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13th Ave. & 6th St. E. Intersection Analysis (West Fargo, ND)

Final Report

November 2004

Prepared for:
City of West Fargo, ND

Prepared by:
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BACKGROUND

The 13th Ave. corridor in West Fargo has experienced dramatic growth over the past several years. Most of the growth has occurred on the south side of 13th Ave. between 17th St. E. and Sheyenne St. The roadway is primarily classified as a minor arterial in West Fargo and a principal arterial in Fargo and serves many high-density dwelling units and commercial facilities.

Many dwelling units, including single family dwellings and apartment complexes continue to be constructed along the corridor and this growth trend is expected to continue. A direct result of increased development is increased traffic volumes, especially along arterials. Currently, traffic is uninterrupted along 13th Ave. between Sheyenne St. and 9th St. E., which is approximately one mile in length. Concerns have been raised about pedestrian safety due to the constant traffic flow along 13th Ave.

The study area spans 13th Ave. S. from Sheyenne St. to 9th St. E., however, the 6th St. E. intersection is the primary area of interest. Sixth St. E. is almost halfway between the Sheyenne St. and 9th St. E. and provides direct access from the south side of 13th Ave. to several facilities on the north side, such as a soccer complex and two elementary schools: Eastwood and Berger.

Traffic Control
Three intersections were analyzed along the study area, which include Sheyenne St., 6th St. E., and 9th St. E. (note Figure 1) . Sheyenne St. and 9th St. E. operate under actuated-uncoordinated signal control, while 6th St. E. operates under two-way stop control (TWSC).

Traffic Volumes
Traffic volumes along the 13th Ave. S. corridor increase from west to east (*1*). Based on traffic counts from the year 2000, the average daily traffic (ADT) on 13th Ave. S. ranges from 4,900 to 13,800 vehicles (Sheyenne St. to 9th St. E.). However, the traffic volumes between the two intersections range from 10,700 and 11,500. Although 13th Ave. is a truck route, the heavy vehicle percentages are low along the western part of the corridor (1 - 4% of the intersection traffic volume) since the area is primarily residential with some office and commercial facilities.

Roadway Geometry
13th Ave. consists of two through lanes for each direction and provides left-turn lane at intersecting side streets. A median separates the opposing traffic between the intersections of 6th St. E. to 9th St. E., while a two-way left turn lane (TWLTL) is used between 6th St. E. and Sheyenne St. The intersections of Sheyenne St. and 9th St. E. have left-turn lanes for every approach and right-turn lanes are common. However, 6th St. E. has one lane of travel for the north and south approaches.

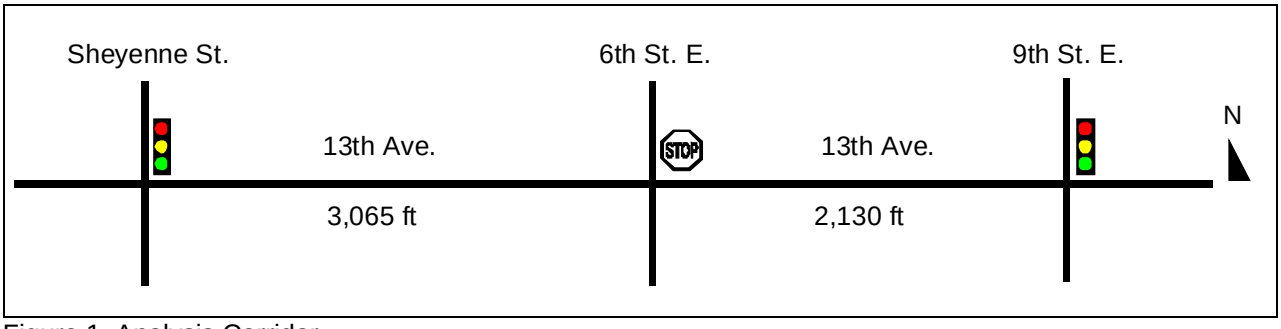


Figure 1. Analysis Corridor

OBJECTIVES

The Advanced Traffic Analysis Center (ATAC) was asked to evaluate the current traffic operations of the intersection of 13th Ave. and 6th St. E. and to determine the impacts that a signal installation would have on the intersection and 13th Ave. The City of West Fargo would like to install a traffic signal at 6th St. E.; however, they request assistance from ATAC in determining if the signal is justified.

The major tasks for this study were to perform a signal warrant analysis at 6th St. E. and a simulation analysis that evaluated different control strategies and traffic volumes along the analysis corridor. The traffic signal warrant analysis was based on a 12-hour count conducted on September 8, 2004. Several traffic simulation scenarios were compared for the AM and PM peak periods to determine the effects of incorporating a traffic signal at 6th St. E.

DATA COLLECTION

Several types of traffic data were collected to perform the signal warrant analysis and traffic simulation analysis. Geometric data and the existing signal timing plans were provided by the City of West Fargo. Traffic volume information was obtained by the City of West Fargo and the Fargo-Moorhead Council of Governments (F-M COG).

Geometric Data

Accurate data related to the roadway's geometry are necessary to portray a realistic view of the transportation network. Insufficient geometric data may cause erroneous output and recommendations. For example, inaccurate link lengths would cause incorrect offsets for the signal coordination. Information related to the road network was obtained from aerial photos and AutoCAD drawings.

Traffic Control Data

The existing signal timing plans were obtained to evaluate the corridor's current performance. Currently, the traffic signals at Sheyenne St. and 9th St. E. operate as actuated-uncoordinated. Actuated input values were used to more accurately simulate the signal controller operation. This data served as a baseline for comparing proposed timing strategies.

Traffic Volume Data

Peak-hour turning movement counts were performed at Sheyenne St. and 9th St. E. by the City of West Fargo and the Fargo-Moorhead Council of Governments (F-M COG). In Addition, F-M COG performed a 12-hour turning movement count at 6th St. E and included vehicles and pedestrians. All of the traffic data were gathered on September 8, 2004 and are illustrated in Appendix A.

TRAFFIC SIGNAL WARRANT ANALYSIS

A traffic signal warrant analysis was performed at the intersection of 13th Ave. and 6th St. E. The 2003 Manual on Uniform Traffic Control Devices (MUTCD) was used for the warrant analysis, which has the same signal warrant information as the 2000 MUTCD. The MUTCD currently has eight traffic signal warrants to evaluate an intersection; however, six of the warrants were analyzed for this study and include the following (*2*):

- Warrant 1, Eight-Hour Vehicular Volume
- Warrant 2, Four-Hour Vehicular Volume
- Warrant 3, Peak Hour
- Warrant 4, Pedestrian Volume
- Warrant 5, School Crossing
- Warrant 6, Coordinated Signal System

The remaining two warrants were not evaluated since they were either not applicable or the required data was not available. Appendix B illustrates the results of the 6 warrants analyzed, while the next section discusses warrants 4, 5 and 6, which had the highest potential for being met.

Warrant 4, Pedestrian Volume

The pedestrian volume warrant takes into account the number of pedestrians crossing the roadway as well as the number of gaps (time needed for pedestrians to cross the street). The gap time is calculated based on road width, pedestrian walking speed, and reaction time. In terms of adequate gap time, at least 60 gaps/hour are required. With the two travel lanes in each direction along with a left-turn lane, pedestrians must travel across five lanes having a distance of approximately 70 ft. Using the 70 ft road width, a walking speed of 3.5 fps, and a 3.0 second reaction time, the gap time for this study was 23 seconds. Due to the steady traffic flow along 13th Ave. and lack of platoons from neighboring intersections, very few allowable gaps were observed during the peak periods. The AM, mid-day, and PM peaks provided six, five, and four gaps, respectively.

The second criterion for Warrant 4 is pedestrian volume. Pedestrian volumes crossing 13th Ave. were fairly low. The highest hour for pedestrian activity (3:00 - 4:00 PM) had 10 pedestrians crossing 13th Ave. To satisfy the signal warrant, 100 ped/hour must cross the major street for any 4 hours or experience 190 ped/hr for any one hour. Therefore, Warrant 4 is not met due to the low pedestrian volume even though the gap criterion was met.

Warrant 5, School Crossing

The school crossing warrant requires a minimum of 20 students crossing the major street per hour and as many gaps as minutes when children are using the crossing. Six students were observed crossing 13th Ave. during the AM peak (7:00 - 8:00 AM). Therefore, the warrant is not satisfied based on student activity. It should be noted that only 2 gaps were observed during the same hour (7:00 - 8:00 AM),

Warrant 6, Coordinated Signal System

The coordinated signal system warrant is satisfied on a two-way street when the adjacent signals do not provide effective platooning and the proposed signal will benefit the adjacent signals by providing progressive operations. As previously mentioned, 6th St. E. is almost at the halfway point of the mile section between Sheyenne St. and 9th Ave. E. The platoons of vehicles were already showing signs of dispersion as they reached 6th St. E. Therefore, the platoons are severely dispersed as they reach the adjacent signal. The current platoon dispersion and other side-street traffic entering 13th Ave. creates minimal gaps at 6th St. E. In fact, the average gap time for crossing 13th Ave. during the AM, mid-day, and PM peak periods was 4-5, 4-5, and 2-3 seconds, respectively (the gap study program creates bins for storing information, e.g., a 4.5 sec gap is stored in 4-5 sec bin) . A signal at 6th St. E. would provide better platoons to 9th St. E. and Sheyenne St. when combined to form a coordinated system. Based on this benefit, Warrant 6 is satisfied for 13th Ave. and 6th St. E.

Satisfying one traffic signal warrant doesn't necessarily mean that a signal should be installed at the intersection. However, access management and safety play a role in an agency's decision to implement a traffic signal. In terms of access management, many agencies recommend spacing traffic signals every ½ mile along arterials so a traffic signal at 6th St. E. is appropriate in terms of location. In addition, the traffic signal would provide pedestrians, especially school children, with a safe location to cross 13th Ave.

TRAFFIC SIMULATION

Traffic simulation models allow practitioners to evaluate different scenarios prior to field implementation. This study used the CORSIM simulation model, a microscopic stochastic simulation model, which was developed for the Federal Highway Administration (*3*). CORSIM provides numerical and visual output to assess the operational conditions of a transportation network, such as queue lengths and delay time.

Several simulation scenarios were compared for the AM and PM peak periods to determine the effects of incorporating a traffic signal at 6th St. E. Since the south side of 13th Ave. continues to be developed, a sensitivity analysis with potential traffic volumes was performed using the existing and future traffic control. Existing traffic control represents the two traffic signals at Sheyenne St. and 9th St. E. and a two-way stop sign control at 6th St. E. For the future control, a signal was added at 6th St. E. and the 3 intersections operated under coordinated operations. Both the AM and PM scenarios used a 90-second cycle length with differing splits and offsets. The scenarios analyzed are summarized as follows:

- Traffic Volume - Existing conditions; 25%, 50%, 75%, and 100% growth for the NB approach of 6th St. E.

- Traffic Control - Existing conditions (actuated-uncoordinated operations) and future conditions (signal at 6th St. E. and actuated-coordinated operations)

The input parameters for CORSIM included the intersection's geometry, turning movement counts, and traffic control. Each scenario was simulated 30 times to represent a normal distribution and had a one-hour duration. It also should be noted that the simulations were "seeded" with traffic for 5 minutes before accumulating the numerical output.

Simulation Output

The numerical output extracted from CORSIM pertained to delay time. Delay time was summarized for the critical approach of 6th St. E. (northbound), the east-west links of 13th Ave., and the overall network. Tables 1 and 2 illustrate the delay time and percent change for the various scenarios during the AM and PM peak periods. The delay time calculated by CORSIM includes the delay encountered at a signal or stop sign (control delay) as well as vehicle interaction or car following delay.

Table 1. Simulation delay time during the AM peak period.

AM Peak	Network Delay (vehicle-min)		13th Ave. Delay (vehicle-min)		6th St. E. NB Approach Delay (sec/vehicle)	
Traffic Growth	Existing	Future	Existing	Future	Existing	Future
0%	1374.6	1872.6	683.3	715.6	10.7	21.7
	36.2%		4.7%		103.6%	
25%	1414.9	1918.1	697.7	747.0	11.2	21.6
	35.6%		7.1%		92.5%	
50%	1457.1	1944.8	726.8	762.7	12.0	21.5
	33.5%		4.9%		79.5%	
75%	1487.8	2010.3	730.4	809.3	13.1	21.4
	35.1%		10.8%		63.5%	
100%	1557.3	2039.5	764.7	822.8	15.6	21.4
	31.0%		7.6%		37.6%	

Table 2. Simulation delay time during the PM peak period.

PM Peak	Network Delay (vehicle-min)		13th Ave. Delay (vehicle-min)		6th St. E. NB Approach Delay (sec/vehicle)	
Traffic Growth	Existing	Future	Existing	Future	Existing	Future
0%	2145.8	2527.2	1190.7	1178.1	12.3	27.1
	17.8%		-1.1%		120.9%	
25%	2157.7	2587.3	1202.2	1199.8	12.5	26.7
	19.9%		-0.2%		113.9%	
50%	2195.5	2622.9	1222.0	1238.5	13.2	24.4
	19.5%		1.4%		84.6%	
75%	2207.3	2654.8	1230.3	1263.4	13.0	22.5
	20.3%		2.7%		72.6%	
100%	2227.1	2679.1	1242.1	1287.5	13.5	22.8
	20.3%		3.7%		68.9%	

AM Peak Period

The implementation of a traffic signal at 6th St. E. created over two times the delay for the northbound approach. The existing conditions with TWSC creates an average delay time of 10.7 seconds per vehicle for all movements while the future condition with a signal creates average delay of 21.7 sec/veh. As traffic increases for 6th St. E., the negative delay impacts of the signal installation decrease. Although the delay time is higher for the signalized scenarios, the motorist's level of service (LOS) is similar. Level of service can be defined as a qualitative measure of operational performance, which may consist of travel time, freedom to maneuver, comfort, and convenience. Motorists can experience anxiety at a stop sign while turning onto or crossing the major street since they need to judge an acceptable gap. This phenomenon adversely affects LOS and is not a factor under signalized control.

Thirteenth Ave. was not significantly affected by implementing a traffic signal at 6th St. E. The additional signal created less than 4.7% more delay time with the existing traffic volume. The other traffic scenarios create delay time increases ranging from 4.9 - 10.8%. Although the additional signal would cause some traffic on 13th Ave. to stop at 6th St. E., the delay time increase for 13th Ave. is not substantial. This can be explained by the implementation of coordinated signal plans between the three signals rather than the current uncoordinated operation. In addition, the demand on 6th St. E. is not large enough to require a high amount of green time so most of the available green time is used by 13th Ave. traffic.

The total network delay ranged from 31.0 - 36.2% when comparing the two traffic control scenarios. The additional signal increases network delay; however, the process of coordinating the traffic signals also may increase network delay. Coordination provides progression on the major street which reduces delay for the major street. As a result, the minor-street approaches will experience higher delay since traffic has to wait longer to cross or access the major street.

PM Peak Period

Similar to the AM peak, the implementation of a traffic signal at 6th St. E. created over two times the delay for the northbound approach, which equates to about 15 sec/veh. As traffic growth increases for 6th St. E., the negative delay impacts of the signal installation decreases, creating about an additional 10 seconds of delay per vehicle.

The additional traffic signal and the coordinated operations of 13th Ave. caused minor delay time impacts. The current traffic levels and the 25% growth scenario actually reduced delay along 13th Ave. while the 50 - 100% growth scenarios experienced minor delay increases. These outcomes are a result of higher traffic volumes along 13th Ave. during the PM peak which receive the benefits of signal coordination.

The total network delay increase ranged from 17.8 - 20.3% when comparing the two traffic control scenarios. As previously discussed, this increase is due to adding a signal at 6th St. E. and providing coordinated operation to 13th Ave.

SUMMARY

This study evaluated the current traffic operations of the intersection of 13th Ave. and 6th St. E. Although the intersection does not have high side-street traffic volumes, the gaps for accessing 13th Ave. are minimal, especially for pedestrians. The results of the traffic signal warrant analysis determined that Warrant 6: Coordinated Signal System was satisfied. The signal would benefit the adjacent signals by providing progressive operations. In addition, the signal would provide a safe crossing for pedestrians that otherwise would not exist along the mile section between Sheyenne St. and 9th St. E.

The simulation analysis provided insight to the effects of adding the traffic signal under various traffic levels for 6th St. E. For the AM and PM peak periods, delay time for 6th St. E. increased under signal control; however, the increase was typically only 10 - 15 seconds per vehicle. Delay increases along 13th Ave. were minimal due to the improved traffic flow under coordinated signal operations.

Based on the signal warrant and traffic simulation analyses, a traffic signal installation at 6th St. E. is recommended. The increased delay for motorists at 6th St. E. would be offset by the benefits of increased pedestrian safety for those crossing 13th Ave., decreased driver anxiety when accessing 13th Ave., and coordinated signal operations along 13th Ave.

REFERENCES

1. Fargo-Moorhead Metropolitan Council of Governments, 2000 *Urban Area Traffic Count Map*, Fargo, ND.

2. Federal Highway Administration - U.S. Department of Transportation, *Manual on Uniform Traffic Control Devices*, 2003 Edition, Washington D.C., July 2004.

3. ITT Industries Inc., *Traffic Software Integrated System Version 5.1, Build 9: User's Guide*, Colorado Springs, CO, 1995-2003.

Appendix A: Traffic Data

13th Ave. & Sheyenne St.

		Southbound				Westbound				Northbound				Eastbound				Auto	Ped	Truck	Hourly	Hourly	Percent
		Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Total	Total	Total	Auto	Truck	Trucks
	7:00 - 7:15	8	41	1	0	18	7	9	0	14	46	15	0	3	25	17	0	204	0	7	1361	35	3%
	7:15 - 7:30	15	40	1	0	31	15	10	0	12	59	39	0	5	28	21	0	276	0	12	1641	33	2%
	7:30 - 7:45	20	53	1	0	37	25	12	0	20	71	35	0	5	66	34	0	379	0	6	1743	34	2%
AM	**7:45 - 8:00**	24	61	2	0	48	22	23	0	45	74	79	0	8	60	56	2	502	2	10	1636	41	3%
Peak	**8:00 - 8:15**	40	64	0	0	48	20	22	0	35	44	94	0	4	68	45	0	484	0	5	1424	43	3%
	8:15 - 8:30	18	78	6	0	18	24	12	0	16	58	49	0	14	58	27	0	378	0	13			
	8:30 - 8:45	17	44	2	0	42	17	10	0	27	32	28	0	10	20	23	0	272	0	13			
	8:45 - 9:00	20	47	0	0	43	20	18	0	23	34	31	0	12	24	18	1	290	1	12			
	Total	162	428	13	0	285	150	116	0	192	418	370	0	61	349	241	3						

		Southbound				Westbound				Northbound				Eastbound				Auto	Ped	Truck	Hourly	Hourly	Percent
		Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Total	Total	Total	Auto	Truck	Trucks
	11:00 - 11:15	14	26	10	0	20	34	20	0	8	28	20	0	4	28	8	0	220	0	8	1016	22	2%
	11:15 - 11:30	26	30	2	0	10	20	26	0	8	58	24	1	2	12	4	0	222	1	2	1080	16	1%
	11:30 - 11:45	41	34	14	0	10	22	24	0	12	39	29	0	4	27	8	0	264	0	8	1119	27	2%
MID	**11:45 - 12:00**	26	42	6	0	26	34	28	0	26	48	28	0	6	24	16	0	310	0	4	1072	23	2%
Peak	**12:00 - 12:15**	32	25	6	0	34	31	26	0	22	26	28	0	8	34	12	0	284	0	2	1050	27	3%
	12:15 - 12:30	13	39	2	0	30	30	34	0	14	26	20	0	2	37	14	0	261	0	13			
	12:30 - 12:45	23	15	2	0	35	20	23	0	7	44	13	0	5	22	8	0	217	0	4			
	12:45 - 1:00	12	20	4	0	46	49	34	0	10	48	22	0	2	23	18	0	288	0	8			
	Total	187	231	46	0	211	240	215	0	107	317	184	1	33	207	88	0						

		Southbound				Westbound				Northbound				Eastbound				Auto	Ped	Truck	Hourly	Hourly	Percent
		Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Total	Total	Total	Auto	Truck	Trucks
	4:00 - 4:15	20	74	4	0	50	54	30	0	30	60	30	0	4	40	22	0	418	0	10	1934	63	3%
	4:15 - 4:30	20	52	0	0	80	52	33	0	31	54	50	0	7	45	18	0	442	0	17	2139	69	3%
	4:30 - 4:45	42	63	0	0	75	54	20	0	34	63	50	0	2	50	45	0	498	0	26	2326	54	2%
PM	**4:45 - 5:00**	46	97	12	0	53	89	38	0	23	79	48	0	0	63	28	0	576	0	10	2425	30	1%
Peak	**5:00 - 5:15**	28	96	4	0	108	107	56	0	23	61	54	0	8	42	36	0	623	0	16	2311	26	1%
	5:15 - 5:30	26	119	6	0	77	101	39	0	58	88	54	0	4	38	19	0	629	0	2			
	5:30 - 5:45	44	103	12	0	74	52	44	0	43	93	44	0	4	57	27	0	597	0	2			
	5:45 - 6:00	28	75	6	0	92	50	24	0	18	37	35	0	6	64	27	0	462	0	6			
	Total	254	679	44	0	609	559	284	0	260	535	365	0	35	399	222	0						

13th Ave. & 6th St. E.

		Southbound				Westbound				Northbound				Eastbound				Auto	Ped	Truck	Hourly	Hourly	Percent
		Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Total	Total	Total	Auto	Truck	Trucks
AM Peak	**7:30 - 7:45**	10	7	4	0	4	69	8	0	15	10	32	0	9	142	5	0	315	0	7	1268	26	2%
	7:45 - 8:00	6	10	6	1	4	62	18	0	12	15	34	1	15	181	9	0	372	2	7			
	8:00 - 8:15	16	25	3	0	7	48	7	0	12	9	28	0	4	179	16	0	354	0	6			
	8:15 - 8:30	4	5	7	0	9	49	4	0	11	11	14	0	6	101	6	0	227	0	6			
	Total	36	47	20	1	24	228	37	0	50	45	108	1	34	603	36	0						

		Southbound				Westbound				Northbound				Eastbound				Auto	Ped	Truck	Hourly	Hourly	Percent
		Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Total	Total	Total	Auto	Truck	Trucks
MID Peak	**11:30 - 11:45**	5	4	1	0	13	111	4	0	4	3	8	0	3	93	5	0	254	0	4	976	20	2%
	11:45 - 12:00	2	1	5	0	14	114	3	0	6	2	9	0	4	96	6	0	262	0	5			
	12:00 - 12:15	3	0	3	0	13	103	2	0	2	0	6	0	4	83	1	0	220	0	10			
	12:15 - 12:30	4	1	3	0	10	93	6	0	3	2	6	1	1	110	1	0	240	1	1			
	Total	14	6	12	0	50	421	15	0	15	7	29	1	12	382	13	0						

		Southbound				Westbound				Northbound				Eastbound				Auto	Ped	Truck	Hourly	Hourly	Percent
		Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Total	Total	Total	Auto	Truck	Trucks
PM Peak	**4:45 - 5:00**	3	2	5	0	18	183	8	0	4	3	12	0	7	95	7	0	347	0	0	1585	10	1%
	5:00 - 5:15	1	10	3	0	30	227	13	0	3	4	18	0	8	90	9	0	416	0	3			
	5:15 - 5:30	5	7	5	0	27	174	15	0	7	3	15	0	7	133	9	0	407	0	4			
	5:30 - 5:45	9	4	7	0	27	170	10	0	2	4	20	0	5	143	14	0	415	0	3			
	Total	18	23	20	0	102	754	46	0	16	14	65	0	27	461	39	0						

Intersection: **13th Ave. & 6th St. E.**
Date: **September 8, 2004**

Direction (Steet)	Southbound (6th St.)				Westbound (13th Ave.)				Northbound (6th St.)				Eastbound (13th Ave.)			
Time Interval	Left	Thru	Right	Ped	Left	Thru	Right	Ped	Left	Thru	Right	Ped	Left	Thru	Right	Ped
7:00 - 7:15 am	1	0	4	0	3	31	1	0	7	3	8	0	2	47	2	0
7:15 - 7:30 am	1	2	8	0	3	38	3	0	9	5	18	0	6	95	3	0
7:30 - 7:45 am	10	7	4	0	5	70	10	0	15	10	32	2	9	143	7	2
7:45 - 8:00 am	6	10	7	3	4	63	18	0	13	15	35	1	15	181	11	3
Hour Total	**18**	**19**	**23**	**3**	**15**	**202**	**32**	**0**	**44**	**33**	**93**	**3**	**32**	**466**	**23**	**5**
8:00 - 8:15 am	16	25	3	3	9	49	7	0	12	9	28	1	4	182	16	0
8:15 - 8:30 am	4	5	7	1	9	58	4	0	11	11	14	0	6	101	6	1
8:30 - 8:45 am	3	0	2	0	5	68	3	0	4	1	15	0	2	71	3	0
8:45 - 9:00 am	2	0	2	0	7	48	3	0	1	1	9	0	1	77	3	1
9:00 - 9:15 am	1	3	2	0	3	34	0	0	0	3	6	0	3	65	1	0
Hour Total	**10**	**8**	**13**	**1**	**24**	**208**	**10**	**0**	**16**	**16**	**44**	**0**	**12**	**314**	**13**	**2**
9:15 - 9:30 am	1	0	1	0	7	60	3	0	2	1	5	0	0	81	2	0
9:30 - 9:45 am	2	2	2	0	4	55	3	0	2	2	7	0	3	82	3	0
9:45 - 10:00 am	4	3	0	0	9	52	2	0	1	2	9	0	1	69	3	0
Hour Total	**17**	**13**	**16**	**1**	**44**	**375**	**18**	**0**	**21**	**21**	**65**	**0**	**16**	**546**	**21**	**2**
10:00 - 10:15 am	2	1	2	0	17	70	2	0	4	1	7	0	3	85	4	0
10:15 - 10:30 am	5	3	1	0	5	49	1	0	4	2	9	0	0	63	2	0
10:30 - 10:45 am	2	0	1	0	10	69	4	0	2	2	11	0	6	82	0	0
10:45 - 11:00 am	3	2	2	0	7	74	4	0	4	1	10	0	0	77	2	0
Hour Total	**12**	**6**	**6**	**0**	**39**	**262**	**11**	**0**	**14**	**6**	**37**	**0**	**9**	**307**	**8**	**0**
11:00 - 11:15 am	0	3	1	2	5	74	0	0	3	3	6	0	1	83	4	0
11:15 - 11:30 am	4	2	1	0	15	82	4	1	4	5	11	0	1	71	3	0
11:30 - 11:45 am	3	5	1	0	6	73	6	0	8	7	14	0	0	99	3	0
11:45 - 12:00 pm	3	4	2	0	14	89	5	0	1	1	8	1	2	104	3	0
Hour Total	**10**	**14**	**5**	**2**	**40**	**318**	**15**	**1**	**16**	**16**	**39**	**1**	**4**	**357**	**13**	**0**
12:00 - 12:15 pm	2	2	4	0	14	90	5	0	4	2	14	0	5	88	4	0
12:15 - 12:30 pm	5	5	1	0	13	111	4	0	5	3	8	0	3	95	5	0
12:30 - 12:45 pm	2	1	5	0	14	115	3	1	7	2	9	0	4	99	6	0
12:45 - 1:00 pm	3	0	4	0	13	108	2	0	2	0	6	0	4	86	2	2
Hour Total	**12**	**8**	**14**	**0**	**54**	**424**	**14**	**1**	**18**	**7**	**37**	**0**	**16**	**368**	**17**	**2**
1:00 - 1:15 pm	4	1	3	0	10	94	6	0	3	2	6	1	1	110	1	0
1:15 - 1:30 pm	4	2	3	0	2	79	2	0	3	1	9	0	1	83	4	0
1:30 - 1:45 pm	0	0	1	0	5	95	2	0	6	1	5	0	0	76	2	0
1:45 - 2:00 pm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hour Total	**8**	**3**	**7**	**0**	**17**	**268**	**10**	**0**	**12**	**4**	**20**	**1**	**2**	**269**	**7**	**0**
2:00 - 2:15 pm	3	2	1	0	10	102	2	0	4	3	8	0	4	74	4	0
2:15 - 2:30 pm	2	1	1	0	11	78	7	0	2	6	8	0	3	74	4	0
2:30 - 2:45 pm	2	2	4	0	15	99	8	0	4	4	4	0	3	80	2	3
2:45 - 3:00 pm	9	10	10	0	10	95	7	0	4	3	9	0	4	94	10	0
Hour Total	**16**	**15**	**16**	**0**	**46**	**374**	**24**	**0**	**14**	**16**	**29**	**0**	**14**	**322**	**20**	**3**
3:00 - 3:15 pm	2	2	2	1	7	86	5	0	1	5	14	0	2	101	5	0
3:15 - 3:30 pm	4	8	1	0	18	105	9	0	2	1	14	0	1	90	9	0
3:30 - 3:45 pm	4	11	4	0	20	147	6	0	9	9	15	0	4	89	3	1
3:45 - 4:00 pm	7	4	3	0	15	129	13	3	16	12	13	9	1	100	9	0
Hour Total	**17**	**25**	**10**	**1**	**60**	**467**	**33**	**3**	**28**	**27**	**56**	**9**	**8**	**380**	**26**	**1**
4:00 - 4:15 pm	4	2	5	0	13	145	6	2	0	3	8	0	3	102	4	1
4:15 - 4:30 pm	4	5	6	0	19	128	3	0	4	3	7	0	5	104	8	0
4:30 - 4:45 pm	6	5	3	0	15	156	8	0	4	5	14	0	4	135	6	0
4:45 - 5:00 pm	3	2	5	0	18	185	8	0	4	3	12	0	7	95	8	1
Hour Total	**17**	**14**	**19**	**0**	**65**	**614**	**25**	**2**	**12**	**14**	**41**	**0**	**19**	**436**	**26**	**2**
5:00 - 5:15 pm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5:15 - 5:30 pm	1	10	3	0	30	228	13	0	3	4	20	0	8	91	9	0
5:30 - 5:45 pm	5	7	5	0	27	174	15	1	7	3	15	0	7	136	9	0
5:45 - 6:00 pm	9	4	7	0	28	173	10	3	2	4	20	1	5	145	14	0
Hour Total	**15**	**21**	**15**	**0**	**85**	**575**	**38**	**4**	**12**	**11**	**55**	**1**	**20**	**372**	**32**	**0**
6:00 - 6:15 pm	11	6	2	0	21	142	3	0	3	3	12	2	5	123	5	0
6:15 - 6:30 pm	3	5	2	0	13	131	5	0	5	5	16	0	3	122	11	0
6:30 - 6:45 pm	4	3	0	0	18	141	3	0	7	1	11	1	2	102	6	1
6:45 - 7:00 pm	6	1	2	0	11	130	7	0	5	3	11	0	1	96	5	0
Hour Total	**24**	**15**	**6**	**0**	**63**	**544**	**18**	**0**	**20**	**12**	**50**	**3**	**11**	**443**	**27**	**1**

13th Ave. & 9th St. E.

		Southbound				Westbound				Northbound				Eastbound				Auto	Ped	Truck	Hourly	Hourly	Percent
		Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Total	Total	Total	Auto	Truck	Trucks
	7:00 - 7:15	9	30	9	0	5	23	10	0	12	45	14	0	16	47	9	0	229	0	7	1772	35	2%
	7:15 - 7:30	37	45	10	0	5	37	27	0	26	73	14	0	43	80	15	0	412	0	12	1958	33	2%
	7:30 - 7:45	38	71	10	0	11	42	34	0	41	97	14	0	78	112	30	0	578	0	6	1792	34	2%
AM	**7:45 - 8:00**	43	94	14	0	13	29	14	0	22	103	16	0	92	84	29	0	553	0	10	1445	41	3%
Peak	**8:00 - 8:15**	32	54	12	0	10	37	19	0	6	84	14	0	61	66	20	0	415	0	5	1108	43	4%
	8:15 - 8:30	14	32	7	0	4	35	9	0	11	49	13	0	14	44	14	0	246	0	13			
	8:30 - 8:45	21	26	6	0	13	34	8	0	12	17	10	0	15	57	12	0	231	0	13			
	8:45 - 9:00	8	26	7	0	12	32	9	0	6	27	11	0	13	50	15	0	216	0	12			
	Total	202	378	75	0	73	269	130	0	136	495	106	0	332	540	144	0						

		Southbound				Westbound				Northbound				Eastbound				Auto	Ped	Truck	Hourly	Hourly	Percent
		Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Total	Total	Total	Auto	Truck	Trucks
	11:00 - 11:15	23	32	14	0	12	57	30	0	6	29	22	0	6	60	8	0	299	0	2	1483	16	1%
	11:15 - 11:30	20	47	23	0	18	55	22	0	11	48	13	0	12	64	17	0	350	0	8	1604	27	2%
	11:30 - 11:45	55	53	13	0	16	69	31	0	11	50	10	0	14	87	19	0	428	0	4	1664	23	1%
MID	**11:45 - 12:00**	27	53	11	0	23	70	19	0	21	55	28	0	15	71	13	0	406	0	2	1624	27	2%
Peak	**12:00 - 12:15**	30	46	20	1	23	88	33	0	13	45	27	0	18	64	13	0	420	1	13	1618	25	2%
	12:15 - 12:30	35	49	14	0	25	73	27	0	17	33	30	0	25	64	18	0	410	0	4			
	12:30 - 12:45	20	33	13	0	25	102	20	0	6	42	22	0	16	76	13	0	388	0	8			
	12:45 - 1:00	33	48	14	0	19	80	21	0	14	46	28	0	11	69	17	0	400	0	0			
	Total	243	361	122	1	161	594	203	0	99	348	180	0	117	555	118	0						

		Southbound				Westbound				Northbound				Eastbound				Auto	Ped	Truck	Hourly	Hourly	Percent
		Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Left	Thru	Right	Peds	Total	Total	Total	Auto	Truck	Trucks
	4:00 - 4:15	32	83	26	0	24	114	29	0	25	51	18	0	22	64	22	0	510	0	10	2170	63	3%
	4:15 - 4:30	33	58	23	0	14	96	41	0	14	67	15	0	23	73	10	1	467	1	17	2320	69	3%
	4:30 - 4:45	38	72	27	0	21	133	32	0	22	73	12	0	23	96	32	0	581	0	26	2483	54	2%
	4:45 - 5:00	46	71	23	0	27	152	42	0	40	84	20	0	18	72	17	0	612	0	10	2549	30	1%
PM	**5:00 - 5:15**	39	84	32	0	40	171	52	0	37	83	13	0	23	64	22	0	660	0	16	2511	26	1%
Peak	**5:15 - 5:30**	48	70	31	0	27	135	44	1	46	71	13	0	23	98	24	0	630	1	2			
	5:30 - 5:45	58	72	32	0	27	125	26	0	29	74	27	0	28	111	38	0	647	0	2			
	5:45 - 6:00	43	80	41	0	37	94	29	0	16	70	24	0	37	83	20	0	574	0	6			
	Total	337	590	235	0	217	1020	295	1	229	573	142	0	197	661	185	1						

Appendix B: Traffic Signal Warrant Analysis

TRAFFIC SIGNAL WARRANT SUMMARY

City: **West Fargo, ND** Organization: **Advanced Traffic Analysis Center**
County: **Cass** Date: **September 8, 2004**

Major Street: **13th Ave.** Lanes: **2** Critical Approach Speed: **35**
Minor Street: **6th St. E.** Lanes: **1**

Volume Level Criteria

1. Is the critical speed of major street traffic > 70 km/h (40 mph)? ☐ Yes ☑ No
2. Is the intersection in a built-up area of isolated community of <10,000 population? ☐ Yes ☑ No

If Question 1 or 2 above is answered "Yes", then use "70%" volume level ☐ 70% ☑ 100%

WARRANT 1 - EIGHT-HOUR VEHICULAR VOLUME

Applicable: ☑ Yes ☐ No
Satisfied: ☐ Yes ☑ No

Warrant 1 is satisfied if Condition A or Condition B is "100%" satisfied.
Warrant is also satisfied if both Condition A and Condition B are "80%" satisfied.

Condition A - Minimum Vehicular Volume

100% Satisfied: ☐ Yes ☑ No
80% Satisfied: ☐ Yes ☑ No

(volumes in veh/hr)	Minimum Requirements (80% Shown in Brackets)				Eight Highest Hours							
Approach Lanes	1		2 or more		16:00 - 17:00	17:00 - 18:00	18:00 - 19:00	15:00 - 16:00	12:00 - 13:00	7:00 - 8:00	14:00 - 15:00	8:00 - 9:00
Volume Level	100%	70%	100%	70%								
Both Approaches on Major Street	500 (400)	350	600 (480)	420	1,185	1,122	1,106	974	893	770	800	742
Highest Approach on Minor Street	150 (120)	105	200 (160)	140	67	78	82	111	62	170	59	116

Record 8 highest hours and the corresponding volumes in boxes provided. Condition is 100% satisfied if the minimum volumes are met for eight hours. Condition is 80% satisfied if parenthetical volumes are met for eight hours.

Condition B - Interruption of Continuous Traffic

Condition B is intended for application where the traffic volume is so heavy that traffic on the minor street suffers excessive delay.

Applicable: ☑ Yes ☐ No
Excessive Delay: ☐ Yes ☑ No
100% Satisfied: ☐ Yes ☑ No
80% Satisfied: ☐ Yes ☑ No

(volumes in veh/hr)	Minimum Requirements (80% Shown in Brackets)				Eight Highest Hours							
Approach Lanes	1		2 or more		16:00 - 17:00	17:00 - 18:00	18:00 - 19:00	15:00 - 16:00	12:00 - 13:00	7:00 - 8:00	14:00 - 15:00	8:00 - 9:00
Volume Level	100%	70%	100%	70%								
Both Approaches on Major Street	750 (600)	525	900 (720)	630	1,185	1,122	1,106	974	893	770	800	742
Highest Approach on Minor Street	75 (60)	53	100 (80)	70	67	78	82	111	62	170	59	116

Record 8 highest hours and the corresponding volumes in boxes provided. Condition is 100% satisfied if the minimum volumes are met for eight hours. Condition is 80% satisfied if parenthetical volumes are met for eight hours.

Sources: Revised from Florida DOT's Traffic Signal Warrant Summary (Form 750-020-01)
NCHRP Report 457, 2001
Manual on Uniform Traffic Control Devices 2003 (July 21, 2004)

TRAFFIC SIGNAL WARRANT SUMMARY

City: **West Fargo, ND** Organization: **Advanced Traffic Analysis Center**
County: **Cass** Date: **September 8, 2004**

Major Street: **13th Ave.** Lanes: **2** Critical Approach Speed: **35**
Minor Street: **6th St. E.** Lanes: **1**

Volume Level Criteria

1. Is the critical speed of major street traffic > 70 km/h (40 mph) ? ☐ Yes ☑ No
2. Is the intersection in a built-up area of isolated community of <10,000 population? ☐ Yes ☑ No

If Question 1 or 2 above is answered "Yes", then use "70%" volume level ☐ 70% ☑ 100%

WARRANT 2 - FOUR-HOUR VEHICULAR VOLUME

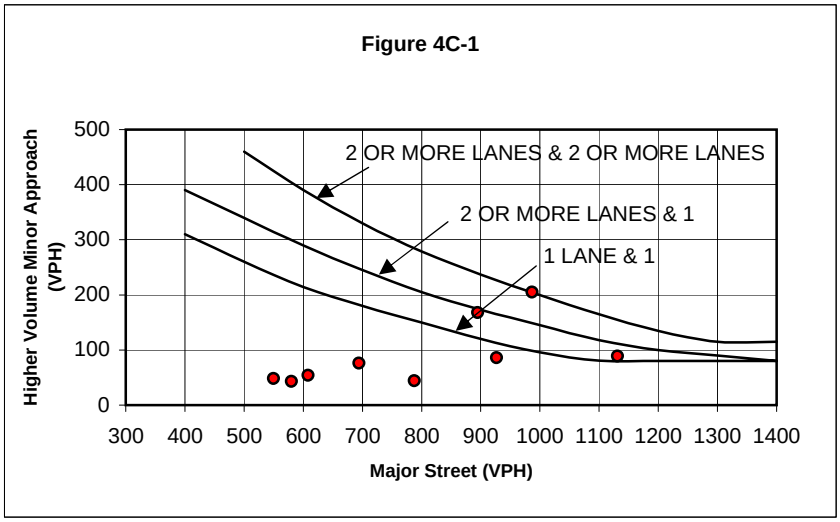
If four or more points lie above the appropriate line, then the warrant is satisfied.

Applicable: ☑ Yes ☐ No
Satisfied: ☐ Yes ☑ No

Four Highest Hours	Volumes	
	Major Street	Minor Street
5:15 PM - 6:15 PM	1,421	96
7:30 AM - 8:30 AM	987	205
3:45 PM - 4:45 PM	1,131	89
2:45 PM - 3:45 PM	927	86

Use the middle curve of Figure 4C-1

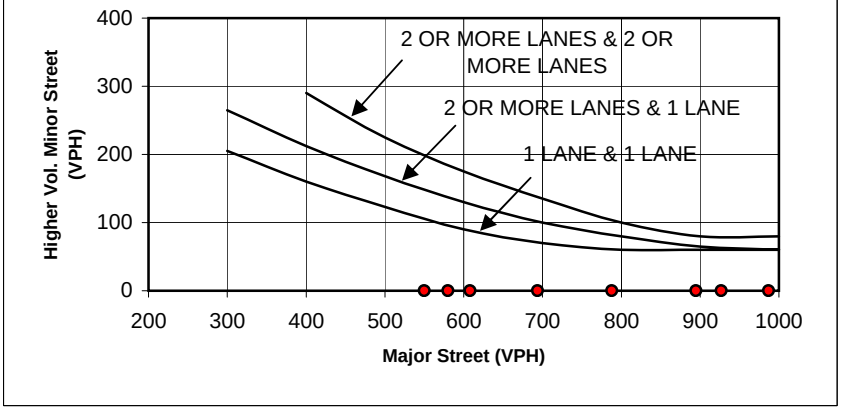
Figure 4C-1



** Note: 115 vph applies as the lower threshold volume for a minor street approach with two or more lanes and 80 vph applies as the lower threshold volume threshold for a minor street approach with one lane.*

Use the middle curve of Figure 4C-1

Figure 4C-2 (70% Factor)



** Note: 80 vph applies as the lower threshold volume for a minor street approach with two or more lanes and 60 vph applies as the lower threshold volume threshold for a minor street approach with one lane.*

Sources: Revised from Florida DOT's Traffic Signal Warrant Summary (Form 750-020-01)
NCHRP Report 457, 2001
Manual on Uniform Traffic Control Devices 2003 (July 21, 2004)

TRAFFIC SIGNAL WARRANT SUMMARY

City: **West Fargo, ND** Organization: **Advanced Traffic Analysis Center**
County: **Cass** Date: **September 8, 2004**

Major Street: **13th Ave.** Lanes: **2** Critical Approach Speed: **35**
Minor Street: **6th St. E.** Lanes: **1**

Volume Level Criteria

1. Is the critical speed of major street traffic > 70 km/h (40 mph) ? ☐ Yes ☑ No
2. Is the intersection in a built-up area of isolated community of <10,000 population? ☐ Yes ☑ No

If Question 1 or 2 above is answered "Yes", then use "70%" volume level ☐ 70% ☑ 100%

WARRANT 3 - PEAK HOUR

Applicable: ☑ Yes ☐ No
Satisfied: ☐ Yes ☑ No

If all three criteria are fullfilled (Condition A) or the plotted point lies above the appropriate line (Condition B),then the warrant is satisfed.

Use the middle curve of Figure 4C-3

Unusual condition justifying use of warrant:
High-occupancy dwelling units

Record hour when criteria are fulfilled and the corresponding delay or volume in boxes provided.

Peak Hour		
7:30	-	8:30

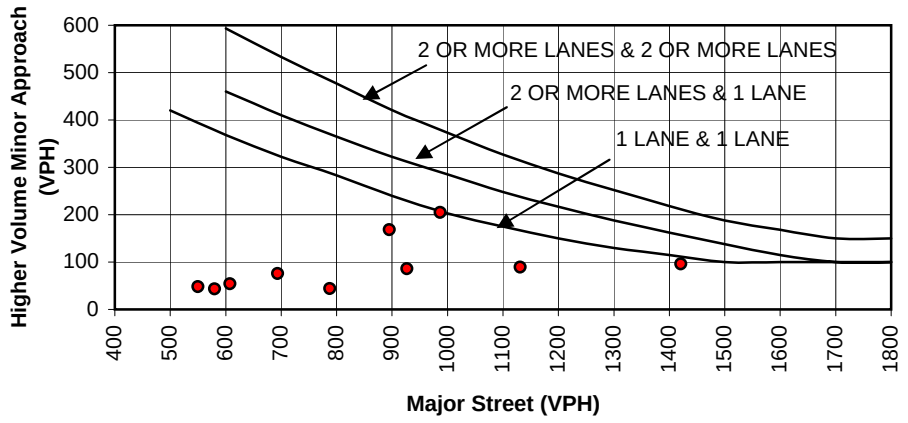
Criteria

1. Delay on Minor Approach *(vehicle-hours)		
Approach Lanes	1	2
Delay Criteria*	4.0	5.0
Delay*	0.8	
Fulfilled?: ☐ Yes	☑ No	

2. Volume on Minor Approach *(vehicles per hour)		
Approach Lanes	1	2
Volume Criteria*	100	150
Volume*	205	
Fulfilled?: ☑ Yes	☐ No	

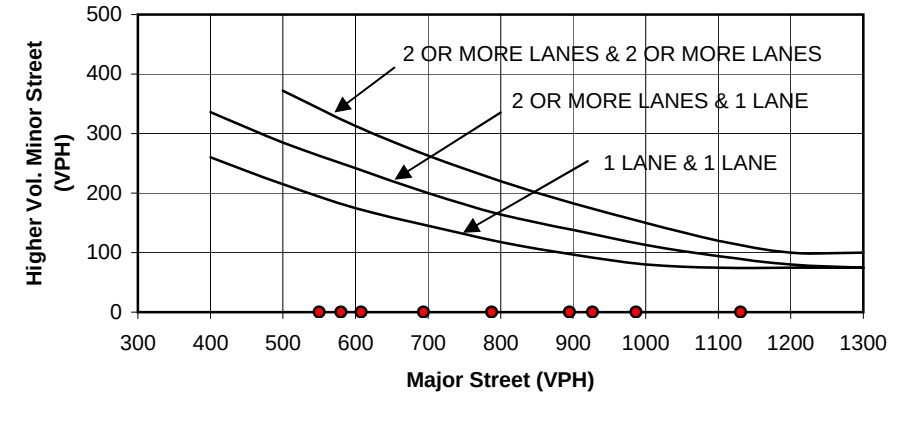
3. Total Entering Volume *(vehicles per hour)		
No. of Approaches	3	4
Volume Criteria*	650	800
Volume*		1,313
Fulfilled?: ☑ Yes	☐ No	

Figure 4C-3



** Note: 150 vph applies as the lower threshold volume for a minor street approach with two or more lanes and 100 vph applies as the lower threshold volume threshold for a minor street approach with one lane.*

Figure 4C-4 (70% Factor)



** Note: 100 vph applies as the lower threshold volume for a minor street approach with two or more lanes and 75 vph applies as the lower threshold volume threshold for a minor street approach with one lane.*

Sources: Revised from Florida DOT's Traffic Signal Warrant Summary (Form 750-020-01)
NCHRP Report 457, 2001
Manual on Uniform Traffic Control Devices 2003 (July 21, 2004)

TRAFFIC SIGNAL WARRANT SUMMARY

City: **West Fargo, ND** Organization: **Advanced Traffic Analysis Center**
County: **Cass** Date: **September 8, 2004**

Major Street: **13th Ave.** Lanes: **2** Critical Approach Speed: **35**
Minor Street: **6th St. E.** Lanes: **1**

WARRANT 4 - PEDESTRIAN VOLUME

Applicable: ☑ Yes ☐ No
Satisfied: ☐ Yes ☑ No

Record hours where criteria are fulfilled and the corresponding volume or gap frequency in the boxes provided. The warrant is satisfied if condition 1 or 2 is fulfilled and condition 3 is fulfilled.

Criteria	Hour		Pedestrian Volume	Pedestrian Gaps	Fulfilled? Yes	Fulfilled? No
1. Pedestrian volume crossing the major street is 100 ped/hr or more for each of any four hours and there are less than 60 gaps/hour in the major street traffic stream of adequate length.	3:00 PM	4:00 PM	10	0		X
	7:00 AM	8:00 AM	6	2		X
	8:00 AM	9:00 AM	5	4		X
	11:00 AM	12:00 PM	3	0		X
2. Pedestrian volume crossing the major street is 190 ped/hr or more for any one hour and there are less than 60 gaps/hour in the major street traffic stream of adequate length.	3:00 PM	- 4:00 PM				X
3. The nearest traffic signal along the major street is located more than 90 m (300 ft) away, or the nearest signal is within 90 m (300 ft) but the proposed traffic signal will not restrict the progressive movement of traffic.					X	

WARRANT 5 - SCHOOL CROSSING

Applicable: ☑ Yes ☐ No
Satisfied: ☐ Yes ☑ No

Record hours where criteria are fulfilled and the corresponding volume or gap frequency in the boxes provided. The warrant is satisfied if all three of the criteria are fulfilled.

Criteria			Fulfilled? Yes	Fulfilled? No
1. A minimum of 20 students crossing the major street during the highest crossing hour.	Students: 6	Hour: 7:00 - 8:00 AM		X
2. Fewer adequate gaps in the major street traffic stream during the period when the children are using the crossing than the number of minutes in the same period.	Minutes: 60	Gaps: 2	X	
3. The nearest traffic signal along the major street is located more than 90 m (300 ft) away, or the nearest signal is within 90 m (300 ft) but the proposed traffic signal will not restrict the progressive movement of traffic.			X	

WARRANT 6 - COORDINATED SIGNAL SYSTEM

Applicable: ☑ Yes ☐ No
Satisfied: ☑ Yes ☐ No

Indicate if the criteria are fulfilled in the boxes provided. The warrant is satisfied if either criterion is fulfilled. This warrant should not be applied when the resulting signal spacing would be less than 300 m (1,000 ft).

Criteria	Fulfilled? Yes	Fulfilled? No
1. On a one-way street or a street that has traffic predominately in one direction, the adjacent signals are so far apart that they do not provide the necessary degree of vehicle platooning.		X
2. On a two-way street, adjacent signals do not provide the necessary degree of platooning, and the proposed and adjacent signals will collectively provide a progressive operation.	X	

Sources: Revised from Florida DOT's Traffic Signal Warrant Summary (Form 750-020-01)
NCHRP Report 457, 2001
Manual on Uniform Traffic Control Devices 2003 (July 21, 2004)

TRAFFIC SIGNAL WARRANT SUMMARY

City: **West Fargo, ND** Organization: **Advanced Traffic Analysis Center**
County: **Cass** Date: **September 8, 2004**

Major Street: **13th Ave.** Lanes: **2** Critical Approach Speed: **35**
Minor Street: **6th St. E.** Lanes: **1**

WARRANT 7 - CRASH EXPERIENCE

Applicable: ☐ Yes ☑ No
Satisfied: ☐ Yes ☐ No

Record hours where criteria are fulfilled, the corresponding volume, and other information in the boxes provided. The warrant is satisfied if all three of the criteria are fulfilled.

Criteria		Hour	Volume	Met? Yes	Met? No	Fulfilled? Yes	Fulfilled? No
1. One of the warrants to the right is met.	Warrant 1, Condition A (80% satisfied)						
	Warrant 1, Condition B (80% satisfied)						
	Warrant 4, Pedestrian Volume at 80% of volume requirements: 80 ped/hr for four (4) hours or 152 ped/hr for one (1) hour						
2. Adequate trial of other remedial measure has failed to reduce crash frequency.		Measure tried:					
3. Five or more reported crashes, of types susceptible to correction by signal, have occurred within a 12-mo. period.		Number of crashes per 12 months:					

WARRANT 8 - ROADWAY NETWORK

Applicable: ☐ Yes ☑ No
Satisfied: ☐ Yes ☐ No

Record hours where criteria are fulfilled, and the corresponding volume or other information in the boxes provided. The warrant is satisfied if at least one of the criteria is fulfilled and if all intersecting routes have one or more of the characteristics listed.

Criteria							Met? Yes	Met? No	Fulfilled? Yes	Fulfilled? No
1. Both of the criteria to the right are met.	a. Total entering volume of at least 1,000 veh/hr during a typical weekday peak hour.		Entering Volume:							
	b. Five-year projected volumes that satisfy one or more of Warrants 1, 2, or 3.	Warrant:	1	2	3					
		Satisfied?:								
2. Total entering volume at least 1,000 veh/hr for each of any 5 hrs of a non-normal business day (Sat. or Sun.)						← Hour				
						← Volume				

Characteristics of Major Routes		Met? Yes	Met? No	Fulfilled? Yes	Fulfilled? No
1. Part of the street or highway system that serves as the principal roadway network for through traffic flow.	Major Street:				
	Minor Street:				
2. Rural or suburban highway outside of, entering, or traversing a city.	Major Street:				
	Minor Street:				
3. Appears as a major route on an official plan.	Major Street:				
	Minor Street:				

CONCLUSIONS

Warrants Satisfied: | | | | | | 6 | | |

Remarks: The number of acceptable gaps crossing 13th Ave. are very minimal due to the dispersed platoons from 9th St. E. and Sheyenne St. The average gap time (combined) for the AM, Mid-day, and PM peaks are 4-5, 4-5, and 2-3 sec., respectively. A signal would assist in the progressive operations of the corridor.

Sources: Revised from Florida DOT's Traffic Signal Warrant Summary (Form 750-020-01)
NCHRP Report 457, 2001
Manual on Uniform Traffic Control Devices 2003 (July 21, 2004)