Figures 6 and 7), are under Attachment B.

2007 and 2017 Existing Conditions Capacity Analysis

C Street/ West Klatt Road/ Timberlane Drive Signal

The following tables summarize operations for 2007 morning and evening peak hours and 2017 morning and evening peak hours during summer traffic for the existing facility conditions. These are based upon factored December 2006 counts to summer volume levels, and include assumed sports park traffic for the PM Peak. Existing phases, cycle times and splits were used for this analysis.

Morning Operations			
HCM Average Control Delay	9.8	HCM Level of Service	A
HCM Volume to Capacity ratio	0.14		
Evening Operations			
HCM Average Control Delay	14.7	HCM Level of Service	B
HCM Volume to Capacity ratio	0.30		

Table 5- 2007 Peak Hour Operations, C Street/ West Klatt Road/ Timberlane Drive Signal

Morning Operations			
HCM Average Control Delay	9.9	HCM Level of Service	A
HCM Volume to Capacity ratio	0.16		
Evening Operations			
HCM Average Control Delay	13.9	HCM Level of Service	B
HCM Volume to Capacity ratio	0.30		

Table 6- 2017 Peak Hour Operations, C Street/ West Klatt Road/ Timberlane Drive Signal

C Street/ West Klatt Road Stop Control

The following table summarizes the 2007 morning and evening peak hour conditions under December evening (observed) and summer morning and evening design conditions (with sports park traffic).

December Evening Operations (NB and SB are C Street Approaches)

Delay, Queue Length, and Level of Service	NB	SB	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Config	L	L	LT				LTR	
v (vph)	1	423	188				3	
C(m) (vph)	1246	1309	106				245	
v/c	0.00	0.32	1.77				0.01	
95% queue length	0.00	1.41	14.96				0.04	
Control Delay	7.9	9.1	452.6				19.9	
LOS	A	A	F				C	
Approach Delay				452.6			19.9	
Approach LOS				F			C	

Summer Morning Operations (NB and SB are C Street Approaches)

Delay, Queue Length, and Level of Service	NB	SB	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Config	L	L	LT				LTR	
v (vph)	16	115	88				23	
C(m) (vph)	1525	1125	257				402	
v/c	0.01	0.10	0.34				0.06	
95% queue length	0.03	0.34	1.46				0.18	
Control Delay	7.4	8.6	26.1				14.5	
LOS	A	A	D				B	
Approach Delay				26.1			14.5	
Approach LOS				D			B	

Summer Evening Operations (NB and SB are C Street Approaches)

Delay, Queue Length, and Level of Service	NB	SB	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Config	L	L	LT				LTR	
v (vph)	1	486	217				3	
C(m) (vph)	1113	1259	68				154	
v/c	0.00	0.39	3.19				0.02	
95% queue length	0.00	1.85	22.28				0.06	
Control Delay	8.2	9.6	1116				28.8	
LOS	A	A	F				D	
Approach Delay				1116			28.8	
Approach LOS				F			D	

Table 7- 2007 Peak Hour Operations, C Street/ West Klatt Road Stop Control Intersection

It is clear from this table that the evening operations are very poor under the assumed conditions of sports area traffic combined with summer traffic levels. Even with the base December volumes presented in Figure 7, HCS2000 computes 7 to 8 minutes of average delay for the Klatt Road approach traffic.

Field observations verify that the Klatt northwest bound leg left-turning traffic experience long delays. Although the observed operations confirm severe congestion and queue backup during the peak hour (northwest bound left-turning traffic queues blocking the free right-turn lane), it is not to the extremes that are computed with the HCM2000 model. It is likely that the actual critical gaps accepted by minor approach left-turning traffic are less than the HCM2000 default values, and that there is some level of cooperation between the C Street left-turning traffic and the Klatt left-turning traffic (decreasing rank impedance and consequently increasing capacity).

Crash Analysis

Crash Rate Analysis

Ten years of crash data was obtained from the State of Alaska using their accident reporting system. From this data, intersection crash rates, crashes per million entering vehicles (MEV) were computed and compared to average rates for similar intersection and to the upper control limit (UCL), or critical rate, at the 95% confidence level (see Attachment D for rate methods). The following table summarizes the 10-year crash rates.

Intersection	Intersection Crashes 1996 to 2005	Crashes / MEV	State Averages (7-year 1999 to 2005)	UCL @ 95.00%	Above Average?	Above UCL?
C Street and Klatt Road	34	0.966	0.736	0.988	Yes	No
C Street/ West Klatt Road/ Timberlane Drive	13	0.648	1.522	2.000	No	No

Table 8- Intersection Crash Rates, 1996 to 2005

The signalized C Street/ West Klatt Road/ Timberlane Drive intersection has performed well with respect to crash experience and requires no further analysis. The C Street and West Klatt Road intersection (stop control) has a rate that exceeds the average rate, but is below the UCL. However, one more crash at this location would result in a rate that exceeds the UCL, and therefore this location is reviewed further.

Contributing Factors for C Street and West Klatt Road Intersection Crashes

Attachment C contains the collision diagram for this intersection. Table 5 presents the crash types for the C Street and West Klatt Road intersection.

Crash Type	Number	%	MOA Population %	Statistical Testing Results (See Attachment D for Methods)
Head On Sideswipe	2	6%	2.56%	Over-represented but not significant.
Left Turn	1	3%	5.97%	Over-represented but not significant.
Left Turn Sideswipe	1	3%	2.44%	Over-represented but not significant.
Other	4	12%	11.08%	Below average %
Overtaking Sideswipe	2	6%	9.77%	Below average %
Rear End	4	12%	30.60%	Below average %
Right Angle	18	53%	18.36%	Right Angle crashes are over-represented and highly significant.
Right Left Turn Sideswipe	2	6%	0.29%	Right Left Turn Sideswipe crashes are over-represented and highly significant.

Table 9- C Street/ West Klatt Road/ Timberlane Drive Crash Type and Over-Represented Crashes

The Right Angle and Right Left Turn Sideswipe collisions are significant for this intersection, resulting in the high crash rate. With regards to crash severity, there was one major injury (3%), 9 minor injuries (26%), and 24 property damage only crashes (71%). These percentages are similar to the overall MOA crash severity profile.

The following figures depict the hourly and monthly distributions for intersection accidents.

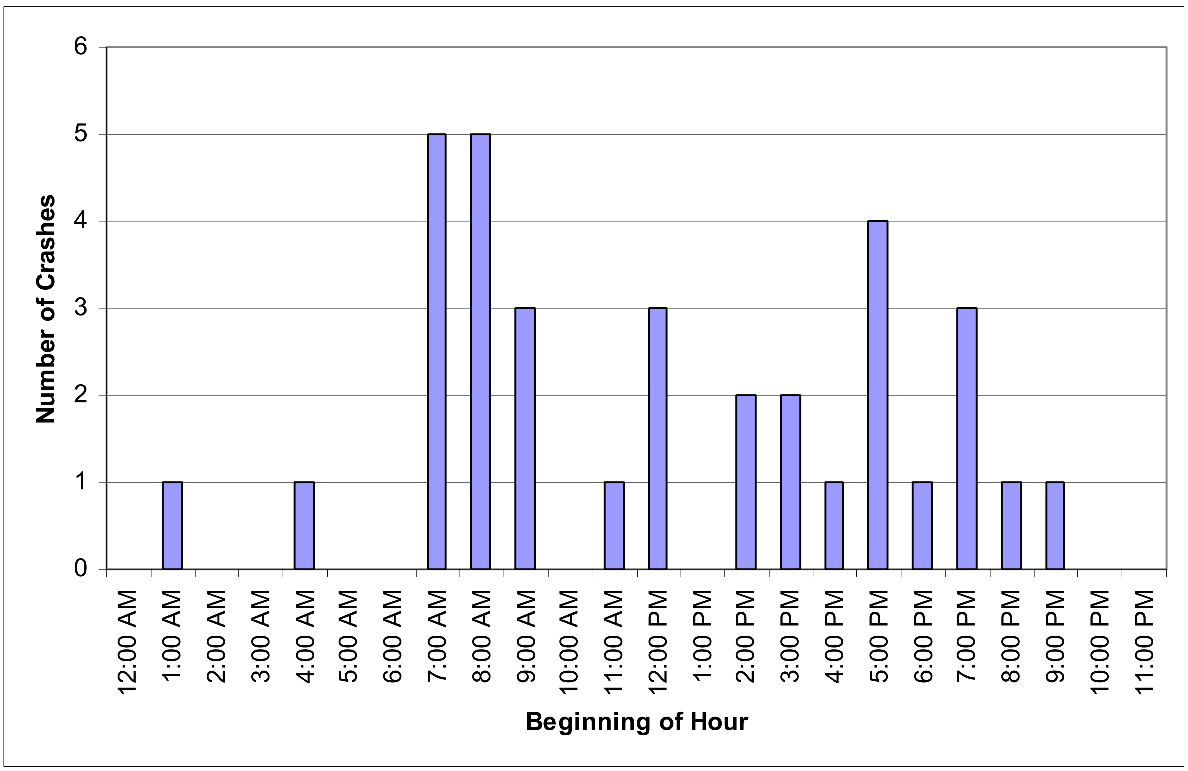


Figure 9- C Street and West Klatt Road, Crash Distribution by Hour of the Day

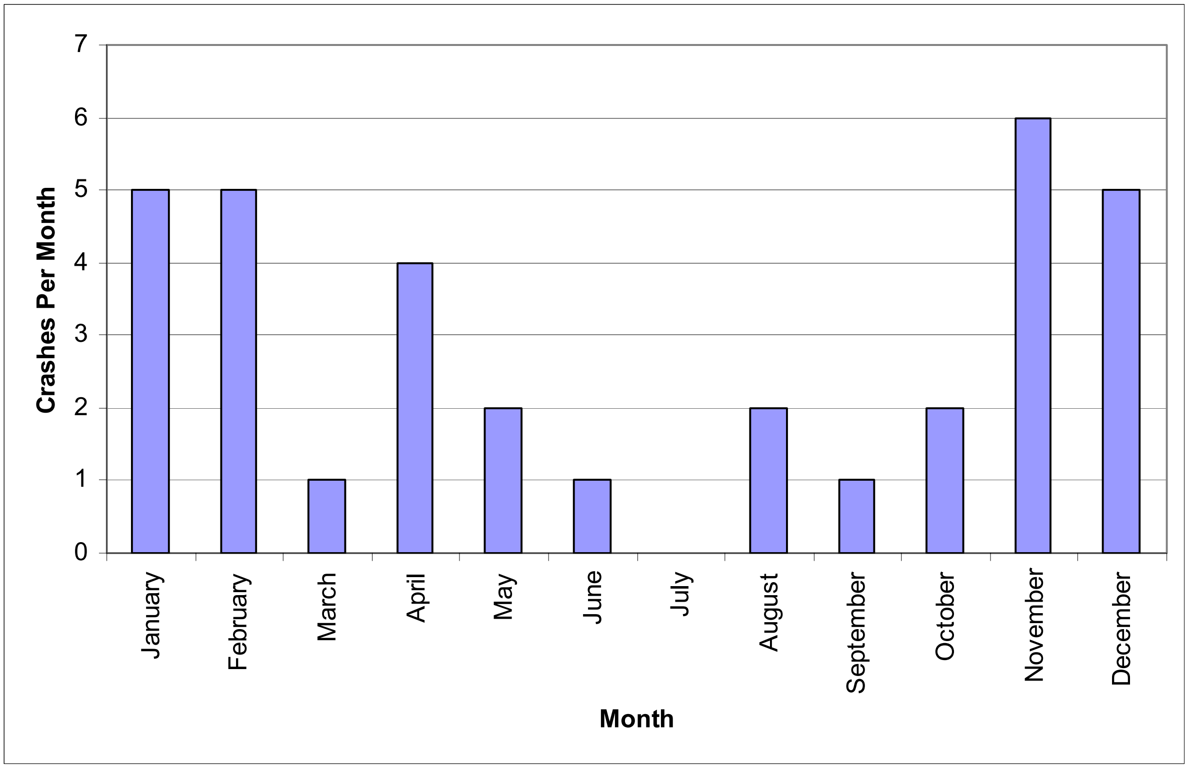


Figure 10- C Street and West Klatt Road, Crash Distribution by Month of the Year

These figures show that the crashes are elevated during the peak commuting times (especially morning), and during the winter months. Winter may be a significant factor because 62% crashes were on snow and ice surfaces, snow accumulation may restrict intersection and stopping sight-distance within the horizontal curve.

Countermeasures for C Street and West Klatt Road Intersection Crashes

Relocate Intersection

This would involve relocation of the intersection out of the horizontal curve to improve sight distance. However, this alternative is not feasible because of property impacts.

Prohibit High-Risk Movements

About 20 to 24 crashes would have been preventable with a fully or partially restrictive median that prohibits left turns from the stop controlled approaches. The Department of

Transportation and Public Facilities Highway Safety Improvement (HSIP) Handbook reports up to 90% crash reduction of crossing collisions. However, there would be significant traffic circulation changes, which would affect other intersections and may cause the crash issues to migrate with the volume. As such, this is likely to be unfeasible unless there is a substantial increase in crashes in the future.

Signalization

Signalization would reduce right angle and crossing crashes. The States HSIP Handbook indicates that signalization can reduce right angle crashes by about 60%. However, rear end crashes may increase (up to 25%).

Roundabouts

This HSIP Handbook reports that roundabouts may reduce up to 75% of all intersection crashes.

Intersection Options

Intersection control options are presented below for each intersection. Each intersection is evaluated for feasibility and operations as a two-way stop controlled intersection, a signalized intersection, and a modern roundabout. Four-way stop controlled intersections are not evaluated because the major road lanes (C Street West Klatt corridor) has more lanes than are commonly used for this type of control.

Warrants and Guidelines

Existing and Current Conditions Signalization

Signals should only be considered for intersections if one or more warrants established by the Manual of Uniform Traffic Control Devices (MUTCD) are satisfied. The warrants include:

- Warrant 1- Eight-Hour Volume (Conditions A, B, and 80% of A & B Combined)
- Warrant 2- Four-Hour Volume
- Warrant 3- Peak Hour Volume (only applicable to unique, high-generation facilities)
- Warrant 4- Minimum Pedestrian Volumes
- Warrant 5- School Crossings
- Warrant 6- Coordinated Signal System
- Warrant 7- Crash Experience (5 or more correctable crashes in a 12-month period, and volume criteria)
- Warrant 8- Roadway Network

These warrants require current vehicle and pedestrian volumes, speeds, and crash history. The warrants are evaluated in accordance with MUTCD procedures for these inputs. Seventy percent of volume warrant values from the MUTCD were used because the speeds through the area are expected to be at 45 mph (posted for southbound to westbound direction, see Figure 5). Warrants 3, 4, 5 and 6 do not apply to the intersections of this project and were not evaluated.

There are several disadvantages to signalization which should be considered. Cross-street delay is reduced, but the mainline traffic is penalized. As such, signals may increase overall system delay. While right angle and left turn collisions are reduced by signalization, rear end collisions may increase, especially on high-speed approaches that were formally free-flow conditions. Lastly, signals have an ongoing maintenance and operations burden. The MUTCD encourages engineers to seek less restrictive alternatives to signals, such as roundabouts or 4-way stop sign control, even in locations where one or more warrants are satisfied.

The MUTCD's warrant discussion encourages the engineer to exercise judgment on the amount of right-turn traffic that should be subtracted from the minor street traffic volume. NCHRP 457 provides a methodology to determine right turn volume adjustments for the warrant analysis. This methodology was used for this analysis.

Future Signal Warrants

The MUTCD warrant system described above only evaluates recent or current conditions. Cal-Trans has a methodology for future signal warrants based that is presented in the Institute of Transportation Engineers (ITE) *Manual of Traffic Signal Design*, Second Edition, by James H. Kell and Iris J. Fullerton. The method uses future estimated average daily traffic as the input variables and estimates whether the intersection with future estimated average daily traffic would meet the Manual of Uniform Traffic Control Devices signal Warrant 1, Condition A- Minimum Vehicular Volume; Condition B- Interruption of Continuous Traffic; and the combination of warrants allowed in MUTCD procedure.

Modern Roundabout Screening Guidelines

The MUTCD describes roundabouts as good alternatives to signals, offering good operational performances, as well as crash reduction. NCHRP 457 Table 2-12, provides a framework to determine if a roundabout would be suitable for a location.

Question
1) Will operation as an uncontrolled or two-way-stop-controlled intersection yield unacceptable delay?
2) Is the daily entering volume less than the maximum service volume for a roundabout? (Use Figure 2-3 of NCHRP 457)
3) Is the subject junction located outside of the coordinated signal network?
4) Is the ratio of major-road to minor-road volume less than 5?
5) Is the entering drivers view free of sight obstructions?
6) Will the subject junction infrequently be used by large or oversized trucks?
7) Will the subject junction infrequently be used by pedestrians and bicyclists?

Table 10- Roundabout Suitability Questions

As NCHRP 457 points out, the more frequently that these questions are answered with "Yes", then the more likely that this intersection would work well as a roundabout.

C Street and West Klatt Road Intersection Control Options

Existing Stop Control for C Street and West Klatt Road

As shown in Table 7, delays for minor street traffic are excessive and will become worse in the future during the peak hour. Therefore, this is not a feasible long-term control solution for this intersection.

Signalization

December counts were factored to summer traffic conditions. Because there is a free-right turn lane on the southeast leg (northwest bound approach) of Klatt, the right-turn volumes were not included in this warrant. The right-turn exclusion was also checked and verified with NCHRP 457 procedure.

The Crash Experience Warrant requires that 5 crashes which would have been correctable by signalization occur within any 12-month duration. Between 1996 and 1998 there were about 2 years when this condition was met. However, recently only 3 correctable crashes have occurred within 12 consecutive months.

The following table summarizes applicable warrant analysis for this intersection.

MUTCD Warrant	Volume Criteria	Condition	2nd Criteria	Condition	Results	
Warrant 1- 8-Hour Vehicular Volume, Condition A- Minimum Vehicular Volume	8 hours	3 hours	[redacted]	[redacted]	Warrant 1A Met?	No
Warrant 1- 8-Hour Vehicular Volume, Condition B- Interruption of Continuous Traffic	8 hours	3 hours	[redacted]	[redacted]	Warrant 1B Met?	No
Warrant 1- 8-Hour Vehicular Volume, Combination of A & B	8 hours	4 hours	[redacted]	[redacted]	Warrant 1 Combination of A&B Met?	No
Warrant 2- 4-Hour Vehicular Volume	4 hours	3 hours	[redacted]	[redacted]	Warrant 2 Met?	No
Warrant 7- Crash Experience	8 hours	5 hours	5 Crashes	3 Crashes	Warrant 7 Met?	No
Warrant 8- Roadway Network	Warrants 1 or 2 Satisfied in 5 Years?	No (very close)	>1000 Entering Vehicles	1,397 Veh/Hr	Warrant 8 Met?	No

Table 11- C Street and West Klatt Road Intersection Signal Warrants

The future signalization warrants using the Cal-Trans methods were applied to 2017 estimate AADT forecasted volumes (1% per year growth rate). The Cal-Trans 70% volume thresholds were used because of the 45 mph speeds, and right-turns were removed from the minor street approach.

The following table summarizes Cal-Trans Warrants for this intersection.

Warrant 1 - Minimum Vehicular			
	Warrant	Forecast	
Major Road Threshold	6,720	10,126	
Minor Road Threshold	1,680	2,061	
Warrant 1 Satisfied?	**Yes**		
Warrant 2- Interruption of Continuous Traffic			
	Warrant	Forecast	
Major Road Threshold	10,080	10,126	
Minor Road Threshold	850	2,061	
Warrant 2 Satisfied?	**Yes**		
Warrant 3-Combination			
	80% W1	80% W2	Forecast
Major Road Threshold	5,376	8,064	10,126
Minor Road Threshold	1,344	680	2,061
80% Levels of 1 & 2 Satisfied?	**Yes**		

Table 12- C Street and West Klatt Road Intersection Cal-Trans Future Signal Warrants

It appears that the intersection would not meet signal warrant now, but would satisfy warrants between 2012 and 2017. Signal operational performance for the 2017 design hour volumes (Attachment B) are summarized in Table 12. This analysis used the 105 second cycle time which is compatible with the Timberlane signal cycle. The analysis assumes a southbound permissive-protective left-turn phasing and that all other turns are permissive. The analysis uses the existing lane configuration for the intersection. The phasing and splits were optimized by Synchro.

Morning Operations			
HCM Average Control Delay	27.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.37		
Evening Operations			
HCM Average Control Delay	26.5	HCM Level of Service	C
HCM Volume to Capacity ratio	0.63		

Table 13- 2017 Peak Hour Operations, C Street/ West Klatt Road Signalization Option

One final consideration for signalization would be that this proposed signal location and the one at Timberlane do not have adequate separation (about 700 feet) for good intra-corridor operations. As such, if this one were to be installed, then the Timberlane signal may have to be removed.

Roundabout Screening Analysis

Modern roundabout guidelines from NCHRP 457 were applied to the intersection.

NCHRP 457 Guideline Questions	**C Street/ West Klatt Road**
1. Will operation as an uncontrolled or 2-way stop controlled intersection yield unacceptable delay?	Yes - LOS F
2a. Is the daily entering volume less than the maximum daily service volume for a ***1-lane*** approach roundabout? If not see next row. *For 70% volume on mainline, 30% left-turn volume, and 1-lane approaches, maximum daily service volume is 19,900 vehicles (NCHRP 457 Fig. 2-3).*	Yes, Entering Volume is 15,000 ADT in 2017 (less than 19,900 maximum)
2b. Is the daily entering volume less than the maximum daily service volume for a ***2-lane*** approach roundabout?	N/A
3. Is the subject junction located outside of a coordinated signal network?	Yes
4. Is the ratio of major-road-to-minor-road volume less than 5.0?	Yes
Ratio→	2.5 : 1
5. Is the entering driver's view free of sight obstructions (i.e. due to grade, curvature, or vegetation)?	Yes
6. Will the subject junction be infrequently used by large or over-sized trucks?	Yes
7. Will the subject junction be infrequently used by pedestrians and bicyclists?	No

Table 14- Modern Roundabout Screening, C Street/ West Klatt Road Intersection

This intersection would be a good candidate for a 1-lane approach, single circulatory lane modern roundabout. If implemented, then the C Street/ West Klatt Road approach lanes would be reconfigured to transition from the 2 existing lanes to 1-lane approaches.

C Street / West Klatt Road / Timberlane Drive

Existing Signalization

This intersection is re-evaluated to ascertain if warrants are continued to be satisfied.

December counts were factored to summer traffic conditions. Because there is an exclusive right-turn lane on the north bound approach of Timberlane, the right-turn volumes were not included in this warrant. The right-turn exclusion was also checked and verified with NCHRP 457 procedure. The following table summarizes applicable warrant analysis for this intersection.

MUTCD Warrant	**Criteria**	**Condition**	**Criteria**	**Condition**	**Results**	
Warrant 1- 8-Hour Vehicular Volume, Condition A- Minimum Vehicular Volume	8 hours	0 hours	[redacted]	[redacted]	Warrant 1A Met?	No
Warrant 1- 8-Hour Vehicular Volume, Condition B- Interruption of Continuous Traffic	8 hours	0 hours	[redacted]	[redacted]	Warrant 1B Met?	No
Warrant 1- 8-Hour Vehicular Volume, Combination of A & B	8 hours	0 hours	[redacted]	[redacted]	Warrant 1 Combination of A&B Met?	No
Warrant 2- 4-Hour Vehicular Volume	4 hours	0 hours	[redacted]	[redacted]	Warrant 2 Met?	No
Warrant 7- Crash Experience	8 hours	0 hours	5 Crashes	2 Crashes	Warrant 7 Met?	No
Warrant 8- Roadway Network	Warrants 1 or 2 Satisfied in 5 Years?	No	>1000 Entering Vehicles	780	Warrant 8 Met?	No

Table 15- C Street/West Klatt Road/Timberlane Drive Intersection Signal Warrants

It does not appear that warrants are met at this location, unless the sports park in the summer generates enough traffic to satisfy the peak hour warrant (not normally used). However, if these volumes levels are met during summer events, there may not be consistency that would mandate a signal.

The following table summarizes Cal-Trans Warrants for this intersection.

Warrant 1 - Minimum Vehicular			
	Warrant	Forecast	
Major Road Threshold	6,720	9,479	
Minor Road Threshold	1,680	438	
Warrant 1 Satisfied?	**No**		
Warrant 2- Interruption of Continuous Traffic			
	Warrant	Forecast	
Major Road Threshold	10,080	9,479	
Minor Road Threshold	850	438	
Warrant 2 Satisfied?	**No**		
Warrant 3-Combination			
	80% W1	80% W2	Forecast
Major Road Threshold	5,376	8,064	9,479
Minor Road Threshold	1,344	680	438
80% Levels of 1 & 2 Satisfied?	**No**		

Table 16- C Street/West Klatt Road/Timberlane Drive Intersection Cal-Trans Future Signal Warrants

It can be concluded that this intersection, if it were to be unsignalized instead of signalized, would not satisfy warrants for the next 10 years.

Two-Way Stop Control (Remove Signal)

If the signal was removed and stop control signs put in place for the north and south legs, the morning operations for existing lanes and 2017 summer volumes (Attachment B) would be movements at LOS B or better, and average control delays of 11 seconds or less.

The evening operations for 2017 summer volumes, existing geometrics, would have movements with LOS C or better except for the southbound left-turn movement, which operates at a LOS E and average control delay of 37 seconds. However, the southbound forecasted volume is light (less than 50 vehicles per hour) and only during sports park hours. As such, this intersection appears to be feasible as a two-way-stop-control intersection.

This change in control does not consider the safety consequences. If the signal is removed, right-angle crashes may occur more frequently.

Roundabout Screening Analysis

Modern roundabout guidelines from NCHRP 457 were applied to the intersection.

NCHRP 457 Guideline Questions	**C Street/ West Klatt Road/Timberlane**
1. Will operation as an uncontrolled or 2-way stop controlled intersection yield unacceptable delay?	No
2a. Is the daily entering volume less than the maximum daily service volume for a ***1-lane*** approach roundabout? If not see next row. *For 89% volume on mainline, 22% left-turn volume, and 1-lane approaches, maximum daily service volume is 18,600 vehicles (NCHRP 457 Fig. 2-3).*	Yes, Entering Volume is 10,400 ADT in 2017 (less than 18,600 maximum)
2b. Is the daily entering volume less than the maximum daily service volume for a ***2-lane*** approach roundabout?	N/A
3. Is the subject junction located outside of a coordinated signal network?	Yes
4. Is the ratio of major-road-to-minor-road volume less than 5.0?	No
Ratio→	9 : 1
5. Is the entering driver's view free of sight obstructions (i.e. due to grade, curvature, or vegetation)?	Yes
6. Will the subject junction be infrequently used by large or over-sized trucks?	Yes
7. Will the subject junction be infrequently used by pedestrians and bicyclists?	No

Table 17- Modern Roundabout Screening, C Street/ West Klatt Road/Timberlane Drive Intersection

This intersection may be a candidate for a 1-lane approach, single circulatory lane modern roundabout, since there are more "yes", than "no" responses to the criteria. However, it is unlikely that the additional right-of-way and construction cost would be justified by operational improvement over a signal or unsignalized option. If implemented, then the C Street/ West Klatt Road approach lanes would be reconfigured to transition from the 2 existing lanes to 1-lane approaches.

Alternatives

Alternative 1: Remove Timberlane Drive Signal, Signalize C Street/ West Klatt Road Intersection

Under this alternative, the following actions would occur:

- The C Street/ West Klatt Road intersection has poor operational performance (minor left-turns) and is forecasted to meet signal warrants between 5 to 10 years from now. This alternative would install a fully actuated signal at this intersection. The southwest bound approach would have permissive-protective left-turn phasing, and all other movement would be permissive.
- The existing signal would be removed from the Timberlane Drive Intersection.
- The C Street/ West Klatt Road/Timberlane Drive intersection would be reconfigured to two-way-stop sign control.
- Additional options include:
  - The primary access road into to the sports park could be realigned opposite the West Klatt leg of the C Street/ West Klatt Road intersection.
  - If the access road is realigned, the C Street/ West Klatt Road/Timberlane Drive intersection could be reconfigured with medians to only allow left-in, right-in, right-out movements from the minor approaches. This would significantly reduce potential right-angle collisions after the signal is removed. This would not affect many vehicles from the southern neighborhoods (see Figures 6 and 7), and those wishing to travel westbound may do so by making an indirect left-turn; that is turn right out of Timberlane, then make u-turn at the new signal. If the access road isn't relocated, then the same left-in, right-in, right-out median configuration could be implemented, but would affects sports park traffic patterns.

The following figure illustrates conceptual intersection configuration for the proposed C Street/ West Klatt Road signalized intersection. With the realignment of the primary sports park access road, left-turn lanes should be added to the northwest and southeast legs as shown below

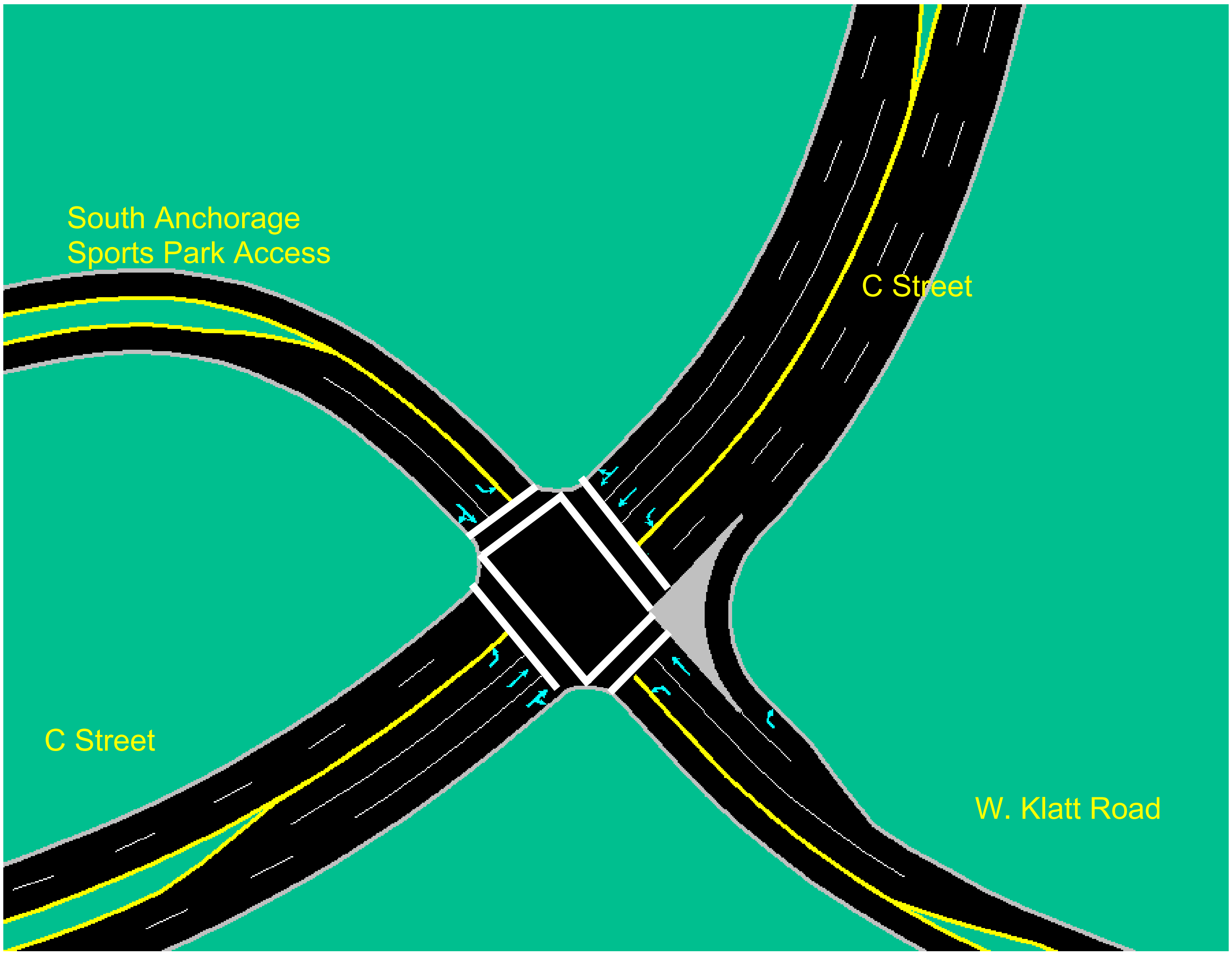


Figure 11- C Street/West Klatt Road/ South Anchorage Sports Park Access Signalized Lane Configuration

The following table summarizes the signal operations, with the relocated sports park access and lane configurations shown above.

Morning Operations			
HCM Average Control Delay	27.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.37		
Evening Operations			
HCM Average Control Delay	25.0	HCM Level of Service	C
HCM Volume to Capacity ratio	0.66		

Table 18- 2017 Alternative 1 Peak Hour Operations, C Street/ West Klatt Road/ South Anchorage Sports Park Access Signalized Intersection

Operations for the proposed signal would be good. In addition, the relocation of the sports park access that currently is opposite of the Timberlane Drive approach improves the unsignalized operation in 2017 to LOS A for all movements. Under the unsignalized control, the problem movement of the existing approach is the southbound left-turn (LOS E) during the summer evening peak hour. Under this alternative that movement would be served by the signal.

Alternative 2: Remove Timberlane Drive Signal, Construct a Modern Roundabout at the C Street/ West Klatt Road Intersection

Under this alternative, actions are identical to those stated in Alternative 1, except a modern roundabout would be installed the C Street/ West Klatt Road intersection.

Preliminary capacity analysis indicates that a combination roundabout would be required because of the southbound through and left-turn volumes. This would be refined during design, but the southbound approach would probably have to be two lanes, with two circulatory lanes through ½ of the roundabout, and the outer lane dropping at the south exit leg. A conceptual configuration is shown below. Without the dual southbound circulatory lanes, the LOS would be F; and with them, the LOS would be A.

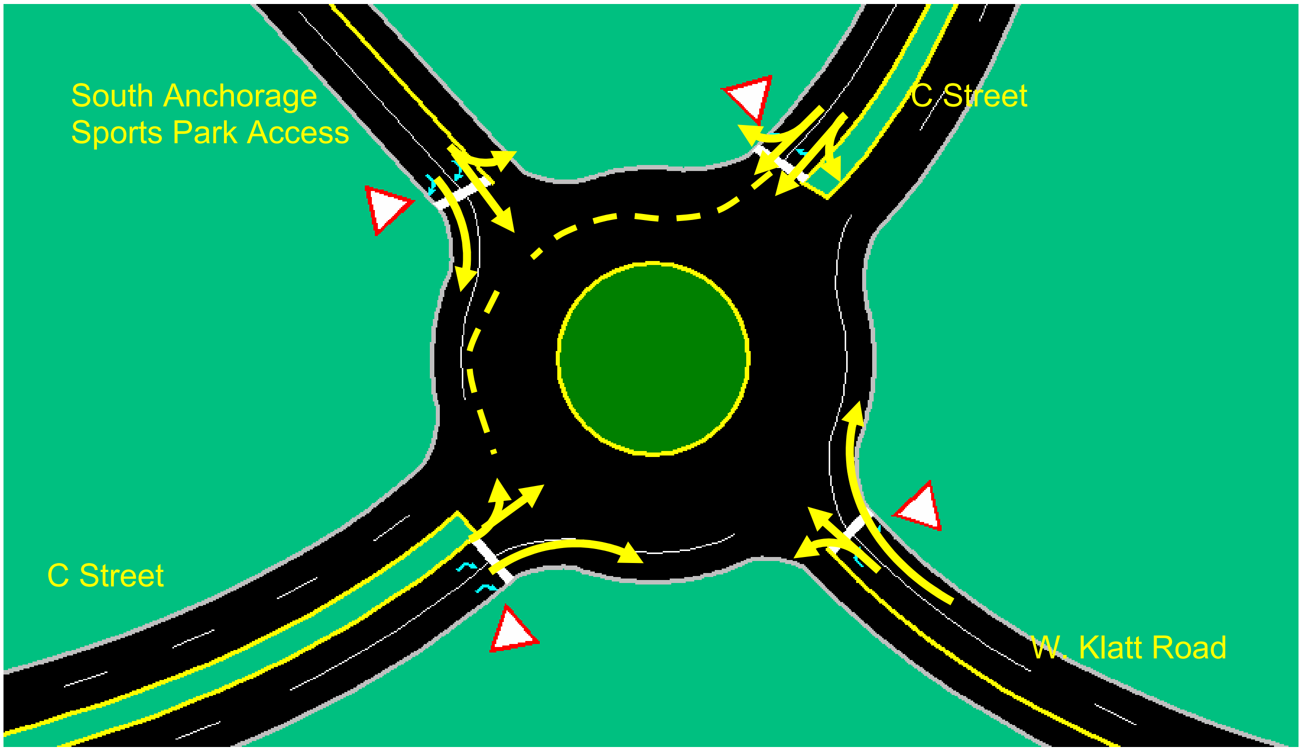


Figure 12- C Street /Klatt Road Modern Roundabout Concept

Figure 13 with corresponding Table 19 presents some of the design elements for the roundabout.

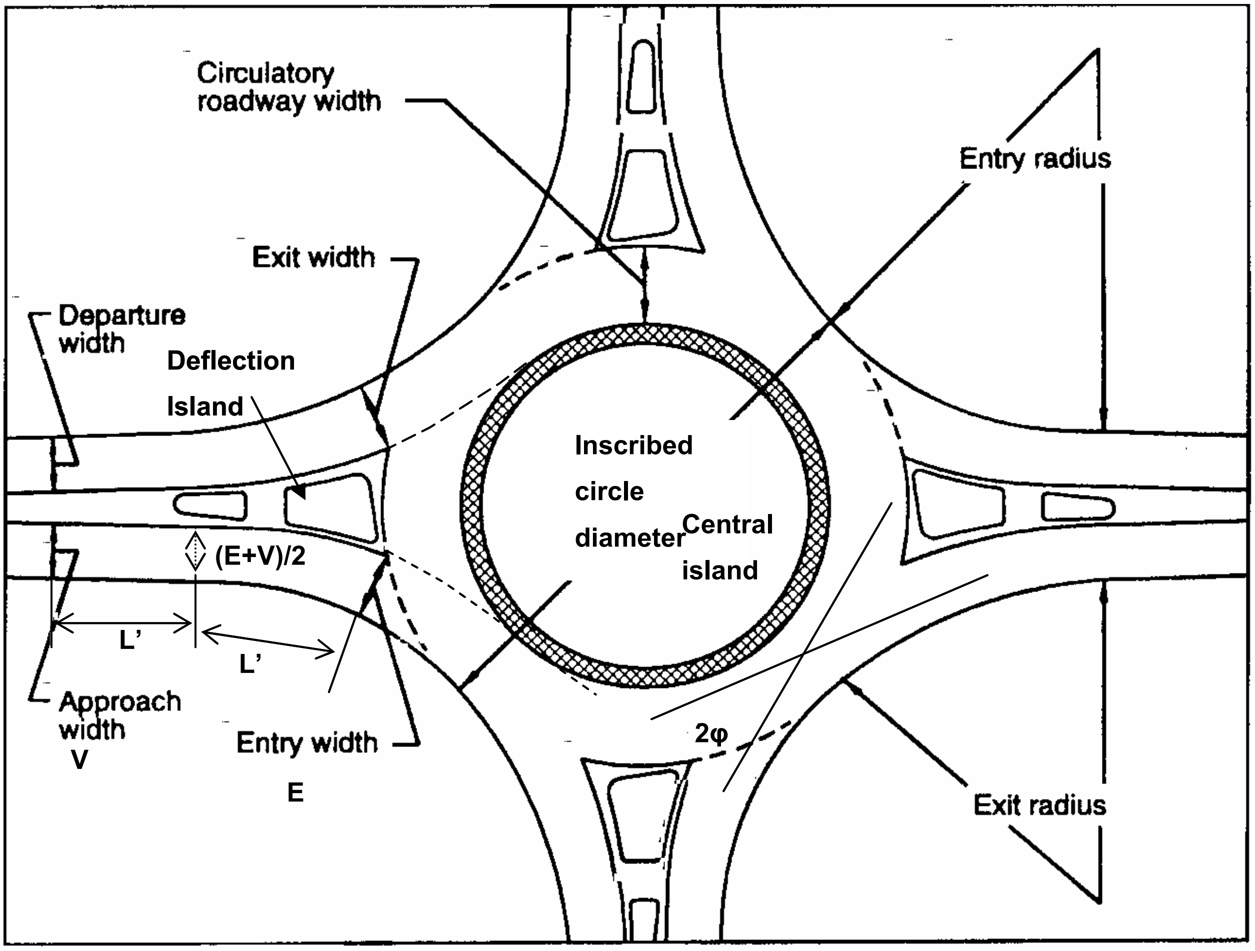


Figure 13- Roundabout Geometric Elements

Element	Value	Source, Comments
Inscribed Circle Diameter	115 to 140 feet single lane; 150 to 180 feet for dual lanes	FHWA range, adjusted for local experience. Larger diameters will enable WB-50 design vehicles to avoid tracking across apron.
Central Island Diameter	Computed base on ICD and CRW to include an outer mountable apron that accommodates occasional truck-trailer combinations larger than WB-50.	Inscribed Circle Diameter- 2 x Circulatory Road Width.
Approach Width, V	Lane Width (assumed 12 feet for 1 lane, 24 for 2 lanes)	FHWA, Rodel
Entry Width, E	14 to 16 feet for single lane (14’ assumed), 24 to 30 feet for dual lanes	FHWA
L′	Minimum 16 feet (Rodel), 40 feet recommended minimum (FHWA) assumed for most cases	Use 40 feet. (derived from FHWA’s recommendation of an 80-foot flare taper in urban areas.)
Φ	25 to 35 degrees	Rodel
Entry Radius, Single Lane	>30 feet, <100 feet	Rodel, FHWA
Exit Radius, Single Lane	>50 feet (FHWA)	Rodel recommend that the exit radius be determined as transition from circulatory road width, through the deflection island, and to the departure width. Radius should be selected so that the taper is 15 or 20 to 1.
Circulatory Road Width	1 to 1.2 x E	Rodel, FHWA
Deflection Island (splitter island), Exit Width	Defined by tangential extensions to the Central Island	FHWA and Rodel. FWHA recommends a minimum of 5-foot pedestrian refuge be located at about 20 feet from the yield line.

Table 19 - Typical Design Values for Modern Roundabout Geometric Elements

Additional Work to Advance Reconnaissance Alternatives

This reconnaissance study has identified two alternatives to address current and future operational issues at the project area. The following additional work should be considered to advance one of these alternatives.

- Perform Spring or Summer Peak Hour Turning Movement Counts at Study Intersections- this reconnaissance study uses counts performed in December, which has less traffic than summer, and could not account for sports park traffic.
- Collect Approach Hose Counts.
- Observe Pedestrian and Bicycle Circulation.
- Collect Additional Speed Data.
- Refine Analysis and Alternatives Based Upon the Above Data

Attachment A- Link Counts

5-Dec-06
TIMBERLAND just south of W KLATT
7:00-18:00

time	NORTH BOUND	SOUTH BOUND
7:00	94	15
8:00	86	24
9:00	33	28
10:00	27	19
11:00	50	37
12:00	42	64
13:00	53	36
14:00	24	26
15:00	54	66
16:00	47	73
17:00	62	93

6-Dec-06
W KLATT between C & Timberland
7:00-18:00

	EASTBOUND	WESTBOUND
7:00	406	116
8:00	331	169
9:00	174	105
10:00	135	142
11:00	152	138
12:00	154	171
13:00	155	155
14:00	195	210
15:00	240	303
16:00	181	329
17:00	225	379

7-Dec-06
Traffic Through E KLATT
7:00-18:00

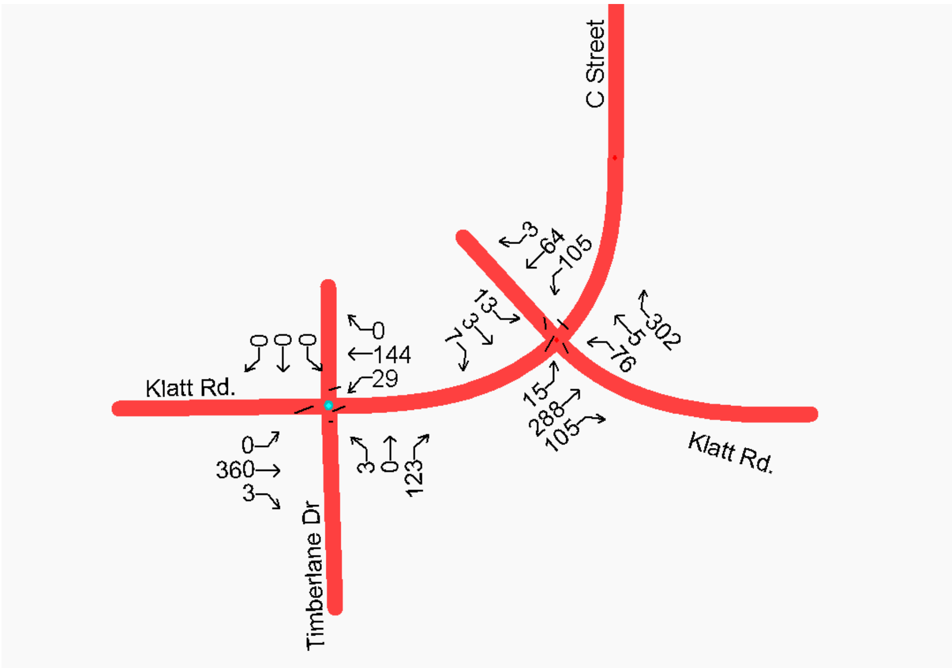
	EASTBOUND	WESTBOUND
7:00	186	336
8:00	172	277
9:00	154	161
10:00	128	131
11:00	158	152
12:00	185	189
13:00	173	156
14:00	258	140
15:00	333	262
16:00	381	234
17:00	468	285

12-Dec-06
C between KLATT & OMALLEY
7:00-18:00

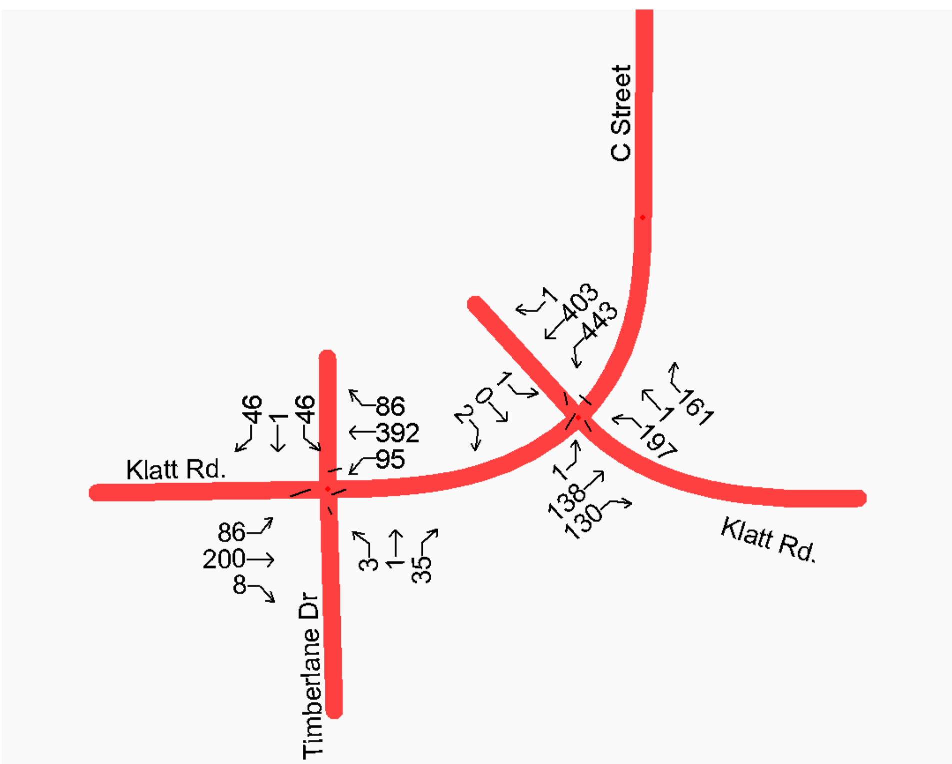
	NORTHBOUND	SOUTHBOUND
7:00	473	93
8:00	365	139
9:00	229	125
10:00	206	103
11:00	169	164
12:00	191	175
13:00	213	186
14:00	287	218
15:00	258	344
16:00	198	362
17:00	270	683

Attachment B- Turning Movement Projections

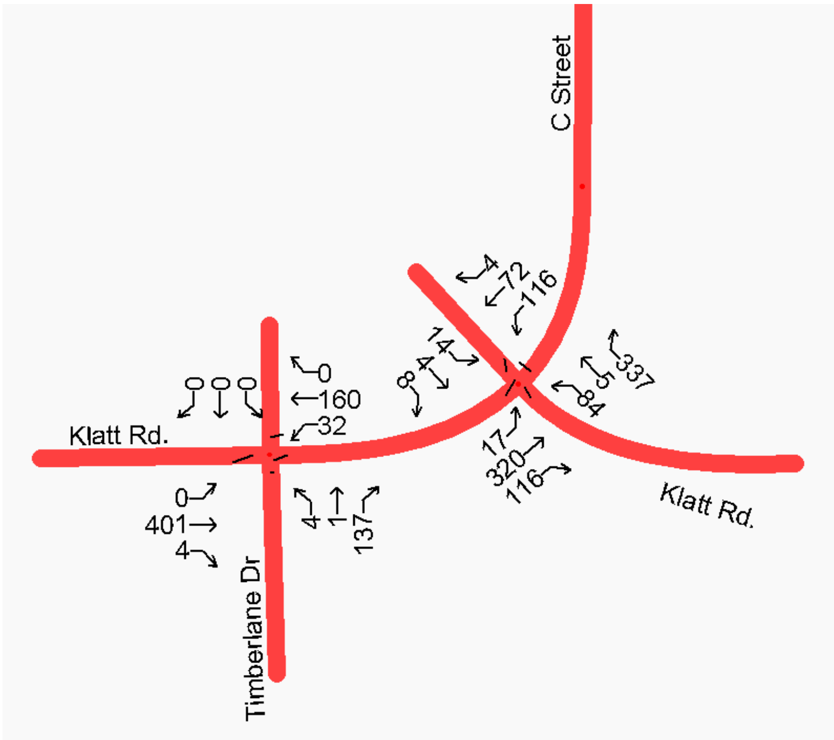
2007 Morning Peak Hour



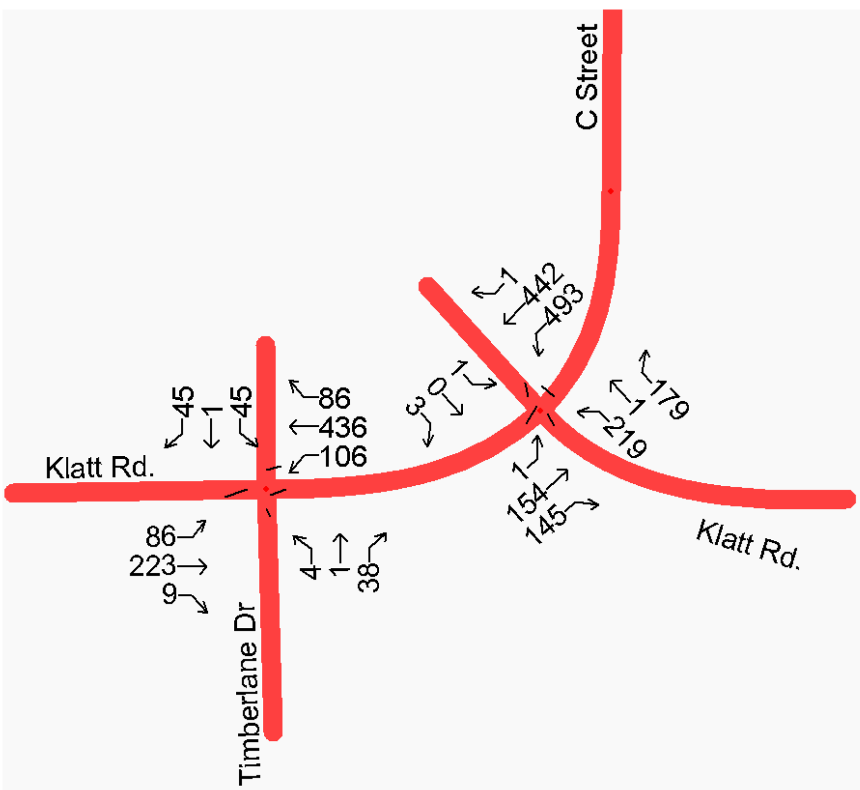
2007 Evening Peak Hour



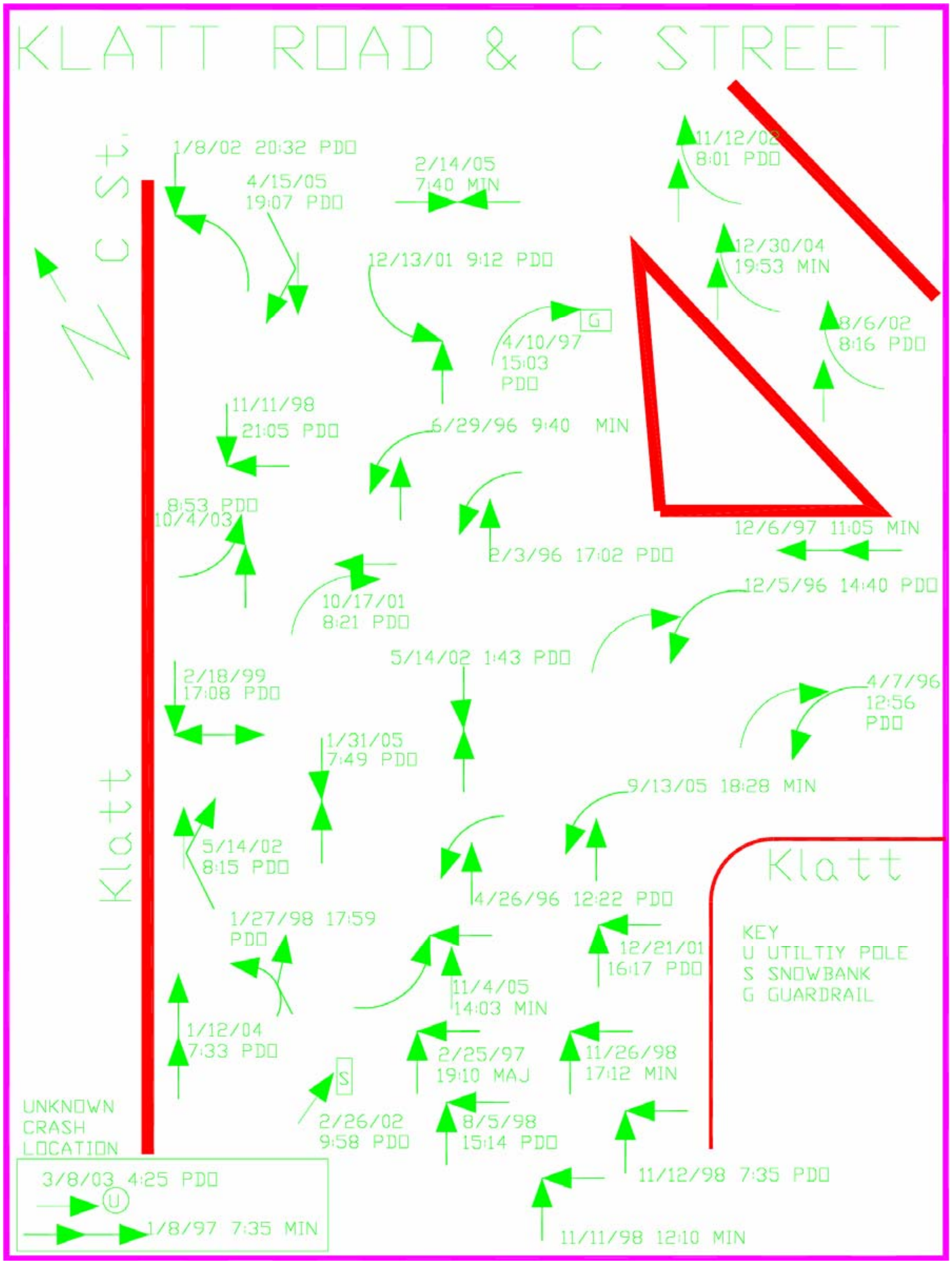
2017 Morning Peak Hour

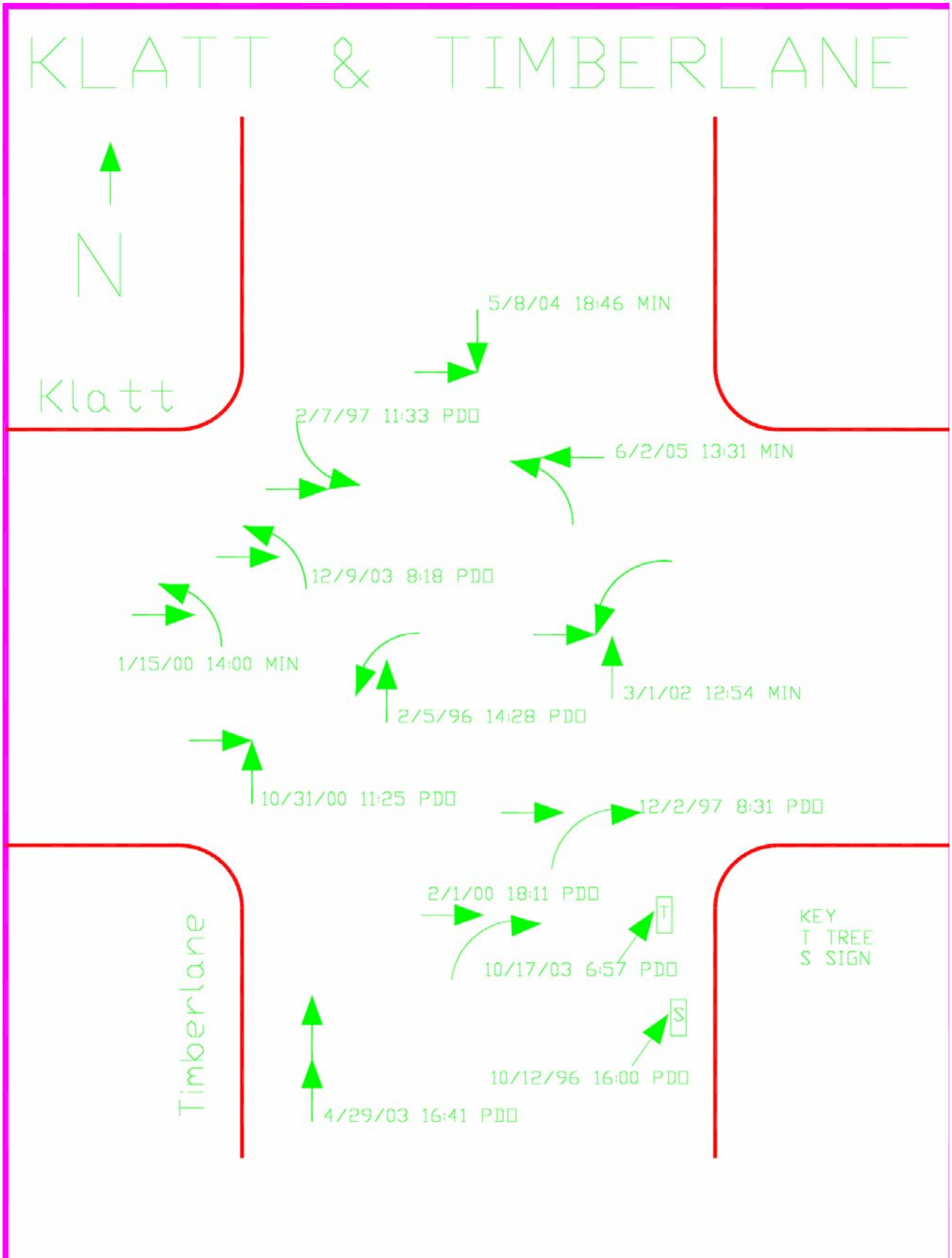


2017 Evening Peak Hour



Attachment C- Crash Diagrams




KLATT & TIMBERLANE
N
Klatt
5/8/04 18:46 MIN
2/7/97 11:33 PDO
6/2/05 13:31 MIN
12/9/03 8:18 PDO
1/15/00 14:00 MIN
2/5/96 14:28 PDO
3/1/02 12:54 MIN
10/31/00 11:25 PDO
12/2/97 8:31 PDO
2/1/00 18:11 PDO
10/17/03 6:57 PDO
T
S
10/12/96 16:00 PDO
4/29/03 16:41 PDO
Timberlane
KEY
T TREE
S SIGN

Appendix D - Crash Rate and Over-Representation Methods and Calculations

The crash rate calculations uses equations found in the *Highway Safety Improvement Program Handbook* (HSIPHB) by ADOT&PF, and NCHRP Report 162 from Transportation Research Board, *Methods for Evaluating Highway Safety Improvements* by John C. Laughland, *et al.,* National Research Council, Washington, D.C. 1975. These formulae appear in many other references as well.

Segment crash rates are calculated as:

Equation D-1. $$R = \frac{1{,}000{,}000 \times A}{365 \times N \times ADT \times L}$$, where

R= Crash rate for the intersection expressed as crashes per million vehicle miles (MVM),
A= Frequency of crashes in the study period,
N= Number of years of data,
ADT= Segment Average Annual Daily Traffic (AADT) volumes, both directions (average over study period),
L= Segment length, miles.

Rate analysis is especially useful when there is a population of facilities to which we can compare the study area. Rates are a good indicator of the individual's risk in being involved in a crash when using the facility because rates consider the motorist's exposure by volume and length of road. ADOT&PF has developed statewide populations for segments and intersections, and provides this data in the HSIPHB and supplements and the 2001 *Traffic Accident Report,* May 2003 (*Traffic Accident Report* is published annually by DOT&PF).

We can calculate crash rates using Equation D-1 to compare the facility to the corresponding State of Alaska average crash rate population. However, by only comparing the rate of the facility under analysis to an average rate, we may erroneously infer that those facilities with higher than average rates are problem areas.

Instead, we would like to establish an upper limit, or *critical* rate that is our threshold of concern. The Rate Quality Control Method establishes an upper control limit (UCL) to determine if the facility's crash rate, as calculated in Equation 1, is significantly higher than crash rates in facilities with similar characteristics. The UCL or critical rate is determined statistically as a function of the statewide average crash rate for the facility category (i.e., highway or intersection) and the vehicle exposure at the location being considered. UCL is calculated with the following equation:

Equation D-2. $$UCL = R_a + Z \times \sqrt{\frac{R_a}{M}} + \frac{1}{2 \times M},$$

The variables in this equation are:

R_a= Average crash rate for the population in crashes per MVM (road segments);
M= Facility exposure in MVM for roadway section, using N, ADT, and L stated above and computed as:

Equation D-3. $$M = \frac{365 \times N \times ADT \times L}{10^6}$$

Z= Normal Distribution Transformation Variable (usually 1.64 for a 95% confidence level)

Segments with rates that exceed the UCL are inferred to be well above the population average at the confidence level reflected in the selection of the "Z" variable, and would therefore have significant crash experience.

Where there are sufficient numbers of crashes, hypothesis testing compares each intersection's crash types and factors to the intersection and crash type population statistics. This can determine if the proportion of the crash type or contributing factor exceeds the populations, and whether these types or factor should be the focus of countermeasures. Populations for crash types are available from the Municipality of Anchorage. Environmental factors and severity population percentages are published in the annual State of Alaska Department of Transportation and Public Facilities *Alaska Traffic Accidents*.

In hypothesis testing, the null hypothesis, H_o, states that the attribute of the intersection that we are interested in, for example proportion of collisions of a certain type, or proportion of damage type crashes, are less than or equal to state populations. The alternative hypothesis, H_a, states that the intersection's proportions exceed the comparative populations.

The crashes are binomially distributed samples. Normal distribution provides a reasonable approximation to binomial probabilities when the sample is sufficiently large. If so, then the standardized value is calculated as:

Equation D-3. $$Z = \frac{\hat{p} - p}{\sqrt{p(1-p)/n}}$$

Where:

Z = Normal Distribution Transformation Variable, the value within the normal distribution curve;

$\hat{p}$ =Sample proportion;

p = Population proportion; and

n = Number of crashes at location.

The large-sample assumption is checked by testing whether $np \geq 5$, and $n(1-p) \geq 5$.

A p-value (not to be confused with $\hat{p}$ or p) is determined by the area (probability) between the z-value and the tail within the standard normal distribution curve. The p-value is the probability of a Type-I error in hypothesis testing. That is, the p-value is the probability that we reject the null hypothesis, H_o, in this case simply stated that "This intersection crash attribute proportion is less than or equal to the proportion of the control population", when H_o is true. A low p-value, usually 0.05 or less indicates that there is strong statistical evidence favoring the alternative hypothesis, H_a, or we could say, "This intersection attribute proportion exceeds the control population proportion".

If an intersection does not have enough crashes to meet the large sample assumption; that is $np < 5$, or $n(1-p) < 5$; we use the Poisson distribution to check crash significance. If K is the number of crashes under examination then the probability that there are less than K crashes is:

Equation D-4. $P(<K) = P(0 \;\; acc) + P(1 \;\; acc) + ... + P((K-1) \;\; acc).$

In this case, the Poisson probability formula estimates the probability of discrete numbers of crashes, and the probability that there are less than K crashes is calculated as:

Equation D-5. $P(<K) = \sum_{i=0}^{i=K-1} (e^{-np}(np)^i)/i!$

Where:

K = number of occurring crashes of type, severity or environmental factor;

e = Base of natural logarithms;

p = Population proportion; and

n = Number of crashes at location.

If the probability of *K* crash of type or contributing factor is calculated to be extremely low, say 5% or less, and *K* crashes occur, we infer that the crash trend is statistically significant.

FIELD BOOKS	BM NO.	LOCATION	ELEV.	DATA	DRAWN BY	CHECKED BY	DATA	DRAWN BY	CHECKED BY	REV	DATE	DESCRIPTION	BY	REV	DATE	DESCRIPTION	BY
DESIGN: NUMBERS	NAME	–	ELEV	BASE	–	–	TELEPHONE	–	–								
STAKING:				TOPOGRAPHY	–	–	ELECTRIC	–	–								
				PROFILE	–	–	CABLE TV	–	–								
ASBUILT:				SANITARY SEWER	–	–	DESIGN	–	–								
				STORM SEWER	–	–	QUANTITIES	–	–								
				WATER	–	–	MUN. FINAL CHECK										
CONTRACTOR:	BASIS OF DATUM: –			GAS	–	–											
INSPECTOR:																	
CONSTRUCTION RECORD	VERTICAL DATUM			PLAN CHECK						REVISIONS							

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No. CE 7649
REGISTERED PROFESSIONAL ENGINEER

SEAL

MUNICIPALITY OF ANCHORAGE

PROJECT MANAGEMENT AND ENGINEERING DEPARTMENT

M5T068 C STREET / W. KLATT TRAFFIC STUDY SCHEDULE A

ALTERNATE 1 – SIGNAL

SCALE: HOR. 1"=400' VER. 1"= | DATE: 01/17/2007 | GRIDS: X | SHEET of .
ACCT. NO.

FILE NO.–

H:\jobs\06-005 MOA Traffic Design Term\Task 20 – C Street-Klatt Traffic Study\cad\drawings\06005–20_C03, 1=50, 01/17/07 at 12:05 by mry
LAYOUT: Layout1
VIEW: C03_L20000, C03_H_L5000, C03_H_X7700
XREF: 06005–20_00_X01, 06005–20_CONTOURS, 06005–20_IMAGE–KLATT, 06005_20_B001

FIELD BOOKS	BM NO.	LOCATION	ELEV.	DATA	DRAWN BY	CHECKED BY	DATA	DRAWN BY	CHECKED BY
DESIGN: NUMBERS	NAME	–	ELEV	BASE	–	–	TELEPHONE	–	–
				TOPOGRAPHY	–	–	ELECTRIC	–	–
STAKING:				PROFILE	–	–	CABLE TV	–	–
				SANITARY SEWER	–	–	DESIGN	–	–
ASBUILT:				STORM SEWER	–	–	QUANTITIES	–	–
				WATER	–	–	MUN. FINAL CHECK		
CONTRACTOR:	BASIS OF DATUM:	–		GAS	–	–			
INSPECTOR:									
CONSTRUCTION RECORD	VERTICAL DATUM			PLAN CHECK					

REV	DATE	DESCRIPTION	BY	REV	DATE	DESCRIPTION	BY

REVISIONS

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PROJECT MANAGEMENT AND ENGINEERING DEPARTMENT

M5T068 C STREET / W. KLATT TRAFFIC STUDY SCHEDULE A

ALTERNATE 2 – ROUNDABOUT

SCALE: HOR. 1"=400' VER. 1"= | DATE: 01/17/2007 | GRIDS: X | ACCT. NO. | SHEET of .

FILE NO.–

H:\jobs\06-005 MOA Traffic Design Term\Task 20 - C Street-Klatt Traffic Study\cad\drawings\06005-20_C03, 1=50, 01/17/07 at 12:05 by rxy
LAYOUT: Layout1
VIEW: C04_P_D0600, C04_H_L5000, C04_H_X7700
XREF: 06005-20_X01, 06005-20_CONTOURS, 06005-20_IMAGE-KLATT, 06005_20_B001