

Traffic Safety Study

Intersection of Flammang Drive and San Marnan Drive Waterloo, Iowa

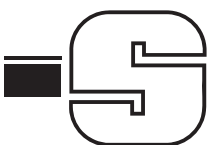


Prepared for:
City of Waterloo



Iowa DOT Project No.
TSF-000(220)- -92-00

January 26, 2011



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TRAFFIC SAFETY STUDY
INTERSECTION OF FLAMMANG DRIVE
AND SAN MARNAN DRIVE
WATERLOO, IOWA

Prepared by:

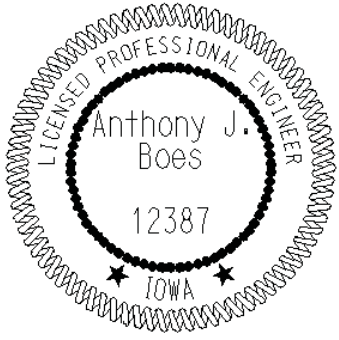
Snyder & Associates, Inc.

Prepared for:

City of Waterloo

Iowa DOT Project No.
TSF-000(220)- -92-00

January 26, 2011

	<p>I hereby certify that this engineering document was prepared by me Or under my direct personal supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Iowa</p> <p>_____</p> <p>Anthony J. Boes, P.E. Date License Number 12387 My License Renewal Date is December 31, 2011 Pages or sheets covered by this seal</p> <p>_____ _____</p>
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Introduction

The intersection of Flammang Drive and San Marnan Drive has historically been a high crash location in the City of Waterloo. In 2007, the intersection was ranked #101 on the Iowa DOT Safety Improvement Candidate List. In order to evaluate safety concerns at this intersection, the City of Waterloo applied for and received Iowa DOT Traffic Safety Improvement Program funds to install a video crash recording system and perform a traffic safety study of the intersection. The location of the study intersection is shown in Figure 1.



Figure 1 – Study Location Map

Existing Conditions

The study intersection is located within a major commercial area of the City, providing access to Crossroads Mall, several “big box” discount stores and area restaurants. San Marnan Drive is a four-lane, divided minor arterial roadway carrying approximately 14,100 vehicles per day (vpd) according to Iowa DOT 2009 traffic count data. The speed limit on San Marnan Drive is 35 mph.

West of San Marnan Drive, Flammang Drive is two-lane local street that terminates at Hammond Avenue. East of San Marnan Drive, Flammang Drive is four-lane, divided street that terminates at Crossroads Boulevard. According to 2005 Iowa DOT Traffic count data, Flammang Drive carries approximately 5,300 and 11,200 vpd west and east of San Marnan Drive, respectively. The existing speed limit along Flammang Drive is 25 mph.



Photo 1 – Looking West



Photo 2 – Looking South

The San Marnan Drive and Flammang Drive signalized intersection operates with protected-only left turn phasing on all approaches. Split phase operation is provided for the Flammang Drive approaches (eastbound followed by westbound). A full movement STOP-controlled frontage road is located approximate 120' northwest of the San Marnan Drive centerline. A right-in/ right-out only frontage road (Alexandra Drive) is located approximately 130' southeast of the San Marnan Drive centerline. Intersection lane configurations are shown in Figure 2.

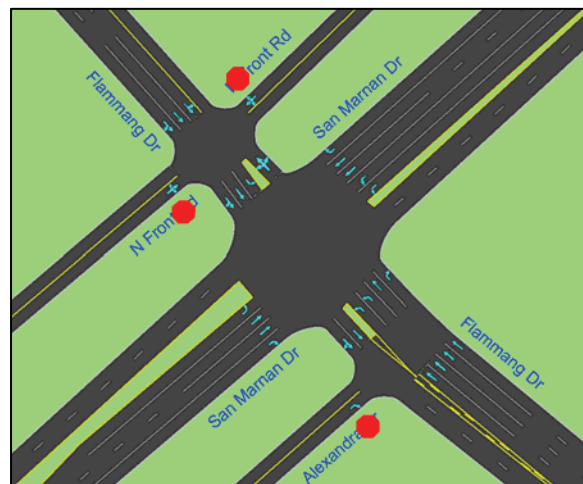


Figure 2 – Intersection Lane Configurations

Video Crash Recording System

In order to improve understanding of intersection safety issues, a video crash recording system was installed at the intersection. The system including two Pelco Spectera IV pan-tilt-zoom cameras mounted on a wood pole in the east quadrant of the intersection and wireless communications to the City of Waterloo Traffic Operation Center DVR. Each week, the Waterloo Police Department provided a list of all motor vehicle incident calls at the intersection. DVR recordings of crashes were then transferred to CD and hard drive. Crash videos were recorded and saved from March 2007 through October 2009. The general location of the video cameras and a photo of the camera installation are shown in Figures 3 and 4.

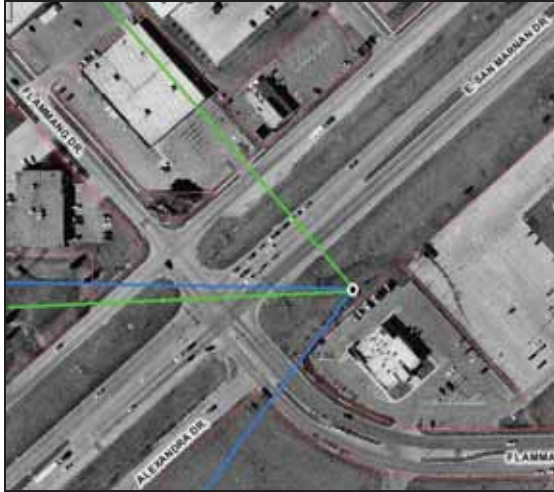


Figure 3 - Camera Locations



Figure 4 - Camera Installation Photo

Several potential camera locations were reviewed, considering view angles and coverage needs, prior to selecting the installed location. After the crash recording period began, an on-site DVR was also installed, due to lightning damage at a radio communications tower. Radio access to the on-site DVR was provided.

Crash Analysis

Preliminary crash analysis included a review of 2001-2009 crash history data from the Iowa DOT CMAT/SAVER crash database. As shown in Figure 5, reported crash occurrences at the study intersection peaked at 25 crashes per year in 2003 and 2004, and have decreased significantly in recent years. Further analysis of 2004-2006 and 2007-2009 crash data was performed, with the following findings:

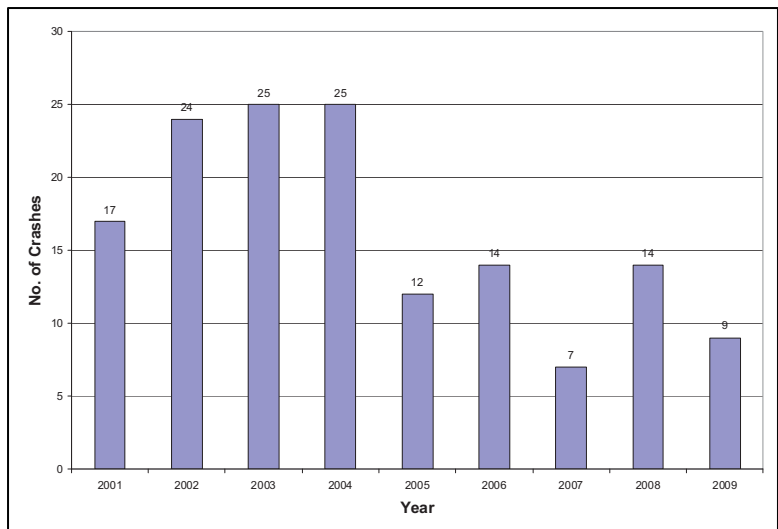
2004 – 2006

- 51 reported crashes
- 26 crashes due to failure to yield at or ran STOP sign
- 2.01 crashes/MEV
- 1 major injury
- 1 minor injury
- 9 possible injuries
- \$201,450 property damage

2007 – 2009

- 30 reported crashes
- 15 crashes due to failure to yield at or ran STOP sign
- 19 crashes at north frontage road intersection.
- 0.96 crashes/MEV overall

Figure 5 – Intersection Crash History



- 1.91 crashes/MEV at north frontage road intersection
- 0.39 crashes/ MEV at San Marnan/ Flammang intersection
- No major or minor injuries
- 3 possible injuries
- \$120,400 property damage

With more than half of the crashes occurring at the north frontage road intersection, the frontage road's close proximity to San Marnan Drive appears to be the primary safety concern. Review of crash videos support this conclusion. In one incident, video showed eastbound cars queued on Flammang Drive in the two outside lanes (through and through/right lanes). Vehicles in these lanes left a gap for frontage road traffic to cross Flammang Drive. The eastbound left turn lane was empty. A northbound vehicle on the frontage road stopped, and not seeing an approaching eastbound vehicle in the left turn lane, proceeded through the intersection and collided with the eastbound vehicle.

Comparing the 2004-2006 period to the 2007-2009 period, crash rates and severities have decreased significantly. This is likely due to traffic control improvements implemented by the City of Waterloo in 2006. These improvements included changing signal phasing on Flammang Drive to split phasing and prohibiting southbound right turns on red from San Marnan Drive towards the north frontage road. The purpose of these changes was to provide gaps and reduce conflicts for the frontage road traffic. However, video observations show that the "RIGHT ON GREEN ARROW ONLY" sign is frequently ignored.

Capacity Analysis

Operational analysis of the study intersections was performed using *Synchro* and *SimTraffic* analysis software. *Synchro* analysis is based on *Highway Capacity Manual* (HCM) methods. *SimTraffic* is a micro-simulation model that considers interactions and vehicle queuing between closely spaced intersections. Peak hour turning movement traffic volumes were estimated for the critical PM peak hour (4:00- 5:00 PM) using available Iowa DOT 2005 and 2009 traffic count data. Analysis results with existing intersection geometry, existing signal phasing and optimized timings are shown in Table 1. Estimated 2009 PM peak hour turning movement volumes are shown in Figure 6.

**Table 1 – Capacity Analysis Results
2009 PM Peak Hour Traffic**

Analysis Type	Intersection	Average Delay (sec/ veh)/ LOS		
		Overall	Critical Movement	
<i>Synchro</i>	Flammang & San Marnan	29.3/ C	NBL	41.9/D
	Flammang & N. Front. Rd	---	SB	19.1/C
	Flammang & Alexandra	---	NBR	*
<i>SimTraffic</i>	Flammang & San Marnan	27.0/C	NBL	51.9/D
	Flammang & N. Front. Rd	---	SB	91.2/F
	Flammang & Alexandra	---	NBR	3.8/A

* HCM analysis not possible

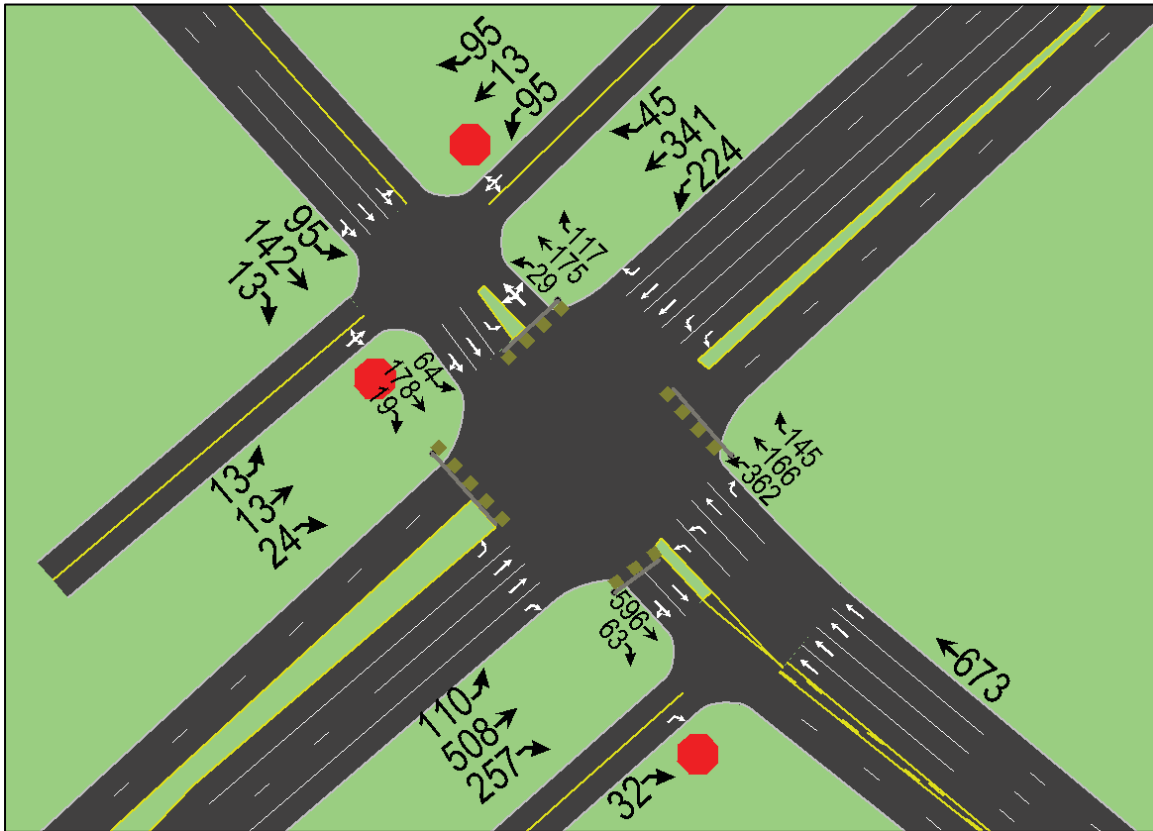


Figure 6 – Est. 2009 PM Peak Hour Traffic

Synchro and *SimTraffic* analysis results for the Flammang Drive and San Marnan Drive intersection are similar, with the intersection operating at LOS C overall and the critical northbound left turn movement operating at LOS D. *SimTraffic* analysis shows significantly higher delays for the southbound approach at the north frontage road intersection than the *Synchro* analysis. This is primarily due to the fact that eastbound queued vehicles at the San Marnan Drive intersection limit opportunities for the frontage road vehicles to turn onto Flammang Drive.

Improvement Alternatives

Despite recent improvements and reduced crash occurrences in recent years, the close spacing between the north frontage road intersection and the San Marnan Drive intersection still presents safety concerns. These safety concerns are due to the lack of separation between conflict points and sight distance obstructions created by queued vehicles. Frontage road drivers have difficulties in identifying and evaluating acceptable gaps in traffic.

Two possible alternatives to improve safety and traffic operations at the frontage road intersection were identified. Following are descriptions of the alternatives. A summary of anticipated benefits and impacts associated with each alternative is provided in Table 2.

Alternative 1 - Construct a raised median along Flammang Drive

This alternative would involve constructing a 4'-wide, approximately 130'-long raised median along Flammang Drive from the San Marnan Drive intersection through the frontage road intersection. This median would restrict turning movements at the frontage road intersection to right-in/right-out only (RIRO). Limited pavement widening in the northeast quadrant of the intersection would also be necessary to provide adequate width for westbound traffic (see Figure 7). Converting the frontage road intersection to a RIRO would significantly reduce turning movement conflicts, but would also reduce accessibility for vehicles to/from commercial properties along the frontage road.

Alternative 2 - Relocate the frontage road intersection to the west

Relocating the frontage road intersection approximately 50' to the west would improve intersection spacing and the ability of drivers to select acceptable gaps in traffic. Eastbound queue storage capacity at the traffic signal would increase from approximately 50' to 100' per lane before spillback into the frontage road intersection. The relocation would require reconstructing sections of the frontage road approximately 200' north and south of Flammang Drive to provide reverse curves to the new intersection location (see Figure 8). Although existing properties adjacent to the intersection would be impacted, total acquisitions would not be necessary.

Table 2 – Alternative Evaluation

Criteria	Alt. 1 – Construct Median	Alt. 2 – Relocate Frontage Road
Safety	Approximately 25% - 45% reduction in crashes expected based on information provided by the Crash Modification Factors Clearinghouse (cmfclearinghouse.org)	No crash reduction factors available, however, crash reduction expected to be similar to Alt. 1.
Traffic Operations	Average PM peak hour delays: <ul style="list-style-type: none">• NB frontage road: 29.9 seconds• SB frontage road: 4.1 seconds	Average PM peak hour delays: <ul style="list-style-type: none">• NB frontage road: 8.2 seconds• SB frontage road: 9.1 seconds
Property/ Access Impacts	No property impacts. Reduced accessibility to/from properties along frontage road due to RIRO access.	Moderate property impacts including parking lot impacts (approx. 12 spaces in NE corner, 1 space in NW corner). Requires removal of existing billboard.
Order of Magnitude Construction Cost Opinion	Construction: \$30,000 Property Acquisition: \$0 Total: \$30,000	Construction: \$200,000 Property Acquisition: \$100,000* Total: \$300,000*

*Billboard acquisition cost not included.



SNYDER & ASSOCIATES
Engineers and Planners

ALTERNATIVE 1 - CONSTRUCT MEDIAN
FLAMMANG DR & SAN MARNAN DR
TRAFFIC SAFETY STUDY
WATERLOO, IOWA

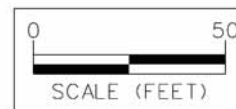
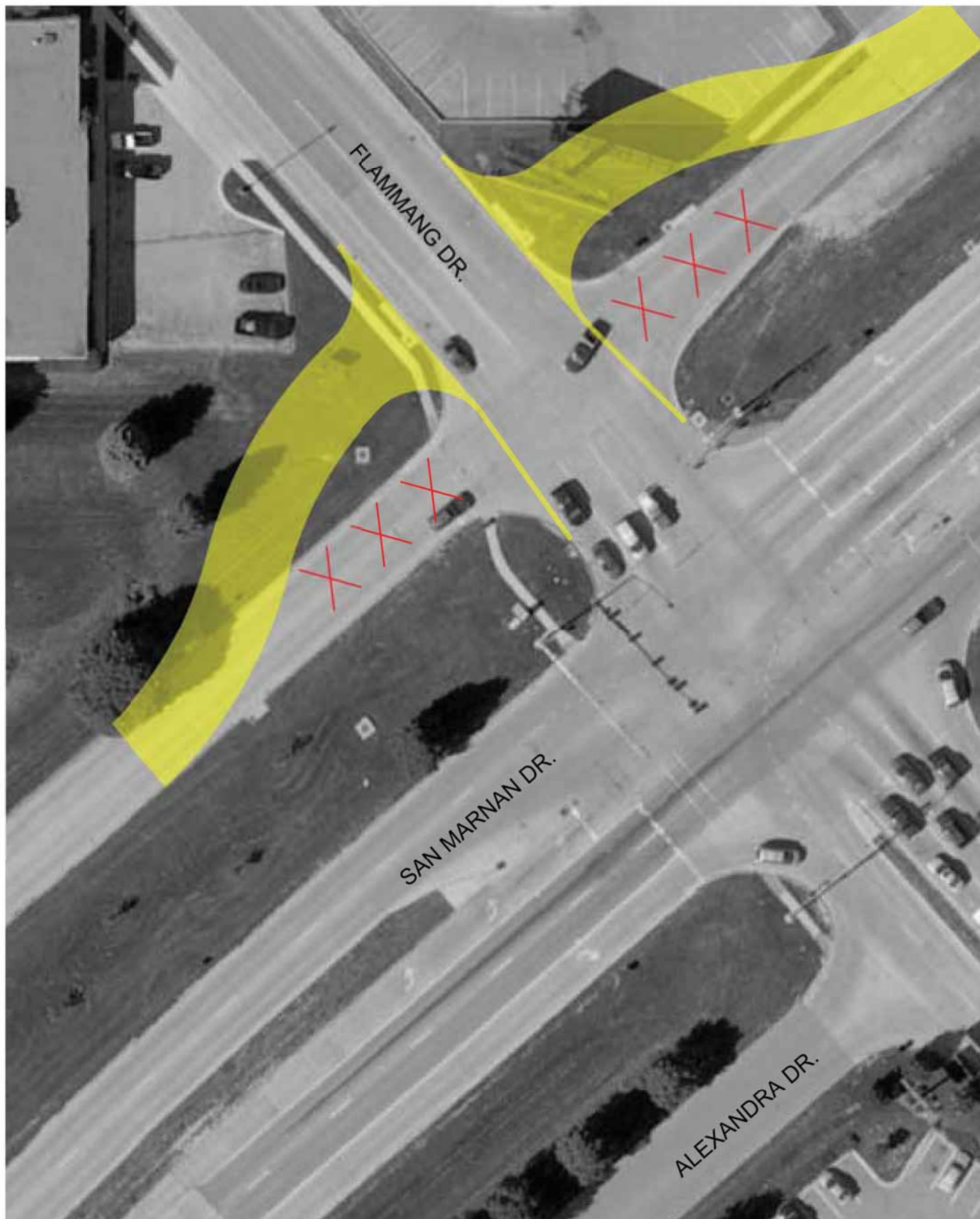


FIGURE 7





SNYDER & ASSOCIATES
Engineers and Planners

**ALTERNATIVE 2 - RELOCATE FRONTAGE ROAD
FLAMMANG DR & SAN MARNAN DR
TRAFFIC SAFETY STUDY
WATERLOO, IOWA**

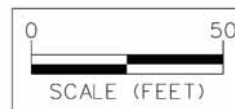


FIGURE 8



Recommendations

Frontage Road Intersection

Although overall crash history has declined in recent years, a relatively high crash rate (1.91 crashes/MEV) still exists at the Flammang Drive north frontage road intersection. Either of the two alternatives discussed would be expected to significantly reduce the crash rate. Taking into consideration the anticipated benefits, impacts and costs, it is recommended that the City of Waterloo further evaluate the proposed improvement alternatives through discussions with affected property owners. If the access impacts of Alternative 1 are deemed to be acceptable, the relatively low cost makes this alternative desirable. Alternative 1 could also be implemented as an initial improvement, with relocation of frontage road intersection (Alternative 2) in the future, as needed.

Video Crash Recording System

Based on experiences with this project, the following recommendations are provided for future video crash recording system installations:

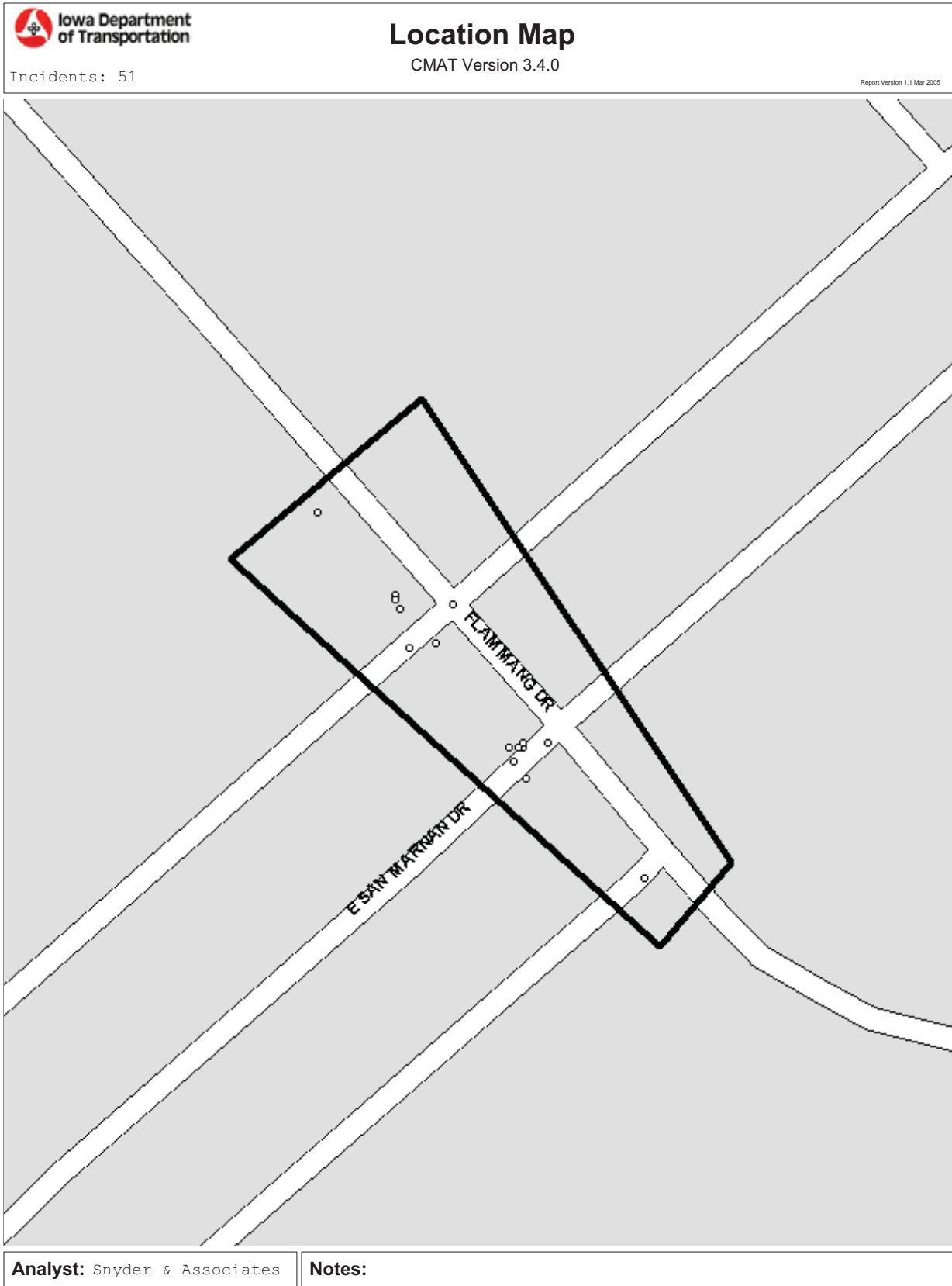
- Locate camera as close to the intersection as possible and zoom in the intersection. Don't worry about approaches unless there is a known crash problem with approaches or there are other areas/segments that require observation.
- Coordinate closely with local law enforcement to get accurate times of events for ease in locating and extracting relevant video.
- If possible, have a remote connection as well as a local recording device suitable for outdoor temperatures. The remote connection can be used to check and adjust camera operation.
- If connected to a network, consider a server-based recording system. This provides the benefits of a familiar operating system (such as Windows) and associated capabilities.
- Use off-the-shelf technology if possible. A sound-activated system (honk, tire squeal, impact sound) would permanently record video a predetermined time period before and after the crash. This would eliminate the need to search through recorded video.

Miscellaneous

Replace the existing "RIGHT ON GREEN ARROW ONLY" sign for San Marnan Drive southbound right turns with a "NO TURN ON RED" (R10-11 or R10-11a) sign. The "NO TURN ON RED" sign is likely more familiar to drivers, and may improve compliance.

Appendix

- *Crash Data*
- *Traffic Count Data*
- *Capacity & Simulation Analyses*
- *Traffic Signal Record Drawing*
- *Existing Traffic Signal Timing*





Major Cause Summary

CMAT Version 3.4.0

Report Version 1.1 Jan 2005

Analysis Years: 2004 [25], 2005 [12], 2006 [14]

Crash Summary:

Fatal	-
Major Injury	1
Minor Injury	1
Possible/Unknown	6
PDO	43
Total Crashes	51

Injury Summary:

Fatal	-
Major Injury	1
Minor Injury	1
Possible	9
Unknown	-
Total Injuries	11

Surface Condition Summary:

Dry	41
Wet	8
Ice	-
Snow	2
Slush	-
Sand/Dirt/Oil/Gravel	-
Water	-
Other	-
Unknown	-
Not Reported	-
Total Crashes	51

TOT Property Damage: \$201,450

AVG Property Damage: \$3,950

Major Cause Summary:

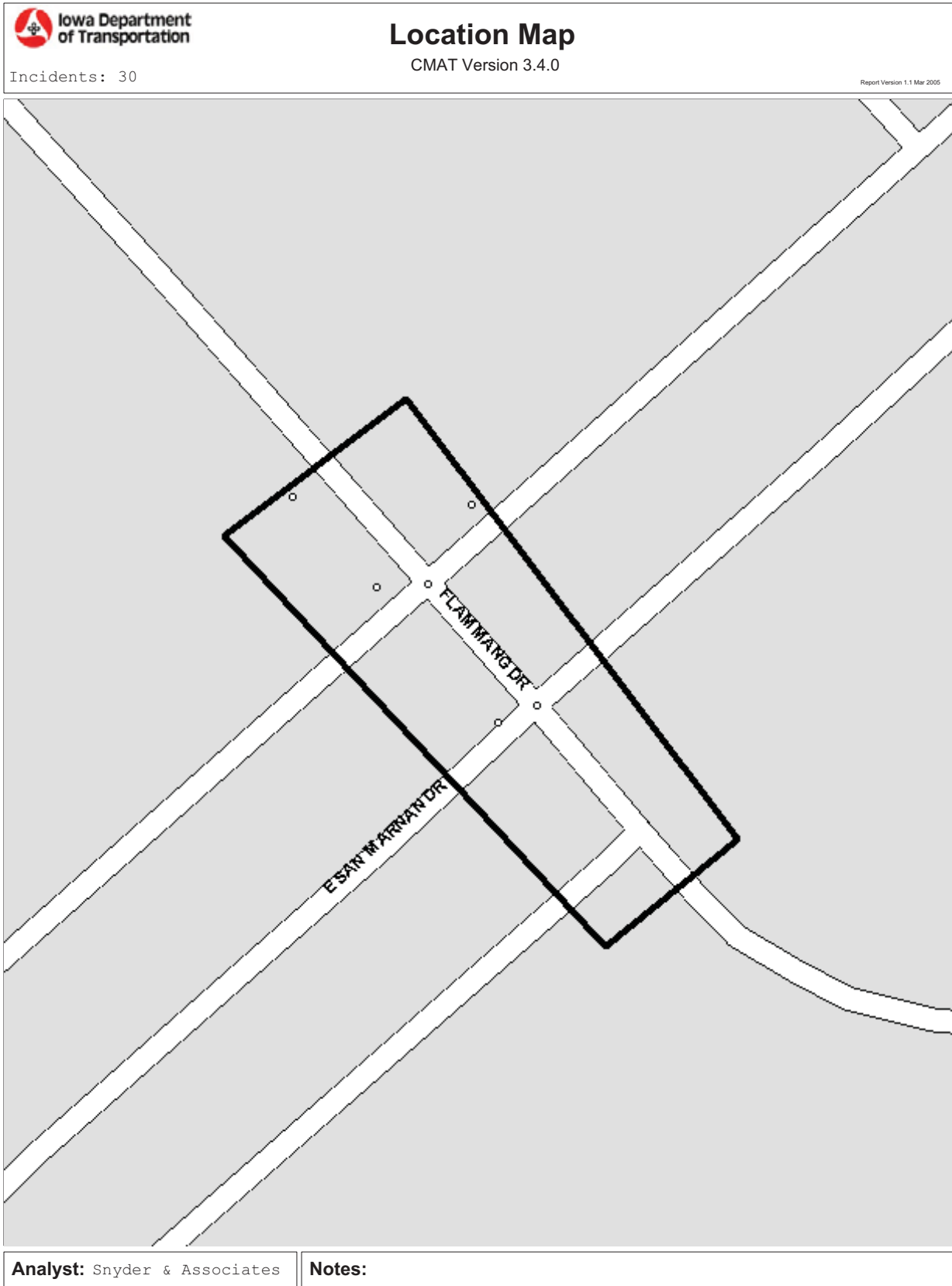
Animal	Improper Backing
1 Ran Traffic Signal	Illegally Parked/Unattended
Ran Stop Sign	1 Swerving/Evasive Action
Crossed Centerline	Over-Correcting/Over-Steering
FTYROW: At Uncontrolled Intersection	Downhill Runaway
1 FTYROW: Making Right Turn on Red Signal	Equipment Failure
26 FTYROW: From Stop Sign	Separation of Units
FTYROW: From Yield Sign	Ran Off Road - Right
3 FTYROW: Making Left Turn	Ran Off Road - Straight
FTYROW: From Driveway	Ran Off Road - Left
FTYROW: From Parked Position	Lost Control
FTYROW: To Pedestrian	Inattentive/Distracted By: Passenger
1 FTYROW: Other (explain in narrative)	Inattentive/Distracted By: Use of Phone or Other
Traveling Wrong Way or on Wrong Side of Rd	1 Inattentive/Distracted By: Fallen Object
1 Driving Too Fast for Conditions	Inattentive/Distracted By: Fatigued/Asleep
Exceeded Authorized Speed	2 Other: Vision Obstructed
2 Made Improper Turn	Oversized Load/ Oversized Vehicle
Improper Lane Change	Cargo/Equipment Loss or Shift
1 Followed Too Close	8 Other: Other Improper Action
Disregarded Railroad Signal	3 Unknown
Disregarded Warning Sign	Other: No Improper Action
Operating Vehicle in Reckless/Aggressive Manner	None Indicated

Selection Filter:

((YEAR = 2004 or YEAR = 2005 or YEAR = 2006))

Analyst: Snyder & Associates

Notes:





Major Cause Summary

CMAT Version 3.4.0

Report Version 1.1 Jan 2005

Analysis Years: 2007 [7], 2008 [14], 2009 [9]

Crash Summary:

Fatal	-
Major Injury	-
Minor Injury	-
Possible/Unknown	2
PDO	28
Total Crashes	30

Injury Summary:

Fatal	-
Major Injury	-
Minor Injury	-
Possible	3
Unknown	-
Total Injuries	3

Surface Condition Summary:

Dry	23
Wet	4
Ice	2
Snow	-
Slush	1
Sand/Dirt/Oil/Gravel	-
Water	-
Other	-
Unknown	-
Not Reported	-
Total Crashes	30

TOT Property Damage: \$120,400

AVG Property Damage: \$4,013

Major Cause Summary:

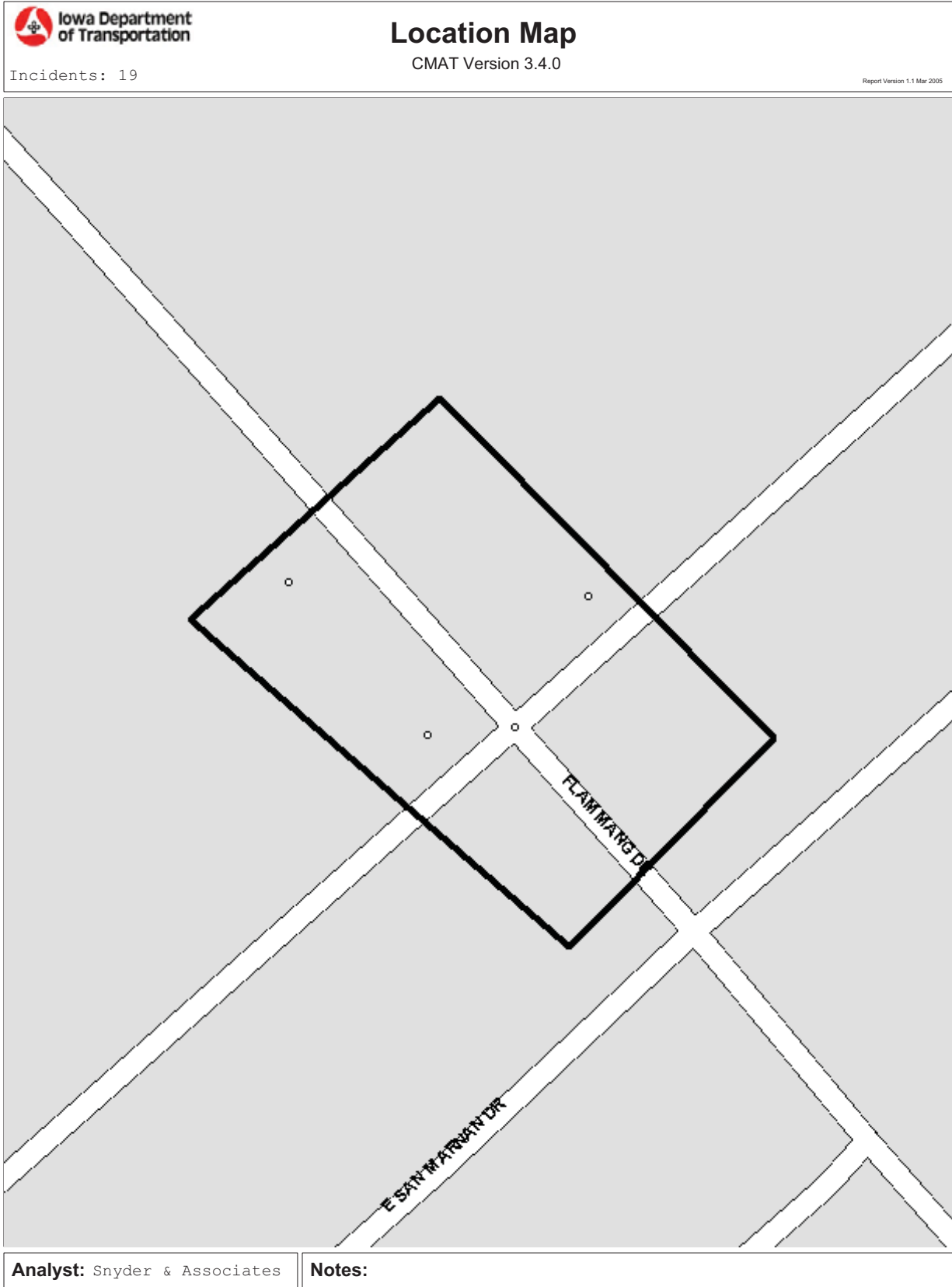
Animal	Improper Backing
3 Ran Traffic Signal	Illegally Parked/Unattended
2 Ran Stop Sign	Swerving/Evasive Action
Crossed Centerline	Over-Correcting/Over-Steering
FTYROW: At Uncontrolled Intersection	Downhill Runaway
1 FTYROW: Making Right Turn on Red Signal	Equipment Failure
13 FTYROW: From Stop Sign	Separation of Units
FTYROW: From Yield Sign	Ran Off Road - Right
1 FTYROW: Making Left Turn	Ran Off Road - Straight
FTYROW: From Driveway	Ran Off Road - Left
FTYROW: From Parked Position	1 Lost Control
FTYROW: To Pedestrian	Inattentive/Distracted By: Passenger
2 FTYROW: Other (explain in narrative)	Inattentive/Distracted By: Use of Phone or Other
Traveling Wrong Way or on Wrong Side of Rd	Inattentive/Distracted By: Fallen Object
1 Driving Too Fast for Conditions	Inattentive/Distracted By: Fatigued/Asleep
Exceeded Authorized Speed	1 Other: Vision Obstructed
Made Improper Turn	Oversized Load/ Oversized Vehicle
Improper Lane Change	Cargo/Equipment Loss or Shift
Followed Too Close	3 Other: Other Improper Action
Disregarded Railroad Signal	2 Unknown
Disregarded Warning Sign	Other: No Improper Action
Operating Vehicle in Reckless/Aggressive Manner	None Indicated

Selection Filter:

((YEAR = 2007 or YEAR = 2008 or YEAR = 2009))

Analyst: Snyder & Associates

Notes:





Major Cause Summary

CMAT Version 3.4.0

Report Version 1.1 Jan 2005

Analysis Years: 2007 [5], 2008 [8], 2009 [6]

Crash Summary:

Fatal	-
Major Injury	-
Minor Injury	-
Possible/Unknown	1
PDO	18
Total Crashes	19

Injury Summary:

Fatal	-
Major Injury	-
Minor Injury	-
Possible	1
Unknown	-
Total Injuries	1

Surface Condition Summary:

Dry	15
Wet	3
Ice	-
Snow	-
Slush	1
Sand/Dirt/Oil/Gravel	-
Water	-
Other	-
Unknown	-
Not Reported	-
Total Crashes	19

TOT Property Damage: \$84,100

AVG Property Damage: \$4,426

Major Cause Summary:

Animal	Improper Backing
Ran Traffic Signal	Illegally Parked/Unattended
2 Ran Stop Sign	Swerving/Evasive Action
Crossed Centerline	Over-Correcting/Over-Steering
FTYROW: At Uncontrolled Intersection	Downhill Runaway
FTYROW: Making Right Turn on Red Signal	Equipment Failure
12 FTYROW: From Stop Sign	Separation of Units
FTYROW: From Yield Sign	Ran Off Road - Right
1 FTYROW: Making Left Turn	Ran Off Road - Straight
FTYROW: From Driveway	Ran Off Road - Left
FTYROW: From Parked Position	1 Lost Control
FTYROW: To Pedestrian	Inattentive/Distracted By: Passenger
FTYROW: Other (explain in narrative)	Inattentive/Distracted By: Use of Phone or Other
Traveling Wrong Way or on Wrong Side of Rd	Inattentive/Distracted By: Fallen Object
Driving Too Fast for Conditions	Inattentive/Distracted By: Fatigued/Asleep
Exceeded Authorized Speed	1 Other: Vision Obstructed
Made Improper Turn	Oversized Load/ Oversized Vehicle
Improper Lane Change	Cargo/Equipment Loss or Shift
Followed Too Close	1 Other: Other Improper Action
Disregarded Railroad Signal	1 Unknown
Disregarded Warning Sign	Other: No Improper Action
Operating Vehicle in Reckless/Aggressive Manner	None Indicated

Selection Filter:

((YEAR = 2007 or YEAR = 2008 or YEAR = 2009))

Analyst: Snyder & Associates

Notes:

City of Waterloo Crash Data Summary

DATE MEANS:

DATE No Report: Only Seen On Camera
 DATE Report Generated City: As Shown ON City Records
 DATE Report Generated State: As shown On DOT Records

Incident Number	DATE			Available			Notes south means southbound area north means northbound area
	No Report	Report Generated		PD Report	Video		
		City	State				
23285		3/10/2007		x	x		
37487		4/18/2007	4/18/2007	x			
43847		5/3/2007	5/4/2007	x			
57829		6/9/2007	6/9/2007	x			
65008		6/27/2007	6/27/2007	x			
85035		8/16/2007	xx	x			
91116		9/1/2007	9/1/2007	x			
5824	1/26/2008				x		south - rear-end
16751	2/19/2008				x		south - cars skid on ice
17259		2/21/2008	2/21/2008	x	x		out of viewing area, police car seen
17822	2/22/2008				x		only police car seen
19406	2/27/2008				x		north
21799		3/5/2008	3/5/2008	x			
22545		3/7/2008	3/7/2008	x			
28997		3/26/2008	3/26/2008	x			
		5/29/2008	5/29/2008	x	x		
64711		6/27/2008	6/27/2008	x	x		
66705		7/2/2008	7/2/2008	x	x		
68538		7/7/2008	7/7/2008	x	x		
75529		7/25/2008	7/25/2008	x	x		north
92284		9/6/2008	6/9/2008	x			
109612		10/23/2008	10/23/2008	x	x		
120231		11/21/2008	11/21/2008	x			
124628		12/3/2008	12/4/2008	x			
??		xx	12/22/2008				
3629		1/10/2009	xx	not avail	x		
6661	1/18/2009						
30767		3/22/2009	3/22/2009	x	x		crash on south
53563	5/19/2009						
??		7/18/2009			x		south
54591		5/21/2009	5/21/2009	x			
99401		9/13/2009	9/13/2009	x			
99850		9/14/2009	9/14/2009	x			
113949		10/22/2009		not avail	x		nothing in view

IOWA DEPARTMENT OF TRANSPORTATION
VEHICULAR TURNING MOVEMENTS
ANNUAL AVERAGE DAILY TRAFFIC - YEAR 2005
IN WATERLOO

DATE: 08-13-2010

COUNTY: BLACK HAWK
E SAN MARNAN DR & FLAMMANG DR

STATION NO. 07 22 8570 0991

FLAMMANG DR

005127

02215

02912

00934

00554

01424

E SAN MARNAN DR

00157 <-----

06400

03399 <-----

02844 <-----

013845

011543

00516

07445

05662

E SAN MARNAN DR

04080

01066

02431

01928

01542

05901

05334

011235

FLAMMANG DR

D1530926

COUNTY TOWNSHIP NODE LOCATION YEAR
07 22 8570 0991 2005

TURNING MOVEMENT SYSTEM
TRAFFIC COUNT SUMMARY
ALL VEHICLES

PRINTER ID: TPRT003W PAGE 0001
CITY: WATERLOO
COUNTY: BLACK HAWK

HOUR	***** NORTH LEG *****			***** EAST LEG *****			***** SOUTH LEG *****			***** WEST LEG *****		
	FLAMMANG DR	LT	TOTAL	E SAN MARNAN DR	ST	RT	FLAMMANG DR	ST	RT	E SAN MARNAN DR	ST	RT
07- 8AM	4	47	11	28	112	90	50	29	39	39	76	54
08- 9AM	2	76	13	32	146	104	76	45	44	32	135	94
09-10AM	8	95	25	40	199	133	98	74	56	55	187	155
11-12PM	9	146	42	58	284	150	241	126	90	76	389	256
12-1 PM	16	137	63	37	360	139	292	125	84	75	441	264
3- 4PM	25	114	40	40	269	143	253	139	89	80	301	151
4- 5PM	15	141	51	36	271	178	287	132	115	87	403	204
5- 6PM	8	96	40	35	237	128	274	117	72	72	322	165
TOTALS	87	852	285	306	1878	1065	1571	787	589	516	2254	1343

STATION DISPLAYED
PF4 QUARTER HOUR

PF5 CLASS

PF7 BKWD

PF8 FWD

PF15 MAIN MENU

PF21 SCREEN PRINT

CLEAR EXIT

D1530927

COUNTY TOWNSHIP NODE LOCATION YEAR
07 22 8570 0991 2005

TURNING MOVEMENT SYSTEM
TRAFFIC COUNT SUMMARY
SINGLE UNIT TRUCKS

PRINTER ID: TPRT003W PAGE 0001
CITY: WATERLOO
COUNTY: BLACK HAWK

HOUR	***** NORTH LEG *****			***** EAST LEG *****			***** SOUTH LEG *****			***** WEST LEG *****		
	RT	ST	TOTAL	RT	ST	TOTAL	LT	ST	TOTAL	LT	ST	TOTAL
7- 8AM	1	1	2	2	9	11	3	1	0	2	3	5
8- 9AM	0	0	0	0	6	6	8	2	1	3	11	18
9-10AM	0	1	1	1	13	14	1	1	0	5	5	13
11-12PM	0	2	2	0	7	7	2	0	4	1	11	16
12- 1PM	0	0	0	0	8	8	1	2	2	3	14	18
3- 4PM	0	1	1	0	12	13	0	0	2	2	8	10
4- 5PM	0	0	0	0	7	7	0	0	0	3	6	9
5- 6PM	0	0	0	2	2	4	1	2	1	0	5	6
TOTALS	1	5	6	5	64	70	16	8	10	19	63	99

STATION DISPLAYED
PF4 QUARTER HOUR

PF5 CLASS

PF7 BKWD

PF8 FWD

PF15 MAIN MENU

PF21 SCREEN PRINT

CLEAR EXIT

D1530928

COUNTY TOWNSHIP NODE LOCATION YEAR
07 22 8570 0991 2005

TURNING MOVEMENT SYSTEM
TRAFFIC COUNT SUMMARY
COMBINATION TRUCKS

PRINTER ID: TPRT003W PAGE 0001
CITY: WATERLOO
COUNTY: BLACK HAWK

HOUR	***** NORTH LEG *****			***** EAST LEG *****			***** SOUTH LEG *****			***** WEST LEG *****		
	FLAMMANG DR	ST	LT	RT	ST	LT	FLAMMANG DR	ST	LT	RT	ST	LT
7- 8AM	0	0	0	0	1	2	1	0	0	0	1	1
8- 9AM	0	0	0	0	1	0	1	0	0	0	1	1
9-10AM	0	1	2	3	1	2	1	0	2	1	0	1
11-12PM	0	0	2	2	1	3	2	1	2	1	1	1
12- 1PM	2	0	2	4	1	1	0	0	3	0	4	0
3- 4PM	0	0	1	1	0	2	2	0	0	0	3	0
4- 5PM	0	0	1	1	0	3	2	0	2	0	0	0
5- 6PM	0	1	0	1	0	0	0	0	0	0	2	1
TOTALS	2	2	8	12	6	11	7	1	15	5	10	20

STATION DISPLAYED
PF4 QUARTER HOUR

PF5 CLASS

PF7 BKWD

PF8 FWD

PF15 MAIN MENU

PF21 SCREEN PRINT

CLEAR EXIT

IOWA DEPARTMENT OF TRANSPORTATION
VEHICULAR TURNING MOVEMENTS
ANNUAL AVERAGE DAILY TRAFFIC - YEAR 2009
IN WATERLOO

DATE: 08-13-2010

COUNTY: BLACK HAWK
E SAN MARNAN DR & SCHUKEI RD

STATION NO. 07 22 8571 0991

SCHUKEI ROAD

000604

00434

00170

00170

00000

E SAN MARNAN DRIVE

07211

06947

014130

013866

06919

06919

E SAN MARNAN DRIVE

00000

00000

00000

00000

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NO ROAD

D1530926

COUNTY TOWNSHIP NODE LOCATION YEAR
07 22 8571 0991 2009

TURNING MOVEMENT SYSTEM
TRAFFIC COUNT SUMMARY
ALL VEHICLES

PRINTER ID: TPRT003W PAGE 0001
CITY: WATERLOO
COUNTY: BLACK HAWK

HOUR	***** SCHUKEI ROAD *****		***** NORTH LEG *****		***** EAST LEG *****		***** SOUTH LEG *****		***** NO ROAD *****		***** E SAN MARNAN DRIVE *****		***** WEST LEG *****	
	RT	LT	ST	LT	RT	ST	ST	RT	LT	RT	LT	ST	RT	TOTAL
07- 8AM	11	0	0	0	11	1	0	0	261	0	0	0	0	134
08- 9AM	14	0	0	0	14	7	0	0	258	0	0	0	0	225
11-12PM	45	0	0	0	45	23	0	0	542	0	0	0	0	541
12-1 PM	36	0	0	0	36	13	0	0	673	0	0	0	0	700
3- 4PM	29	0	0	0	29	11	0	0	594	0	0	0	0	640
4- 5PM	49	0	0	0	49	19	0	0	624	0	0	0	0	670
5- 6PM	36	0	0	0	36	12	0	0	569	0	0	0	0	597
TOTALS	220	0	0	0	220	86	0	0	3521	0	0	0	0	3507

STATION DISPLAYED
PF4 QUARTER HOUR

PF5 CLASS

PF7 BKWD

PF8 FWD

PF15 MAIN MENU

PF21 SCREEN PRINT

CLEAR EXIT

D1530927

COUNTY TOWNSHIP NODE LOCATION YEAR
07 22 8571 0991 2009

TURNING MOVEMENT SYSTEM
TRAFFIC COUNT SUMMARY
SINGLE UNIT TRUCKS

PRINTER ID: TPR003W PAGE 0001
CITY: WATERLOO
COUNTY: BLACK HAWK

HOUR	***** NORTH LEG *****			***** SCHUKEL ROAD *****			***** EAST LEG *****			***** NO ROAD *****			***** SOUTH LEG *****			***** E SAN MARNAN DRIVE *****			***** WEST LEG *****		
	RT	ST	LT	RT	ST	LT	RT	ST	LT	RT	ST	LT	RT	ST	LT	RT	ST	LT	RT	ST	LT
7- 8AM	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8- 9AM	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-12PM	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12- 1PM	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3- 4PM	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4- 5PM	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5- 6PM	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

STATION DISPLAYED
PF4 QUARTER HOUR

PF5 CLASS

PF7 BKWD

PF8 FWD

PF15 MAIN MENU

PF21 SCREEN PRINT

CLEAR EXIT

D1530928

COUNTY TOWNSHIP NODE LOCATION YEAR
07 22 8571 0991 2009

TURNING MOVEMENT SYSTEM
TRAFFIC COUNT SUMMARY
COMBINATION TRUCKS

PRINTER ID: TPRT003W PAGE 0001
CITY: WATERLOO
COUNTY: BLACK HAWK

HOUR	***** SCHUKEI ROAD *****		***** NORTH LEG *****		***** EAST LEG *****		***** SOUTH LEG *****		***** NO ROAD *****		***** E SAN MARNAN DRIVE *****		***** WEST LEG *****	
	RT	ST	LT	TOTAL	RT	ST	LT	TOTAL	LT	RT	LT	ST	RT	TOTAL
7- 8AM	0	0	0	0	0	3	0	3	0	0	0	0	2	2
8- 9AM	0	0	0	0	0	2	0	2	0	0	0	0	3	3
11-12PM	0	0	0	0	0	2	0	2	0	0	0	0	2	2
12- 1PM	0	0	0	0	0	2	0	2	0	0	0	0	3	3
3- 4PM	0	0	0	0	0	0	0	0	0	0	0	0	3	3
4- 5PM	0	0	0	0	0	2	0	2	0	0	0	0	2	2
5- 6PM	0	0	0	0	0	1	0	1	0	0	0	0	3	3
TOTALS	0	0	0	0	0	12	0	12	0	0	0	18	0	18

STATION DISPLAYED
PF4 QUARTER HOUR

PF5 CLASS

PF7 BKWD

PF8 FWD

PF15 MAIN MENU

PF21 SCREEN PRINT

CLEAR EXIT

PORTABLE RECORDER TRAFFIC COUNT

CURRENT DATE 08-13-2010

STATION NUMBER: COUNTY 07 BLACK HAWK
TWP 22 CITY: WATERLOO
NODE 8969
N LOC 2101

LOCATION: FLAMING DR & FRONTAGE RD

LEGAL DESC: SEC TWP RGE

RECORDER LEG NE

2005 AADT 003522

PRINTER ID: TPRT003W

LOCATION 2101

NODE 8968

TOWNSHIP 22

STATION: COUNTY 07

BEGINNING TIME AND DATE	TIME	MONTH	DAY	YEAR	DOW
ENDING TIME AND DATE	0200 PM	07	18	2005	2
	1200 PM	07	20	2005	4

[illegible]

PF7 BKWD

PF8 FWD

PF9 SELECT DIFFERENT CONTROLS

PF15 MAIN MENU

PF21 SCREEN PRINT

CLEAR EXIT

PORTABLE RECORDER TRAFFIC COUNT

CURRENT DATE 08-13-2010

STATION NUMBER: COUNTY 07 BLACK HAWK
TWP 22 CITY: WATERLOO
NODE 8969
N LOC 6101

LOCATION: FLAMMING RD & FRONTAGE RD

LEGAL DESC: SEC TWP RGE

RECORDER LEG SW

2005 AADT 000891

PRINTER ID: TPRT003W

LOCATION 6101

NODE 8968

TOWNSHIP 22

STATION: COUNTY 07

BEGINNING TIME AND DATE	TIME 0800 AM	MONTH 06	DAY 13	YEAR 2005	DOW 2
ENDING TIME AND DATE	TIME 0100 PM	MONTH 06	DAY 15	YEAR 2005	DOW 4

[illegible]

PF7 BKWD

PF8 FWD

PF9 SELECT DIFFERENT CONTROLS

PF15 MAIN MENU

PF21 SCREEN PRINT

CLEAR EXIT

PORTABLE RECORDER TRAFFIC COUNT

CURRENT DATE 08-13-2010

STATION NUMBER: COUNTY 07 BLACK HAWK
TWP 22 CITY: WATERLOO
NODE 8969
N LOC 8101

LOCATION: FLAMMING RD & FRONTAGE RD

LEGAL DESC: SEC TWP RGE

RECORDER LEG NW

2005 AADT 005257

PRINTER ID: TPRT003W

LOCATION 8101

NODE 8969

TOWNSHIP 22

STATION: COUNTY 07

DOW 2
DOW 4YEAR 2005
YEAR 2005DAY 18
DAY 20MONTH 07
MONTH 07PM
PMTIME 0200
TIME 1200DATE
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HCM Signalized Intersection Capacity Analysis

3: Flammang Dr & San Marnan Dr

2009 PM Existing Conditions

1/26/2011

















												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (vph)	51	141	15	287	132	115	87	403	204	178	271	36
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	5.5	5.5		5.5	5.5	5.5	5.0	6.0	5.5	5.0	6.0	6.0
Lane Util. Factor	1.00	0.95		0.97	1.00	1.00	1.00	0.95	1.00	0.97	0.95	1.00
Frt	1.00	0.99		1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85
Flt Protected	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (prot)	1770	3487		3433	1863	1583	1770	3539	1583	3433	3539	1583
Flt Permitted	0.95	1.00		0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00
Satd. Flow (perm)	1770	3487		3433	1863	1583	1770	3539	1583	3433	3539	1583
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor (vph)	126%	126%	126%	126%	126%	126%	126%	126%	126%	126%	126%	126%
Adj. Flow (vph)	70	193	21	393	181	158	119	552	279	244	371	49
RTOR Reduction (vph)	0	9	0	0	0	130	0	0	52	0	0	0
Lane Group Flow (vph)	70	205	0	393	181	28	119	552	227	244	371	49
Turn Type	Split			Split		Perm	Prot		pm+ov	Prot		Prot
Protected Phases	4	4		8	8		5	2	8	1	6	6
Permitted Phases						8			2			
Actuated Green, G (s)	9.8	9.8		16.1	16.1	16.1	10.4	31.2	47.3	10.9	31.7	31.7
Effective Green, g (s)	9.8	9.8		16.1	16.1	16.1	10.4	31.2	47.3	10.9	31.7	31.7
Actuated g/C Ratio	0.11	0.11		0.18	0.18	0.18	0.12	0.35	0.53	0.12	0.35	0.35
Clearance Time (s)	5.5	5.5		5.5	5.5	5.5	5.0	6.0	5.5	5.0	6.0	6.0
Vehicle Extension (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Lane Grp Cap (vph)	193	380		614	333	283	205	1227	832	416	1247	558
v/s Ratio Prot	0.04	c0.06		c0.11	0.10		0.07	c0.16	0.05	c0.07	0.10	0.03
v/s Ratio Perm						0.02			0.09			
v/c Ratio	0.36	0.54		0.64	0.54	0.10	0.58	0.45	0.27	0.59	0.30	0.09
Uniform Delay, d1	37.2	38.0		34.3	33.6	30.9	37.7	22.8	11.8	37.4	21.1	19.5
Progression Factor	1.00	1.00		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Incremental Delay, d2	1.2	1.5		2.3	1.8	0.2	4.1	1.2	0.2	2.1	0.6	0.3
Delay (s)	38.4	39.4		36.5	35.4	31.0	41.9	24.0	12.0	39.5	21.7	19.8
Level of Service	D	D		D	D	C	D	C	B	D	C	B
Approach Delay (s)		39.2			35.1			22.7			28.1	
Approach LOS		D			D			C			C	
Intersection Summary												
HCM Average Control Delay			29.3			HCM Level of Service				C		
HCM Volume to Capacity ratio			0.53									
Actuated Cycle Length (s)			90.0			Sum of lost time (s)			22.0			
Intersection Capacity Utilization			55.8%			ICU Level of Service			B			
Analysis Period (min)			15									
c Critical Lane Group												

HCM Unsignalized Intersection Capacity Analysis

10: Flammang Dr & N Front Rd

2009 PM Existing Conditions

1/26/2011

												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (veh/h)	75	113	10	23	139	93	10	10	19	75	10	75
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	103	155	14	32	190	127	14	14	26	103	14	103
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage (veh)												
Upstream signal (ft)					120							
pX, platoon unblocked	0.91						0.91	0.91		0.91	0.91	0.91
vC, conflicting volume	318			168			794	748	58	607	691	254
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	205			168			726	676	58	521	613	135
tC, single (s)	4.1			4.1			7.5	6.5	6.9	7.5	6.5	6.9
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	92			98			94	96	97	70	96	87
cM capacity (veh/h)	1245			1407			222	306	995	347	332	812
Direction, Lane #	SE 1	SE 2	SE 3	NW 1	NE 1	SW 1						
Volume Total	141	77	52	349	53	219						
Volume Left	103	0	0	32	14	103						
Volume Right	0	0	14	127	26	103						
cSH	1245	1700	1700	1407	403	472						
Volume to Capacity	0.08	0.05	0.03	0.02	0.13	0.46						
Queue Length 95th (ft)	7	0	0	2	11	60						
Control Delay (s)	6.1	0.0	0.0	0.9	15.3	19.1						
Lane LOS	A			A	C	C						
Approach Delay (s)	3.2			0.9	15.3	19.1						
Approach LOS					C	C						
Intersection Summary												
Average Delay			6.9									
Intersection Capacity Utilization			51.6%		ICU Level of Service				A			
Analysis Period (min)			15									

Summary of All Intervals

Run Number	1	2	3	4	5	Avg
Start Time	3:57	3:57	3:57	3:57	3:57	3:57
End Time	4:15	4:15	4:15	4:15	4:15	4:15
Total Time (min)	18	18	18	18	18	18
Time Recorded (min)	15	15	15	15	15	15
# of Intervals	2	2	2	2	2	2
# of Recorded Intvls	1	1	1	1	1	1
Vehs Entered	700	692	658	641	632	662
Vehs Exited	688	674	662	650	621	658
Starting Vehs	36	40	48	47	40	43
Ending Vehs	48	58	44	38	51	46
Denied Entry Before	1	2	3	1	0	0
Denied Entry After	3	2	4	0	3	2
Travel Distance (mi)	129	125	120	117	116	121
Travel Time (hr)	11.8	10.8	10.5	11.2	9.4	10.8
Total Delay (hr)	6.9	6.1	6.0	6.8	5.0	6.1
Total Stops	572	492	500	477	474	503
Fuel Used (gal)	7.5	6.9	6.8	6.8	6.3	6.9

Interval #0 Information Seeding

Start Time	3:57
End Time	4:00
Total Time (min)	3
Volumes adjusted by Growth Factors.	
No data recorded this interval.	

Interval #1 Information Recording

Start Time	4:00
End Time	4:15
Total Time (min)	15
Volumes adjusted by Growth Factors.	

Run Number	1	2	3	4	5	Avg
Vehs Entered	700	692	658	641	632	662
Vehs Exited	688	674	662	650	621	658
Starting Vehs	36	40	48	47	40	43
Ending Vehs	48	58	44	38	51	46
Denied Entry Before	1	2	3	1	0	0
Denied Entry After	3	2	4	0	3	2
Travel Distance (mi)	129	125	120	117	116	121
Travel Time (hr)	11.8	10.8	10.5	11.2	9.4	10.8
Total Delay (hr)	6.9	6.1	6.0	6.8	5.0	6.1
Total Stops	572	492	500	477	474	503
Fuel Used (gal)	7.5	6.9	6.8	6.8	6.3	6.9

3: Flammang Dr & San Marnan Dr Performance by movement

Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Delay / Veh (s)	40.7	36.5	15.6	28.7	31.6	5.1	51.9	24.5	11.0	45.4	21.2	23.8
Vehicles Entered	16	43	5	82	42	38	28	132	54	55	84	13
Vehicles Exited	16	42	5	81	41	39	29	135	55	56	82	12
Hourly Exit Rate	64	168	20	324	164	156	116	540	220	224	328	48
Input Volume	64	178	19	362	166	145	110	508	257	224	341	45
% of Volume	100	94	105	90	99	108	105	106	86	100	96	107
Denied Entry Before	0	0	0	0	0	0	0	0	0	0	0	0
Denied Entry After	0	0	0	0	0	0	0	0	0	0	0	0

3: Flammang Dr & San Marnan Dr Performance by movement

Movement	All
Delay / Veh (s)	27.0
Vehicles Entered	592
Vehicles Exited	593
Hourly Exit Rate	2372
Input Volume	2419
% of Volume	98
Denied Entry Before	0
Denied Entry After	0

8: Flammang Dr & S Front Rd Performance by movement

Movement	SET	SER	NWT	NER	All
Delay / Veh (s)	0.8	0.7	1.6	3.8	1.3
Vehicles Entered	136	16	162	9	323
Vehicles Exited	136	16	162	9	323
Hourly Exit Rate	544	64	648	36	1292
Input Volume	596	63	673	32	1364
% of Volume	91	102	96	112	95
Denied Entry Before	0	0	0	0	0
Denied Entry After	0	0	0	0	0

10: Flammang Dr & N Front Rd Performance by movement

Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Delay / Veh (s)	3.9	1.0	0.1	2.9	1.6	1.2	13.1	20.8	40.3	100.4	99.4	84.0
Vehicles Entered	22	36	3	7	46	30	4	4	5	26	3	22
Vehicles Exited	23	36	3	7	46	30	3	4	6	22	3	19
Hourly Exit Rate	92	144	12	28	184	120	12	16	24	88	12	76
Input Volume	95	142	13	29	176	117	13	13	24	95	13	95
% of Volume	97	101	92	97	105	103	92	123	100	93	92	80
Denied Entry Before	0	0	0	0	0	0	0	0	0	0	0	0
Denied Entry After	0	0	0	0	0	0	0	0	0	1	0	1

10: Flammang Dr & N Front Rd Performance by movement

Movement	All
Delay / Veh (s)	24.0
Vehicles Entered	208
Vehicles Exited	202
Hourly Exit Rate	808
Input Volume	825
% of Volume	98
Denied Entry Before	0
Denied Entry After	2

Total Network Performance

Delay / Veh (s)	33.6
Vehicles Entered	662
Vehicles Exited	658
Hourly Exit Rate	2632
Input Volume	7301
% of Volume	36
Denied Entry Before	0
Denied Entry After	2

Intersection: 3: Flammang Dr & San Marnan Dr

Movement	SE	SE	SE	NW	NW	NW	NW	NE	NE	NE	NE	SW
Directions Served	L	T	TR	L	L	T	R	L	T	T	R	L
Maximum Queue (ft)	60	67	85	96	98	96	71	141	170	186	82	94
Average Queue (ft)	40	38	61	69	84	76	41	78	113	129	46	55
95th Queue (ft)	66	68	96	105	106	118	71	139	170	189	86	98
Link Distance (ft)	26	26	26	33	33	33	33		544	544		
Upstream Blk Time (%)	56	59	63	31	52	40	9					
Queuing Penalty (veh)	49	51	55	53	87	68	16					
Storage Bay Dist (ft)								200			300	255
Storage Blk Time (%)								1	0			
Queuing Penalty (veh)								2	0			

Intersection: 3: Flammang Dr & San Marnan Dr

Movement	SW	SW	SW	SW
Directions Served	L	T	T	R
Maximum Queue (ft)	122	92	111	52
Average Queue (ft)	80	55	73	16
95th Queue (ft)	131	104	116	46
Link Distance (ft)		531	531	
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)	255			255
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 8: Flammang Dr & S Front Rd

Movement	SE	NW	NW	NW	NE
Directions Served	TR	T	T	T	R
Maximum Queue (ft)	20	22	39	82	48
Average Queue (ft)	4	4	11	22	23
95th Queue (ft)	23	21	38	80	51
Link Distance (ft)	33	223	223	223	200
Upstream Blk Time (%)	0				
Queuing Penalty (veh)	0				
Storage Bay Dist (ft)					
Storage Blk Time (%)					
Queuing Penalty (veh)					

Intersection: 10: Flammang Dr & N Front Rd

Movement	SE	SE	SE	NW	NE	SW
Directions Served	LT	T	TR	LTR	LTR	LTR
Maximum Queue (ft)	48	7	6	67	60	201
Average Queue (ft)	23	1	1	13	36	144
95th Queue (ft)	55	10	9	56	69	234
Link Distance (ft)	320	320	320	26	206	179
Upstream Blk Time (%)				1		30
Queuing Penalty (veh)				3		0
Storage Bay Dist (ft)						
Storage Blk Time (%)						
Queuing Penalty (veh)						

Network Summary

Network wide Queuing Penalty: 384

SimTraffic Simulation Summary

Construct Median at North Frontage Road

1/26/2011

Summary of All Intervals

Run Number	1	2	3	4	5	Avg
Start Time	3:57	3:57	3:57	3:57	3:57	3:57
End Time	4:15	4:15	4:15	4:15	4:15	4:15
Total Time (min)	18	18	18	18	18	18
Time Recorded (min)	15	15	15	15	15	15
# of Intervals	2	2	2	2	2	2
# of Recorded Intvls	1	1	1	1	1	1
Vehs Entered	702	672	721	621	617	665
Vehs Exited	703	671	722	640	625	672
Starting Vehs	48	45	48	47	44	43
Ending Vehs	47	46	47	28	36	40
Denied Entry Before	1	2	1	3	1	2
Denied Entry After	1	1	1	0	1	1
Travel Distance (mi)	134	130	136	122	117	128
Travel Time (hr)	10.7	10.2	10.6	9.4	9.0	10.0
Total Delay (hr)	5.6	5.4	5.5	4.9	4.5	5.2
Total Stops	518	485	519	468	441	486
Fuel Used (gal)	7.3	7.0	7.4	6.5	6.2	6.9

Interval #0 Information Seeding

Start Time	3:57
End Time	4:00
Total Time (min)	3
Volumes adjusted by Growth Factors.	
No data recorded this interval.	

Interval #1 Information Recording

Start Time	4:00
End Time	4:15
Total Time (min)	15
Volumes adjusted by Growth Factors.	

Run Number	1	2	3	4	5	Avg
Vehs Entered	702	672	721	621	617	665
Vehs Exited	703	671	722	640	625	672
Starting Vehs	48	45	48	47	44	43
Ending Vehs	47	46	47	28	36	40
Denied Entry Before	1	2	1	3	1	2
Denied Entry After	1	1	1	0	1	1
Travel Distance (mi)	134	130	136	122	117	128
Travel Time (hr)	10.7	10.2	10.6	9.4	9.0	10.0
Total Delay (hr)	5.6	5.4	5.5	4.9	4.5	5.2
Total Stops	518	485	519	468	441	486
Fuel Used (gal)	7.3	7.0	7.4	6.5	6.2	6.9

3: Flammang Dr & San Marnan Dr Performance by movement

Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Delay / Veh (s)	33.1	35.3	19.0	30.5	30.5	5.1	46.6	23.9	12.0	43.8	21.6	25.6
Vehicles Entered	9	27	3	91	37	39	35	147	67	71	92	12
Vehicles Exited	9	27	3	92	38	39	35	153	68	70	92	12
Hourly Exit Rate	36	108	12	368	152	156	140	612	272	280	368	48
Input Volume	42	113	11	377	152	145	146	568	257	289	360	42
% of Volume	86	96	109	98	100	108	96	108	106	97	102	114
Denied Entry Before	0	0	0	0	0	0	0	1	1	0	0	0
Denied Entry After	0	0	0	0	0	0	0	0	1	0	0	0

3: Flammang Dr & San Marnan Dr Performance by movement

Movement	All
Delay / Veh (s)	26.5
Vehicles Entered	630
Vehicles Exited	638
Hourly Exit Rate	2552
Input Volume	2502
% of Volume	102
Denied Entry Before	2
Denied Entry After	1

8: Flammang Dr & S Front Rd Performance by movement

Movement	SET	SER	NWT	NER	All
Delay / Veh (s)	0.6	0.5	2.7	4.4	1.7
Vehicles Entered	147	18	167	7	339
Vehicles Exited	147	18	167	7	339
Hourly Exit Rate	588	72	668	28	1356
Input Volume	596	63	673	32	1364
% of Volume	99	114	99	88	99
Denied Entry Before	0	0	0	0	0
Denied Entry After	0	0	0	0	0

10: Flammang Dr & N Front Rd Performance by movement

Movement	SET	SER	NWT	NWR	NER	SWR	All
Delay / Veh (s)	0.9	2.1	1.6	1.0	29.9	4.1	2.7
Vehicles Entered	33	3	43	41	5	26	151
Vehicles Exited	33	3	44	41	5	26	152
Hourly Exit Rate	132	12	176	164	20	104	608
Input Volume	142	13	175	164	24	95	613
% of Volume	93	92	101	100	83	109	99
Denied Entry Before	0	0	0	0	0	0	0
Denied Entry After	0	0	0	0	0	0	0

Total Network Performance

Delay / Veh (s)	27.8
Vehicles Entered	665
Vehicles Exited	672
Hourly Exit Rate	2688
Input Volume	7120
% of Volume	38
Denied Entry Before	2
Denied Entry After	1

Queuing and Blocking Report
Construct Median at North Frontage Road

1/26/2011

Intersection: 3: Flammang Dr & San Marnan Dr

Movement	SE	SE	SE	NW	NW	NW	NW	NE	NE	NE	NE	SW
Directions Served	L	T	TR	L	L	T	R	L	T	T	R	L
Maximum Queue (ft)	71	46	99	99	104	94	72	151	163	174	105	123
Average Queue (ft)	29	22	58	78	91	73	39	91	114	132	63	77
95th Queue (ft)	67	52	104	116	113	109	76	152	169	181	110	135
Link Distance (ft)	26	26	26	33	33	33	33		544	544		
Upstream Blk Time (%)	28	21	54	36	51	37	9					
Queuing Penalty (veh)	15	12	30	61	86	62	15					
Storage Bay Dist (ft)								200			300	255
Storage Blk Time (%)									0			
Queuing Penalty (veh)									0			

Intersection: 3: Flammang Dr & San Marnan Dr

Movement	SW	SW	SW	SW
Directions Served	L	T	T	R
Maximum Queue (ft)	148	111	133	41
Average Queue (ft)	91	59	70	19
95th Queue (ft)	151	107	129	46
Link Distance (ft)		531	531	
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)	255			255
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 8: Flammang Dr & S Front Rd

Movement	SE	NW	NW	NW	NE
Directions Served	TR	T	T	T	R
Maximum Queue (ft)	12	75	74	54	47
Average Queue (ft)	2	20	34	15	24
95th Queue (ft)	14	74	89	64	51
Link Distance (ft)	33	223	223	223	200
Upstream Blk Time (%)	0				
Queuing Penalty (veh)	0				
Storage Bay Dist (ft)					
Storage Blk Time (%)					
Queuing Penalty (veh)					

Queuing and Blocking Report
Construct Median at North Frontage Road

1/26/2011

Intersection: 10: Flammang Dr & N Front Rd

Movement	SE	SE	NE	SW
Directions Served	T	TR	R	R
Maximum Queue (ft)	6	27	39	59
Average Queue (ft)	1	6	19	35
95th Queue (ft)	10	42	51	56
Link Distance (ft)	320	320	206	179
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Network Summary

Network wide Queuing Penalty: 281

SimTraffic Simulation Summary

Relocate North Frontage Road

1/26/2011

Summary of All Intervals

Run Number	1	2	3	4	5	Avg
Start Time	3:57	3:57	3:57	3:57	3:57	3:57
End Time	4:15	4:15	4:15	4:15	4:15	4:15
Total Time (min)	18	18	18	18	18	18
Time Recorded (min)	15	15	15	15	15	15
# of Intervals	2	2	2	2	2	2
# of Recorded Intvls	1	1	1	1	1	1
Vehs Entered	703	694	662	641	632	664
Vehs Exited	693	674	668	655	625	663
Starting Vehs	36	33	48	47	38	40
Ending Vehs	46	53	42	33	45	40
Denied Entry Before	1	2	3	1	0	0
Denied Entry After	0	0	0	0	3	0
Travel Distance (mi)	131	127	123	120	117	124
Travel Time (hr)	10.9	9.7	9.6	9.2	9.2	9.7
Total Delay (hr)	5.9	4.8	4.9	4.7	4.7	5.0
Total Stops	584	513	523	492	487	519
Fuel Used (gal)	7.4	6.7	6.6	6.4	6.3	6.7

Interval #0 Information Seeding

Start Time	3:57
End Time	4:00
Total Time (min)	3
Volumes adjusted by Growth Factors.	
No data recorded this interval.	

Interval #1 Information Recording

Start Time	4:00
End Time	4:15
Total Time (min)	15
Volumes adjusted by Growth Factors.	

Run Number	1	2	3	4	5	Avg
Vehs Entered	703	694	662	641	632	664
Vehs Exited	693	674	668	655	625	663
Starting Vehs	36	33	48	47	38	40
Ending Vehs	46	53	42	33	45	40
Denied Entry Before	1	2	3	1	0	0
Denied Entry After	0	0	0	0	3	0
Travel Distance (mi)	131	127	123	120	117	124
Travel Time (hr)	10.9	9.7	9.6	9.2	9.2	9.7
Total Delay (hr)	5.9	4.8	4.9	4.7	4.7	5.0
Total Stops	584	513	523	492	487	519
Fuel Used (gal)	7.4	6.7	6.6	6.4	6.3	6.7

3: Flammang Dr & San Marnan Dr Performance by approach

Approach	SE	NW	NE	SW	All
Delay / Veh (s)	36.0	23.8	24.6	29.4	26.8
Vehicles Entered	67	162	214	152	595
Vehicles Exited	66	161	218	151	596
Hourly Exit Rate	264	644	872	604	2384
Input Volume	261	673	875	610	2419
% of Volume	101	96	100	99	99
Denied Entry Before	0	0	0	0	0
Denied Entry After	0	0	0	0	0

8: Flammang Dr & S Front Rd Performance by approach

Approach	SE	NW	NE	All
Delay / Veh (s)	0.8	1.6	3.8	1.3
Vehicles Entered	154	162	9	325
Vehicles Exited	154	162	9	325
Hourly Exit Rate	616	648	36	1300
Input Volume	659	673	32	1364
% of Volume	93	96	112	95
Denied Entry Before	0	0	0	0
Denied Entry After	0	0	0	0

10: Flammang Dr & N Front Rd Performance by approach

Approach	SE	NW	NE	SW	All
Delay / Veh (s)	1.9	1.8	8.2	9.1	4.0
Vehicles Entered	61	83	13	53	210
Vehicles Exited	62	82	13	50	207
Hourly Exit Rate	248	328	52	200	828
Input Volume	250	322	50	203	825
% of Volume	99	102	104	99	100
Denied Entry Before	0	0	0	0	0
Denied Entry After	0	0	0	0	0

Total Network Performance

Delay / Veh (s)	27.1
Vehicles Entered	664
Vehicles Exited	663
Hourly Exit Rate	2652
Input Volume	7301
% of Volume	36
Denied Entry Before	0
Denied Entry After	0

Queuing and Blocking Report
Relocate North Frontage Road

1/26/2011

Intersection: 3: Flammang Dr & San Marnan Dr

Movement	SE	SE	SE	NW	NW	NW	NW	NE	NE	NE	NE	SW
Directions Served	L	T	TR	L	L	T	R	L	T	T	R	L
Maximum Queue (ft)	84	85	107	96	97	96	71	136	158	183	82	80
Average Queue (ft)	50	54	71	71	84	76	41	75	109	127	42	48
95th Queue (ft)	93	94	114	106	107	118	71	134	165	186	82	88
Link Distance (ft)	84	84	84	33	33	33	33		540	540		
Upstream Blk Time (%)	2	2	5	32	52	40	10					
Queuing Penalty (veh)	2	1	4	53	88	67	16					
Storage Bay Dist (ft)								200			300	255
Storage Blk Time (%)								1				
Queuing Penalty (veh)								2				

Intersection: 3: Flammang Dr & San Marnan Dr

Movement	SW	SW	SW	SW
Directions Served	L	T	T	R
Maximum Queue (ft)	118	80	107	46
Average Queue (ft)	78	49	69	14
95th Queue (ft)	128	93	114	41
Link Distance (ft)		531	531	
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)	255			255
Storage Blk Time (%)				
Queuing Penalty (veh)				

Intersection: 8: Flammang Dr & S Front Rd

Movement	SE	NW	NW	NW	NE
Directions Served	TR	T	T	T	R
Maximum Queue (ft)	20	26	43	78	48
Average Queue (ft)	4	4	12	21	23
95th Queue (ft)	20	26	42	78	51
Link Distance (ft)	33	223	223	223	200
Upstream Blk Time (%)	0				
Queuing Penalty (veh)	0				
Storage Bay Dist (ft)					
Storage Blk Time (%)					
Queuing Penalty (veh)					

Intersection: 10: Flammang Dr & N Front Rd

Movement	SE	SE	NW	NE	SW
Directions Served	LT	TR	LTR	LTR	LTR
Maximum Queue (ft)	52	4	43	48	105
Average Queue (ft)	25	1	10	27	55
95th Queue (ft)	56	7	47	56	93
Link Distance (ft)	320	320	84	207	176
Upstream Blk Time (%)			0		
Queuing Penalty (veh)			0		
Storage Bay Dist (ft)					
Storage Blk Time (%)					
Queuing Penalty (veh)					

Network Summary

Network wide Queuing Penalty: 233

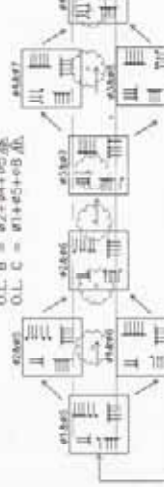
RIGHT OF WAY INTERVALS

PHASE	PHASE	PHASE	PHASE	PHASE	PHASE	PHASE	PHASE
1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88
89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104
105	106	107	108	109	110	111	112
113	114	115	116	117	118	119	120

1) THROUGHT BETWEEN PHASES SHALL INCLUDE APPROPRIATE YELLOW AND RED TIMES.
 2) CLEARANCE INTERVALS FOR PHASES 1 AND 5 TO BE YELLOW ARROW.
 3) THE FROM FLAMMANG DRIVE OPERATIONS SHALL RETURN TO PHASES 2 AND 5.
 4) ALL NEW TRAFFIC SIGNAL INDICATORS SHALL BE LED.

F&S EXISTING MAST ARM AND POLE
 F&S NEW 50' MAST ARM AND POLE
 REPLACE EXISTING SIGNAL EQUIPMENT
 F&S NEW 3-SECTION SIGNAL HEAD 11" FROM END
 RELOCATE EXISTING 3-SECTION SIGNAL HEAD 24' FROM END
 F&S NEW 3-SECTION SIGNAL HEAD 36" FROM END
 F&S NEW 3-SECTION SIGNAL HEAD 48" FROM END
 F&S 5' OF 2" RSC FROM BASE TO EXISTING
 2" RSC SEE NOTES FOR HOLE AND EXTEND
 10' OF 2" RSC TO EXISTING SAW CUT.
 45+00

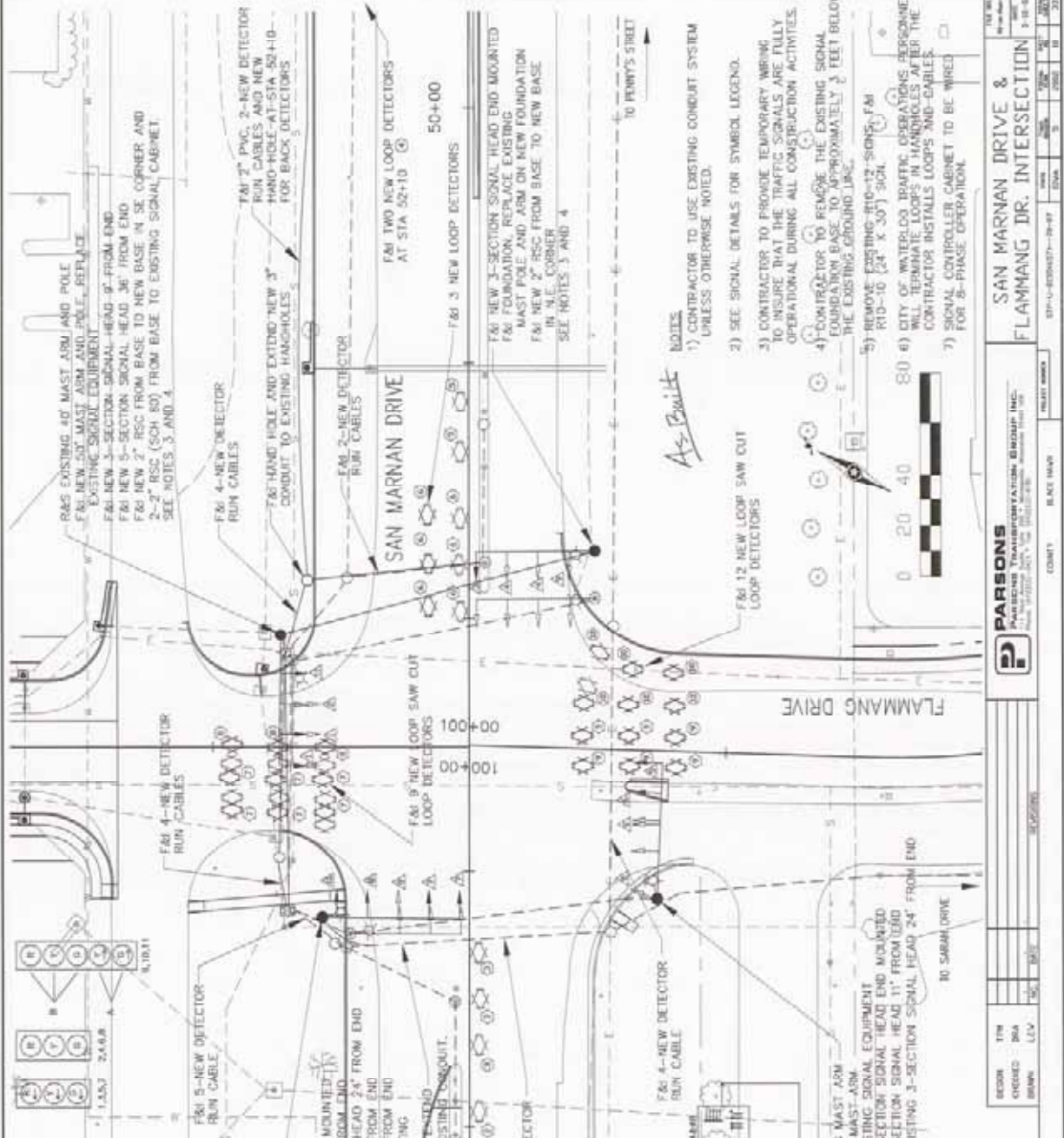
BACK DETECTORS
 F&S 1-NEW DETECTOR
 RUN CABLE TO
 BACK DETECTORS
 TO HAMMOND AVE
 O.L. A = 96+48+01.01
 O.L. B = 92+94+05.01
 O.L. C = 91+45+05.01



F&S EXISTING MAST ARM
 F&S NEW 50' MAST ARM
 REPLACE EXISTING SIGNAL EQUIPMENT
 F&S NEW 3-SECTION SIGNAL HEAD 11" FROM END
 F&S NEW 3-SECTION SIGNAL HEAD 24' FROM END
 RELOCATE EXISTING 3-SECTION SIGNAL HEAD 24' FROM END
 TO SAN MARN DRIVE

DETECTOR SUMMARY

LOOP NO.	NO. OF LOOPS	PHASE	DETECTOR	CHAMBER
1	1	A	1	1
2	1	B	1	1
3	1	C	1	1
4	1	D	1	1
5	1	E	1	1
6	1	F	1	1
7	1	G	1	1
8	1	H	1	1
9	1	I	1	1
10	1	J	1	1
11	1	K	1	1
12	1	L	1	1
13	1	M	1	1
14	1	N	1	1
15	1	O	1	1



NOTES

- 1) CONTRACTOR TO USE EXISTING CONDUIT SYSTEM UNLESS OTHERWISE NOTED.
- 2) SEE SIGNAL DETAILS FOR SYMBOL LEGEND.
- 3) CONTRACTOR TO PROVIDE TEMPORARY WIRING TO INSURE THAT THE TRAFFIC SIGNALS ARE FULLY OPERATIONAL DURING ALL CONSTRUCTION ACTIVITIES.
- 4) CONTRACTOR TO REMOVE THE EXISTING SIGNAL FOUNDATION BASE TO APPROXIMATELY 2 FEET BELOW THE EXISTING GROUND LINE.
- 5) REMOVE EXISTING R10-12 SIGNALS, F&S R10-10 (24" X 30") SIGNALS.
- 6) CITY OF WATERLOO TRAFFIC OPERATIONS PERSONNEL WILL TERMINATE LOOPS IN HANDHOLES AFTER THE CONTRACTOR INSTALLS LOOPS AND CABLES.
- 7) SIGNAL CONTROLLER CABINET TO BE WIRED FOR 8-PHASE OPERATION.

PARSONS
 PARSONS TRANSPORTATION GROUP, INC.
 1000 WEST 1ST ST. SUITE 200
 WATERLOO, ONT. N2L 2G6
 TEL: 519-885-1100
 FAX: 519-885-1101
 E-MAIL: info@parsons.com

SAN MARNAN DRIVE & FLAMMANG DR. INTERSECTION

STATION: 45+00 TO 50+00
 SHEET: 1 OF 1
 DATE: 1/26/05

Date 10/20/2010 Time 12:26:12

Date 10/20/2010 Time 12:26:12

SAN MARNAN DR. & FLAMMANG

AVE.
User

Phase	1	2	3	4	5	6	7	8
Minimum Green	6	12	0	8	6	12	0	8
Passage	1.5	1.0	0.0	1.5	1.5	1.0	0.0	1.5
Maximum 1	25	25	25	25	25	25	40	25
Maximum 2	25	50	25	40	25	50	35	25
Yellow Change	4.0	5.0	3.0	4.5	4.0	5.0	4.0	4.5
Red Clearance	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

[illegible]