Appendix C Transportation Plan Technical Memorandum

MEMO

To: Mark Koegler, RLA

From: Howard Preston, PE
Chris Albrecht

Subject: Rice County Model Validation

Date: May 3, 2002

As part of the overall comprehensive planning effort in the City of Faribault, Howard R. Green Company will utilize the Rice County travel demand model developed by the Minnesota Department of Transportation. With input from the pending future land use plan, the Rice County model will be used to estimate the impact of future land use on traffic volumes and subsequent levels of congestion on the city's road network. Prior to utilizing the model, our staff reviewed it for possible errors and verified how well the model replicates travel patterns in the base year.

Model Corrections

Through the model validation process, as well as initial use of the model, several errors were discovered and corrected. The following is a list of the corrections made to the Rice County travel demand model prior to developing the forecast traffic volumes.

- Minor updates were made to the 2001 socioeconomic (SE) data in a few traffic analysis zones (TAZs) to reflect actual conditions.
- The 2021 trip generation spreadsheet was corrected so that the 2021 estimates of households (HHs) were used in the calculations rather than the number of HHs in 1999.
- Since the 2021 trip generation spreadsheet was using the 2001 productions and attractions (P&As) for the external stations, the 2021 P&As for the external stations were updated to the appropriate values.
- Through use of the model, it was discovered that the intersections of Old 4th Street and Highland Place with CSAH 48 and the intersection of CR 76 with TH 21 were not coded correctly. Therefore, the model network was corrected to properly model the existing geometry and allowed maneuvers.
- In using the 2001 model, it was noted that the volume of traffic on the 14th Street NE crossing of the Straight River was under predicted while the TH 60 and 3rd Street NE river crossings were significantly over predicted. In order to divert more vehicles to the 14th Street NE bridge, a new centroid connector was added from TAZ #47 to Shumway Avenue near the intersection with 14th Street NE. TAZ #47 is the area generally bounded by the Shumway Avenue to the west, Ravine Street and St. Paul Avenue to the south, 14th Street NE to the north, and the city limits to the east.

Validation Findings

To determine how well the model was calibrated for Rice County as a whole and for the City of Faribault specifically, a variety of standard validation statistics were calculated. The following are results of the validation process.

Rice County

- The recommended minimum value for correlation coefficient between ground counts and base year model volumes is 0.88[1]. The Rice County model has a correlation coefficient of 0.86, which is slightly lower than the recommended minimum value.
- A desired maximum value for the Percent Root Mean Square of the Error (%RMSE) is 30%[2]. Overall, the Rice County model %RMSE is 34.5%, just slightly higher than the desired maximum.

City of Faribault

- In reviewing the link deviations for Faribault, a total of 38 out of 224 links (17%) exceed the maximum desirable link deviations recommended in NCHRP 255[3] (see Figure 1). In Faribault, most of the links exceeding the maximum desirable link deviation have an ADT of 10,000 vehicles per day or less. This indicates that most links on the high volume facilities; such as I-35, TH 60, TH 21, and TH 3; meet the recommendations in NCHRP 255.
- Referring to the link cluster diagram (see Figure 2), it can be seen that the model does have a good spread around the desired relationship, indicating that there is no general trend to the error.
- Eight "cutlines" were used to check the major directional movements in Faribault. Cutlines are essentially checkpoints across parallel roadways where model produced traffic volumes can be compared to actual ground counts. All cutlines have a percent deviation well below the recommended maximum desirable cutline deviation suggested in NCHRP 255 (see Figure 3 and Table 1).

Recommendation

Though the model does not pass all of the individual link validation checks, the cutlines demonstrate that the model reasonably accounts for regional flows within Faribault. Therefore, we propose to utilize the Rice County travel demand model "as is" and post-calibrate the future/forecast volumes to account for errors between the existing ground counts and the existing model volumes.

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[1] Ismart, Dane. *Calibration and Adjustment of System Planning Models*. FHWA. 1990.
[2] *Model Validation and Reasonableness Checking Manual*. Barton-Aschman Associates, Inc. and Cambridge Systematics, Inc. 1997.
[3] Samdahl, D.R. and N.J. Pedersen. *NCHRP Report 255: Highway Traffic Data for Urbanized Area Project Planning and Design*. TRB, National Research Council, Washington, D.C., 1982.

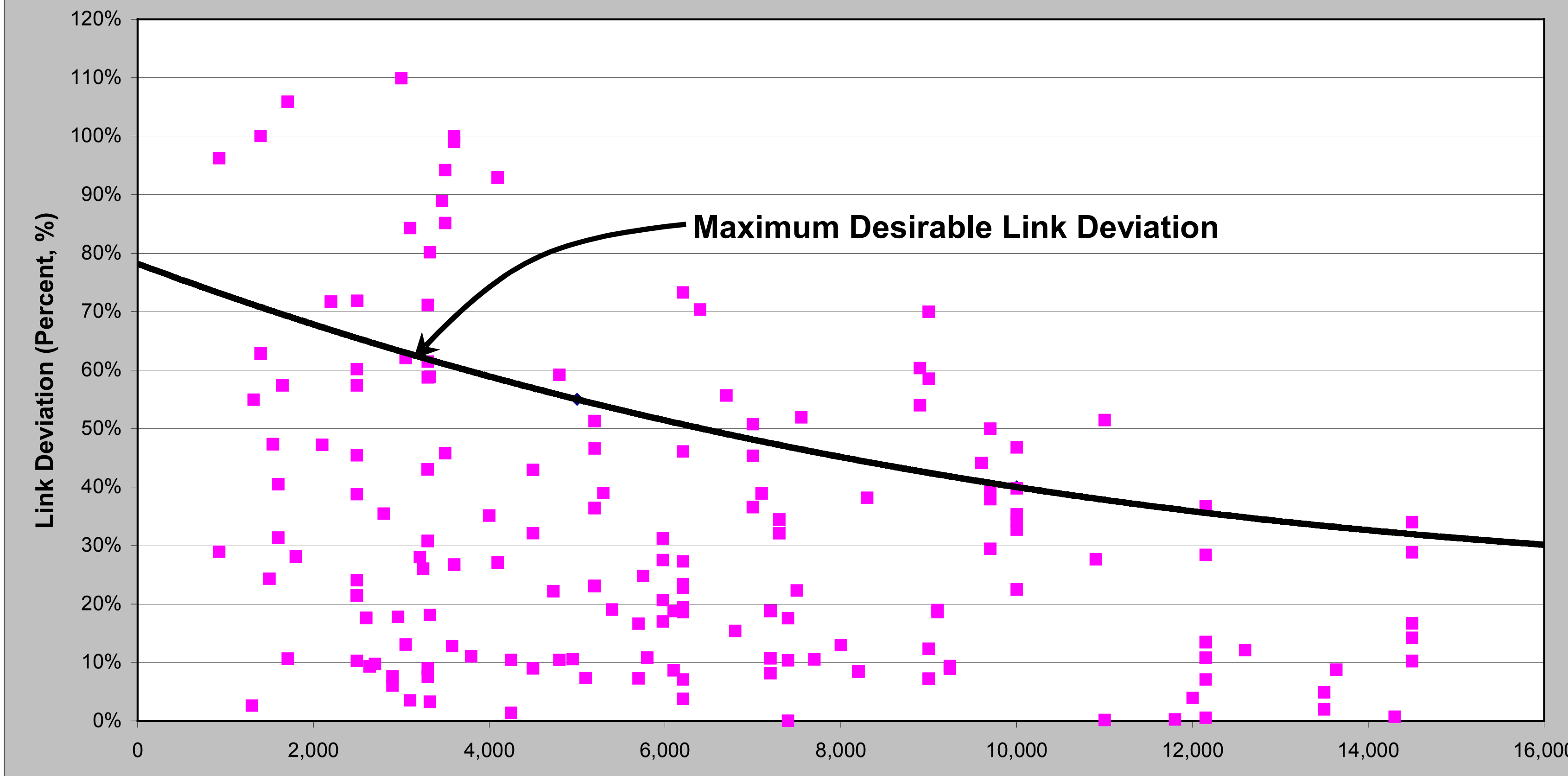


Figure 1: Link Based Deviations for the City of Faribault

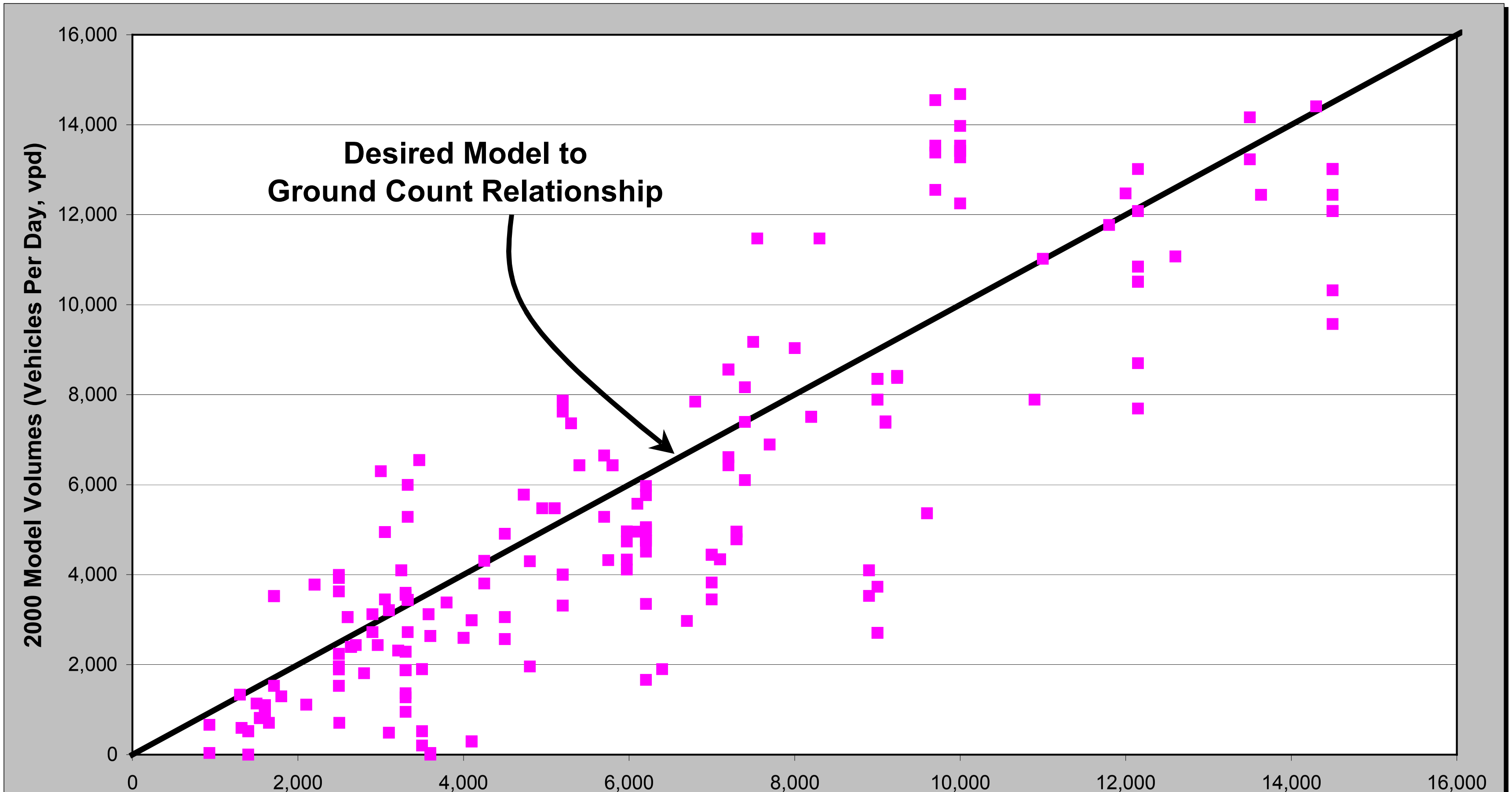


Figure 2: Link Cluster Diagram for the City of Faribault

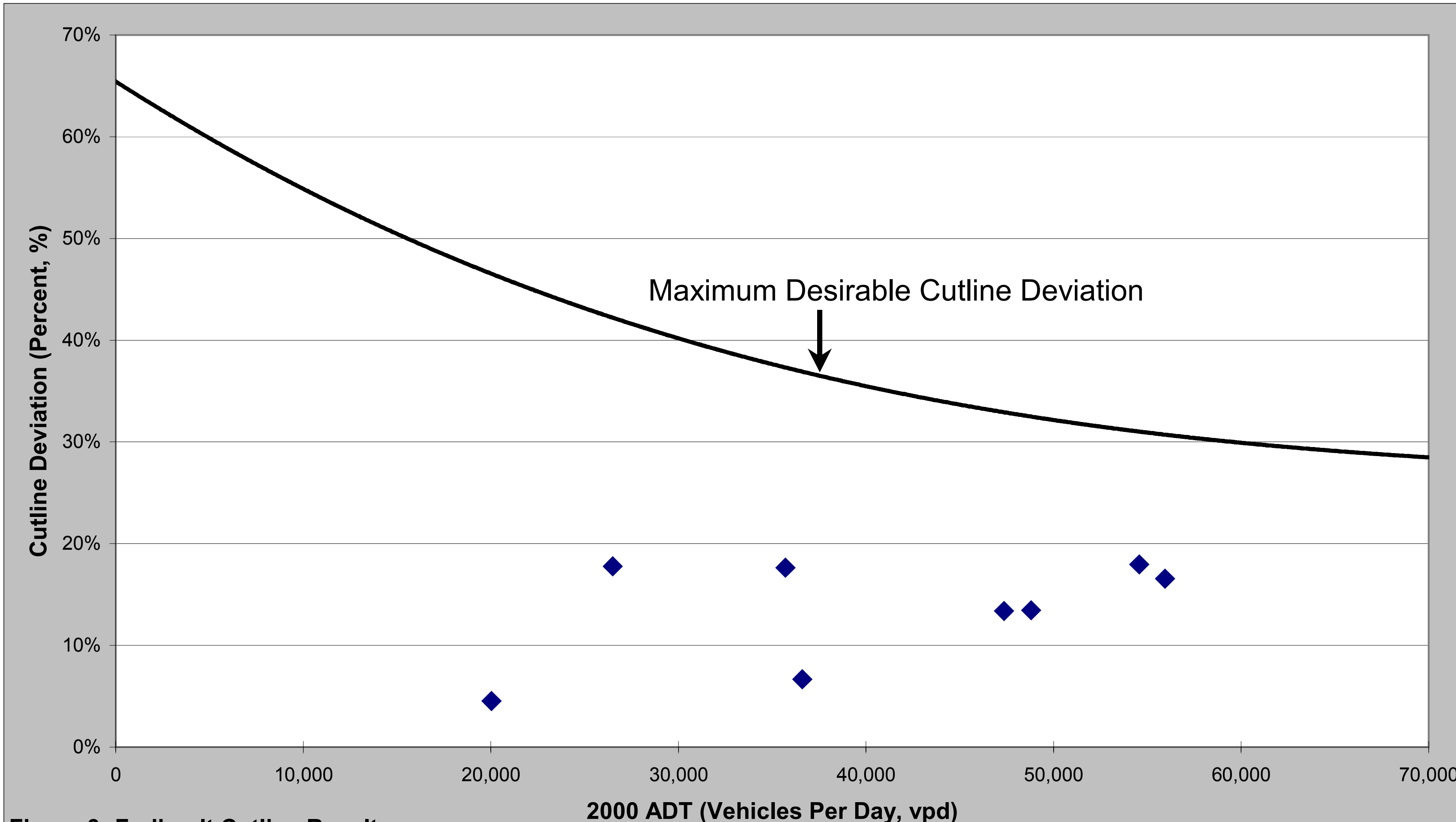


Figure 3: Faribault Cutline Results

Table 1: Faribault Cutlines

Cutlines	2001 Ground Count	2001 Model Volume	Percent Difference	Maximum Allowable Deviation	Meets Criteria?
Straight River	20,040	20,949	4.5%	46%	**Yes**
Cannon River	55,940	46,681	16.6%	31%	**Yes**
East-West across Faribault (just south of I-35/TH 21 interchange)	48,810	42,240	13.5%	33%	**Yes**
East-West across Faribault (between 9th and 10th Streets NW)	54,570	44,768	18.0%	31%	**Yes**
East-West across Faribault (between 2nd and 3rd Streets NW)	26,500	21,787	17.8%	42%	**Yes**
East-West across Faribault (between 8th and 9th Streets SW)	47,360	41,026	13.4%	33%	**Yes**
North-South across Faribault (just east of TH 21/CSAH 48)	36,600	34,157	6.7%	37%	**Yes**
North-South across Faribault (between 7th and 8th Avenues)	35,700	29,402	17.6%	38%	**Yes**

MEMO

To: Mark Koegler, RLA

From: Howard Preston, PE
Chris Albrecht, AICP

Subject: Faribault Crash Analysis

Date: August 2, 2002

An important step in the development of the transportation plan for Faribault involves conducting a safety review utilizing Minnesota Department of Transportation (Mn/DOT) crash records. The objective of the safety review was to identify high crash frequency locations, both at intersections and along roadway segments in Faribault, so that appropriate strategies could be considered when planning Faribault's capital improvement program. The methodology used to identify locations where safety might be of concern is described in the following paragraph.

Methodology

Crash data for the safety review was provided by the Mn/DOT Office of Traffic Engineering and Intelligent Transportation Systems. The dataset covered three years of crash information, from January 1999 through December 2001. The crash record database was separated into two categories: intersection-related crashes and mid-block crashes. There are approximately 700 intersections throughout the City of Faribault. Rather than calculating the crash rate for each, the crash rate was calculated for an intersection if the two following conditions were met:

1) The crash record database had at least two crashes occurring at an intersection.
2) At least one leg of the intersection is a trunk highway, county state aid highway, county road, or part of the municipal state aid street system.

Use of the above two criteria reduced the total number of intersections included in the safety analysis to 87.

In addition to the number of crashes, the number of vehicles entering the intersection on an average day was needed to calculate the crash rate for each intersection. Crash rates are expressed in crashes per million entering vehicles, in order to normalize for varying traffic conditions. To estimate the number of entering vehicles, the average daily traffic (ADT) volumes[1] from the intersection approaches were used. If ADT counts were unavailable for an intersection approach, then the missing approach volume was estimated based on street volumes from neighboring streets with similar characteristics. If daily volumes were not available from a nearby street, then an approach volume of 1,000 vehicles per day was used.

From the number of crashes occurring at each intersection and the intersection volume, the crash rate was calculated for the 87 intersections identified. Based on the intersection traffic control type, the expected crash rate was obtained from the Minnesota Department of Transportation's *Traffic Safety Fundamentals Handbook* (see Table 1).

[1] Source: Mn/DOT traffic flow maps, 1997.

Table 1: Expected Intersection Crash Rates

Intersection Control Type	Expected Crash Rate (Crashes per MEV)
All Stop	0.6
Thru-Stop	0.4
Signalized – Low Volume and Low Speed	0.8
Signalized – Low Volume and Low Speed	0.5

Source: *Traffic Safety Fundamentals Handbook.*
Note: High volume is an entering ADT greater than 15,000 vehicles per day. Low volume intersections have an entering ADT less than 15,000 vehicles per day.
Note: Low speed is a posted speed limit less than 45 mph. High speed is a posted speed limit of 45 mph or greater.

Guidance from this handbook was also used to determine each intersection's critical crash rate. The critical crash rate is a statistical quality control technique. An intersection with a crash rate above this level is most likely above the average crash rate due to conditions at the intersection. Intersections with a crash rate between the expected and critical rates may have more crashes than expected due to the random nature of crashes.

For each investigated intersection, the calculated crash rate was compared to the expected and critical rates. Intersections were classified as high crash frequency locations, and as a deficient location, when the existing crash rate was greater than the critical crash rate.

Following the intersection analysis, roadways were investigated in order to identify high crash frequency corridors. Similar to the process for calculating intersection crash rates, segment crash rates were not calculated for all 121 miles of streets located within Faribault. Roadways included in the analysis were either functionally classified roads or chosen because of their importance to the local street system. This reduced the total mileage of investigated roadways to approximately 27 miles. Roadways were broken into segments primarily based upon changes in facility type (i.e., 2-lane versus 4-lane undivided).

The number of crashes in a segment included both the mid-block crashes and crashes occurring at intersections along the corridor. In addition to the number of crashes and segment length, traffic volumes were needed for each segment. Where a segment had more than one listed ADT value, the segment traffic volume was determined using a weighted average. Similar to intersections, the crash rate for each segment was compared to the expected (see Table 2) and critical crash rate.

Table 2: Expected Segment Crash Rates

Segment Facility Type	Expected Crash Rate (Crashes per MVM)
Two-Lane	3.0
Four-Lane Undivided	5.9
Four-Lane Divided Arterial	4.0

Source: *Traffic Safety Fundamentals Handbook.*
Note: Expected crash rates are for "urban" classified roadways.

Analysis Results

Table 3 summarizes the intersection crash rates. In this table, intersections are first organized by intersection control type and then by crash rate. In the column next to the critical crash rate, a "X" identifies the 25 intersections with a crash rate above the critical crash rate. The "+" symbol is for the 34 intersections with a crash rate between the expected and critical crash rates, and the "-" notes the 28 intersections where the crash rate is below the expected crash rate.

For signal controlled intersections seven (7) of the ten (10) were determined to have a crash rate above the critical rate, while two of the remaining three intersections fell between the critical crash rate and expect crash rate. For the all stop controlled intersections, despite seven of the eleven having a crash rate above the expected rate, none were found to have a crash rate above the critical crash rate. The thru-stop controlled intersections also had only about one-fourth of the intersections (18 of 66) with a crash rate above the critical crash rate. Reviewing the location of the intersections with a crash rate above the critical crash rate, 18 of the 25 intersections were located on either the TH 60 or TH 21/CSAH 48 corridors.

From a crash rate and frequency perspective, the top ten intersection in need of safety related improvements include:

1. TH 60 at CSAH 18
2. TH 60 at CSAH 21 / CSAH 48
3. TH 60 at 1st Avenue NW
4. TH 21 at CSAH 11
5. TH 60 at 4th Avenue NW
6. TH 60 at 30th Avenue
7. TH 60 at 2nd Avenue NW
8. CSAH 48 at Division Street
9. CSAH 48 at Old 4th Street
10. TH 60 at Division Street

The results of the segment crash rate analysis are summarized in Table 4. For the 27 miles of roadway analyzed, 17 miles have crash rate above the critical crash rate, while three miles fall between the expected and critical crash rate and the remainder are below the expected crash rate. The pattern evident within the roadway segment analysis is the most of the roads with a crash rate above the critical crash rate are located at or near the center of the city.

From a crash rate and frequency perspective, the top ten segment in need of a safety related improvement include:

1. TH 60 from TH 21 to 1st Avenue NE
2. TH 60 from West City Limits to TH 21
3. 7th Street NW from TH 21 to Central Avenue
4. TH 21 from TH 60 to TH 3
5. Division Street from Old 4th Street to TH 60
6. TH 60 from 1st Avenue NE to East City Limits
7. CSAH 48 from I-35 to TH 60
8. CSAH 18 from South City Limits to TH 60
9. TH 3 from TH 21 to 2nd Avenue NW
10. Old 4th Street from Western Avenue to TH 60

Table 3: Intersection Crash Rate Results

Major Street	Minor Street	Intersection Control	Number of Crashes	Entering ADT	Crash Rate	Expected Crash Rate	Critical Crash Rate		Fatality	Personal Injury A	Personal Injury B	Personal Injury C	PDO
TH 60	TH 21 / CSAH 48	Sig. Low V. High S.	36	20,400	1.61	0.5	0.72	X	1	4	5	10	16
TH 21	CSAH 11	Sig. Low V. High S.	29	18,000	1.47	0.5	0.74	X		4	4	5	16
CSAH 48	Division St.	Sig. Low V. High S.	22	15,625	1.29	0.5	0.75	X		2	4	7	9
TH 60	Western Avenue	Sig. Low V. High S.	13	10,350	1.15	0.5	0.80	X		1	1	2	9
TH 60	CSAH 18	Sig. Low V. Low S.	47	14,700	2.92	0.8	1.14	X		1	3	11	32
TH 60	4th Ave. N.W.	Sig. Low V. Low S.	23	13,975	1.50	0.8	1.14	X		1	1	5	16
TH 60	2nd Ave. N.W.	Sig. Low V. Low S.	22	14,325	1.40	0.8	1.14	X		1	2	4	15
TH 60	Ravine St	Sig. Low V. Low S.	15	15,050	0.91	0.8	1.13	+		1	1	2	11
TH 60	Division St.	Sig. Low V. Low S.	16	16,525	0.88	0.8	1.12	+			2	4	10
TH 60	Central Ave.	Sig. Low V. Low S.	3	8,200	0.33	0.8	1.24	-			1		2
CSAH 18	10th St. S.W.	All Stop	6	6,325	0.87	0.6	1.01	+				1	5
TH 3	2nd Ave. N.W.	All Stop	9	9,725	0.85	0.6	0.94	+				4	5
7th St. N.W.	2nd Ave. N.W.	All Stop	12	14,600	0.75	0.6	0.89	+			1	2	9
2nd Ave. N.W.	3rd St. N.W.	All Stop	3	3,850	0.71	0.6	1.10	+					3
CSAH 18	3rd St. S.W.	All Stop	4	5,175	0.71	0.6	1.05	+				3	1
Division St.	Prairie Ave. S.W.	All Stop	7	9925	0.64	0.6	0.94	+				2	5
Division St.	4th Ave. W.	All Stop	6	8950	0.61	0.6	0.96	+			1	2	3
1st Ave. N.W.	3rd St. N.W.	All Stop	3	4975	0.55	0.6	1.05	-					3
CSAH 18	Division St.	All Stop	6	11,625	0.47	0.6	0.92	-			1	2	3
Division St.	Central Ave.	All Stop	2	6475	0.28	0.6	1.01	-				2	
10th St. S.W.	Willow St.	All Stop	2	6600	0.28	0.6	1.00	-					2
TH 60	1st Ave. N.W.	Thru Stop	23	11,325	1.85	0.4	0.66	X		1	2	5	15
7th Ave. N.W.	8th St. N.W.	Thru Stop	3	1,580	1.73	0.4	0.90	X			1		2
TH 60	30th Ave.	Thru Stop	27	17,000	1.45	0.4	0.61	X		2	7	6	12
1st Ave. N.W.	6th St. N.W.	Thru Stop	6	4050	1.35	0.4	0.78	X				1	5
CSAH 48	Old 4th St.	Thru Stop	19	13,650	1.27	0.4	0.64	X			1	8	10
7th St. N.W.	Central Ave.	Thru Stop	11	8,725	1.15	0.4	0.68	X			2	3	6
TH 21	TH 3	Thru Stop	15	12,625	1.09	0.4	0.64	X		1	6		8
TH 60	Park Ave. N.W.	Thru Stop	12	10,250	1.07	0.4	0.67	X	1		1	1	9
TH 60	6th Ave. N.W.	Thru Stop	15	13,400	1.02	0.4	0.64	X		1	1	5	8
TH 60	1st Ave. N.E.	Thru Stop	13	12,775	0.93	0.4	0.64	X				3	10
CSAH 11	Park Ave. N.W.	Thru Stop	6	5,900	0.93	0.4	0.73	X			1	1	4
2nd St. N.W.	3rd Ave. N.W.	Thru Stop	3	3000	0.91	0.4	0.82	X				1	2
4th Ave. N.W.	5th St. N.W.	Thru Stop	2	2000	0.91	0.4	0.87	X					2
CSAH 18	3rd St. N.W.	Thru Stop	5	5,200	0.88	0.4	0.75	X			1	1	3
TH 60	Irving Ave.	Thru Stop	11	11,800	0.85	0.4	0.65	X			2	2	7
TH 60	3rd Ave. N.W.	Thru Stop	11	12,400	0.81	0.4	0.65	X			3	2	6
TH 60	Wilson St.	Thru Stop	10	11,400	0.80	0.4	0.65	X			1	4	5
17th St. S.W.	Prairie Ave. S.W.	Thru Stop	2	2350	0.78	0.4	0.85	+			2		
Lincoln Ave. N.W.	3rd St. N.W.	Thru Stop	2	2350	0.78	0.4	0.85	+					2
2nd Ave. N.W.	2nd St. N.W.	Thru Stop	3	3550	0.77	0.4	0.80	+					3
TH 60	Hulet Ave N.W.	Thru Stop	9	10,800	0.76	0.4	0.66	X			1	4	4
1st Ave. N.W.	2nd St. N.W.	Thru Stop	3	3815	0.72	0.4	0.79	+					3
4th Ave. N.W.	3rd St. N.W.	Thru Stop	3	4150	0.66	0.4	0.78	+				2	1
4th Ave. S.W.	3rd St. S.W.	Thru Stop	3	4150	0.66	0.4	0.78	+				2	1
2nd Ave. N.W.	5th St. N.W.	Thru Stop	6	8,600	0.64	0.4	0.69	+			1	2	3
Hulet Ave. N.W.	17th St. N.W.	Thru Stop	2	3025	0.60	0.4	0.82	+					2
7th St. N.W.	Hulet Ave N.W.	Thru Stop	7	10,750	0.59	0.4	0.66	+				4	3
Division St.	1st Ave. W.	Thru Stop	4	6200	0.59	0.4	0.73	+				1	3
TH 60	Lincoln Ave. N.W.	Thru Stop	7	11,525	0.55	0.4	0.65	+				2	5
TH 21	17th St. N.W.	Thru Stop	7	12,200	0.52	0.4	0.65	+		1		2	4
7th St. N.W.	1st Ave. N.W.	Thru Stop	5	8,825	0.52	0.4	0.68	+				1	4
TH 60	George St. N.W.	Thru Stop	6	10,800	0.51	0.4	0.66	+			1	2	3
TH 3	Hulet Ave N.W.	Thru Stop	3	5,475	0.50	0.4	0.74	+					3
14th St.	Central Ave.	Thru Stop	2	3675	0.50	0.4	0.79	+				1	1
CSAH 48	Highland Pl.	Thru Stop	4	7,375	0.50	0.4	0.70	+	1			2	1
CSAH 47	CSAH 45	Thru Stop	2	3,825	0.48	0.4	0.79	+				2	
Hulet Ave. N.W.	Cannon Cir.	Thru Stop	2	4000	0.46	0.4	0.78	+				1	1
Old 4th St.	Lincoln Ave. N.W.	Thru Stop	2	4000	0.46	0.4	0.78	+					2
4th Ave. S.W.	1st St. S.W.	Thru Stop	2	4150	0.44	0.4	0.78	+			1		1
TH 60	CR 85	Thru Stop	4	8,500	0.43	0.4	0.69	+				1	3
TH 60	7th Ave. N.W.	Thru Stop	6	13,400	0.41	0.4	0.64	+		1	1	1	3
10th St. S.W.	7th Ave. S.W.	Thru Stop	2	4500	0.41	0.4	0.77	+					2
Division St.	3rd Ave. W.	Thru Stop	3	6800	0.40	0.4	0.71	+					3
CSAH 48	Jensen Dr.	Thru Stop	3	6,925	0.40	0.4	0.71	-		1		2	
Prairie Ave. S.W.	Highland Pl.	Thru Stop	2	4925	0.37	0.4	0.76	-			1		2
TH 60	1st St. N.W.	Thru Stop	4	10,100	0.36	0.4	0.67	-			1		3
7th St. N.W.	7th Ave. N.W.	Thru Stop	3	8,990	0.30	0.4	0.68	-				2	1
30th St. N.W.	Industrial Dr.	Thru Stop	2	6050	0.30	0.4	0.73	-					2
TH 298	Division St.	Thru Stop	2	6,100	0.30	0.4	0.73	-				1	1
7th St. N.W.	4th Ave. N.W.	Thru Stop	3	9,200	0.30	0.4	0.68	-			1	1	1
7th St. N.W.	Lincoln Ave. N.W.	Thru Stop	3	9,300	0.29	0.4	0.68	-					3
CSAH 11	Western Avenue	Thru Stop	2	6,400	0.29	0.4	0.72	-					2
CSAH 48	Town Square Ln.	Thru Stop	2	6,550	0.28	0.4	0.72	-			1		1
5th St. N.E.	1st Ave. N.E.	Thru Stop	5	16,500	0.28	0.4	0.62	-		1		2	2
7th St. N.W.	8th Ave. N.W.	Thru Stop	3	9,950	0.28	0.4	0.67	-					3
TH 60	5th Ave. N.W.	Thru Stop	4	13,400	0.27	0.4	0.64	-		1	1	1	1
2nd Ave. N.W.	6th St. N.W.	Thru Stop	2	7200	0.25	0.4	0.71	-				1	1
Willow St.	Tower Pl.	Thru Stop	2	7700	0.24	0.4	0.70	-			1		1
Division St.	Lincoln Ave. N.W.	Thru Stop	2	8075	0.23	0.4	0.69	-			1		1
TH 21	Bradley Rd.	Thru Stop	3	12,200	0.22	0.4	0.65	-		1	2		
2nd Ave. N.W.	11th St. N.W.	Thru Stop	2	9000	0.20	0.4	0.68	-			1		1
TH 60	Shumway Ave.	Thru Stop	2	9,075	0.20	0.4	0.68	-				1	1
2nd Ave. N.W.	13th S. N.W.	Thru Stop	2	9,280	0.20	0.4	0.68	-			1		1
2nd Ave. N.W.	12th St. N.W.	Thru Stop	2	9350	0.20	0.4	0.68	-				1	1
Division St.	8th Ave. N.W.	Thru Stop	2	11475	0.16	0.4	0.65	-					2
TH 60	Frontage Road	Thru Stop	3	18,200	0.15	0.4	0.61	-					3

Table 4: Segment Crash Rate Results

Corridor	Beginning Point	Ending Point	Facility Type	Length (miles)	ADT (vpd)	Intersection Crashes	Segment Crashes	Total Number of Crashes	Crash Rate	Expected Crash Rate	Critical Crash Rate	Fatality	"A" Injury	"B" Injury	"C" Injury	PDO
TH 60	West City Limits	TH 21	4-Lane Div.	1.15	8,400	77	28	105	9.9	4.0	5.0	1	3	14	24	63
TH 60	TH 21	1st Ave. N.E.	4-Lane Undiv.	1.12	10,300	229	57	286	22.6	5.9	7.0	1	11	30	64	180
TH 60	1st Ave. N.E.	East City Limits	2-Lane	1.12	7,300	55	10	65	7.3	3.0	3.9		2	6	14	43
TH 21	TH 60	TH 3	4-Lane Div.	1.15	11,100	88	18	106	7.6	4.0	4.8	1	11	13	21	60
TH 21	TH 3	North City Limits	4-Lane Div.	0.99	8,469	18	4	22	2.4	4.0	5.0		1	7	1	13
TH 3	TH 21	2nd Ave. N.W.	2-Lane	0.91	4,350	21	4	25	5.8	3.0	4.3		1	8	2	14
TH 3	2nd Ave. N.W.	North City Limits	2-Lane	0.78	6,700	12	7	19	3.3	3.0	4.1			1	7	11
CSAH 11	West City Limits	TH 21	2-Lane	0.94	5,300	8	7	15	2.7	3.0	4.1			1	4	10
CSAH 18	South City Limits	TH 60	2-Lane	1.79	3,500	24	14	38	5.5	3.0	4.0			5	9	24
CSAH 19	CSAH 45	South City Limits	2-Lane	0.55	3,050	0	1	1	0.5	3.0	4.8					1
CSAH 20	TH 60	East City Limits	2-Lane	1.09	2,500	2	3	5	1.7	3.0	4.5			1	1	3
CSAH 45	CSAH 47	CSAH 19	2-Lane	0.45	3,700	2	2	4	2.2	3.0	4.8				2	2
CSAH 47	Prairie Ave. S.W.	CSAH 45	2-Lane	0.70	1,500	2	1	3	2.6	3.0	5.2			2		1
CSAH 48	I-35	TH 60	4-Lane Div.	1.45	7,000	52	5	57	5.1	4.0	4.9	1	3	6	20	27
7th St. N.W.	TH 21	Central Ave.	2-Lane	1.05	8,000	70	22	92	10.0	3.0	3.9		7	8	20	57
1st Ave. N.E.	Central Ave.	TH 60	2-Lane	0.30	6,550	11	1	12	5.6	3.0	4.7			2	3	7
2nd Ave. N.W.	Division St.	TH 60	2-Lane	0.30	1,500	7	0	7	14.2	3.0	6.0					7
2nd Ave. N.W.	7th St. N.W.	TH 3	2-Lane	0.94	8,300	23	14	37	4.3	3.0	3.9		2	7	7	21
Central Ave.	7th St.	14th St.	2-Lane	0.53	2,200	12	3	15	11.7	3.0	5.1			2	4	9
14th St. N.W./N.E.	2nd Ave N.W.	Shumway Ave.	2-Lane	0.61	2,400	3	3	6	3.7	3.0	4.9			2	1	3
Shumway Ave.	2nd St. N.E.	14th St. N.E.	2-Lane	1.36	1,500	1	1	2	0.9	3.0	4.7					2
Ravine St.	1st Ave. N.E.	St. Paul Ave.	2-Lane	0.61	3,500	17	2	19	8.1	3.0	4.6		1	1	2	15
Division St.	Old 4th St.	TH 60	2-Lane	1.47	6,100	60	19	79	8.0	3.0	3.9		2	9	21	47
Old 4th St.	Western Ave.	Th 60	2-Lane	1.00	5,100	24	4	28	5.0	3.0	4.1			2	9	17
Prairie Ave. S.W.	Merrywood Ct.	Division St.	2-Lane	1.24	4,100	17	3	20	3.6	3.0	4.1			4	2	14
4th Ave. S.W./N.W.	10th St. S.W.	TH 60	2-Lane	1.03	2,600	16	1	17	5.8	3.0	4.5			2	7	8
Willow St.	CSAH 19	TH 60	2-Lane	1.06	6,200	9	12	21	2.9	3.0	4.0		1	3	5	12
10th St. S.W.	Prairie Ave. S.W.	Willow St.	2-Lane	0.67	3,300	10	2	12	5.0	3.0	4.6			1	1	10
Highland Pl.	CSAH 48	Prairie Ave. S.W.	2-Lane	0.45	1,800	5	1	6	6.8	3.0	5.5	1			2	3
3rd St. S.W.	Prairie Ave. S.W.	CSAH 18	2-Lane	0.30	1,000	0	1	1	3.0	3.0	6.4				1	

Elk River Example:

2.3 Traffic Safety Analysis

Methodology

Crash records maintained by the Minnesota Department of Transportation (Mn/DOT) were used to analyze the safety characteristics of roadways in Elk River. Every reported crash over the three-year period between 1999 and 2001 was compiled for the major roadways within the city. The crash records were broken into two categories: intersection crashes and road segment crashes. In order to account for the fact that roadways and intersections with higher traffic volumes have more crashes than lower volume locations, crash rates for intersections and road segments were calculated. The rates allow for the comparison of intersections and road segments that have different traffic volumes

At intersections, the actual crash rate was calculated if at least two crashes were located there over the three-year period. The rates were calculated using traffic volumes derived from turning movement and/or daily traffic counts. In order to calculate crash rates for major road segments, the segments first needed to be defined. Roadways were segmented based on logical breaks such as changes in facility type (i.e. number of lanes) or land use location (urban, rural, etc.). The crashes used in the calculation of actual crash rates included those at intersections and mid-block locations. The rates were calculated using traffic volumes derived from daily traffic counts.

Each intersection with a calculated crash rate was grouped into classifications based on traffic control (stop sign, traffic signal, etc), traffic volume, and speed. Each road segment with a calculated rate was grouped into classifications based on land use (urban or rural) and facility type (number of lanes). This was done so the calculated rates could be compared to statewide average rates for segments and intersections with similar characteristics. In other words, crash rates for intersections and road segments in Elk River could be compared the aggregate average rates for similar types of intersections and road segments across the state of Minnesota.
FIGURE 7: Existing Level of Congestion

Comparing calculated crash rates for intersections and segments to statewide averages does not necessarily tell you if a certain intersection or segment has a potential safety issue. Given the random nature of crashes, a location with a rate above average may not have a statistically significant difference from the average rate. Therefore, a further statistical check, called a critical crash rate, was used. The critical crash rate is based on the idea of being confident to a certain level that the actual crash rate is statistically above the average crash rate.

Although varying confidence levels can be utilized, the 95th percentile confidence interval was utilized to determine critical crash rates for Elk River. In other words, at locations where the actual crash rate exceeds the critical crash rate, it is 95% certain that the intersection or segment has characteristics that cause it to have a higher crash rate than the statewide average. Having an actual crash rate that exceeds the critical crash rate suggests that the intersection or road segment *may* have a safety deficiency. In the case of Elk River, determining which road segments and intersections have an actual crash rate that exceeds the critical rate effectively highlights which locations may be in need of safety improvements and which ones do not. This is discussed in more detail in the following section.

Analysis Results

Figure 8 displays the major intersections and road segments that have crash rates above statewide averages and above the respective critical crash rates. The figure shows that most of the road segments with rates that exceed the respective critical rate are located in the more rural portion of the city while the intersections that exceed the respective critical rate are located in the more urban portion of the city.

Nine different road segments representing six different roadways were found to have actual crash rates that exceed their respective critical rates. A total of eleven different intersections were found to have actual crash rates that exceed their respective critical rates. As mentioned previously, segments or intersections with rates that exceed the critical rate *may* have a safety deficiency. However, knowing only the critical rate does not tell you what may be causing the rate of crashes to be at their current levels. Further investigation is required to determine the nature of the safety deficiency. Also, segments or intersections that exceed the critical rate may not have a deficiency that can be feasibly resolved. Low traffic volumes and numbers of crashes may make improvements infeasible.

In order to help determine which segments and intersections above the critical rate are a higher priority for further study, the number of crashes between 1999 and 2001 on each road segment was examined. **Figure 9** displays the number of crashes over the three-year period for each segment of road. The figure shows that roadways with the highest number of crashes are typically the state highways and roadways in the more urban areas of the city. Roadways with a relatively high number of crashes that have road segments and intersections that exceed the critical rate should be investigated further for potential safety deficiencies before roadways above the critical rate that have a relatively low number of crashes.

FIGURE 8: Existing Breakdown of Crash Rates

FIGURE 9:Existing Road Segment Crash Totals

A comparison of the number of crashes (**Figure 9**) to the actual crash rates (**Figure 8**) brings up the question why so many road segments in the more rural areas of the city have rates above the critical rate. The reason for this is because these roadways are being compared to the critical rates for rural roadways. In other words, the crash rates on these roadways are significantly different than similar *rural* roadways. In contrast, even though the roadways in the urban parts of the city have many more total crashes, the rates of crashes are generally not significantly different than similar *urban* roadways. This is why TH 169 north of 201st Avenue exceeds the critical rate even though TH 169 south of 201st Avenue has a greater number of crashes. TH 169 north of 201st Avenue is considered to be a rural expressway while TH 169 south of 201st Avenue is considered to be an urban expressway.

Prioritization and Recommended Actions

As discussed above, the identification of intersections and road segments with crash rates that exceed their respective critical rate does not tell you the nature of the safety deficiency at that location. Its primary purpose is to act as a screening tool to determine which intersections and road segments to focus on. Each of these intersections and road segments should be investigated further to determine what improvements, if any, may reduce the number of crashes at these locations in the future.

Table 2 was developed to guide Elk River in determining the order in which intersections with rates above the critical rate should be investigated for potential safety deficiencies. The order was based on the number and general nature of crashes at each intersection location. The first two intersections shown in the table, TH 169/CR 33 and TH 169/Main Street, have been recently improved or have improvements planned. Therefore, these intersections only need to be monitored to determine if the roadway improvements reduce the number and rate of crashes at these locations.

A safety study for the Elk River High School included a review of the intersection of School Street & Jackson Avenue. The study recommended that both roadways should be converted to 3-lane roadways with traffic signal modifications to facilitate left-turn movements through the intersection. The study also made reference to making improvements to School Street at the TH 169 intersection. The city should consider implementing these recommendations in order to improve safety.

Any additional study of intersections to confirm where safety deficiencies are present and what could be done to resolve the deficiency should begin with the intersection of TH 10 and Upland Avenue. The last three intersections listed in **Table 2** were found to have only two crashes in three years. Further investigation of these intersections will not likely result in finding mitigation measures that are feasible to implement. However, all of these intersections should be monitored to determine if safety problems persist or worsen over time.

RANKING OF INTERSECTIONS FOR FURTHER SAFETY STUDY

Intersection	Reason for Ranking	Recommended Action
1. TH 169 & CR 33 (205th Ave)	No current need to investigate – problem likely resolved with new interchange	Monitor after construction of interchange to determine if crashes go
2. TH 169 & Main St	No current need to investigate – problem likely resolved with recent intersection improvements	Monitor to determine if crashes go down.
3. TH 169 & School St	A total of 32 crashes were reported – 13 were personal injury	Consider implementing previous safety study recommendations.
4. School St & Jackson Ave	A total of 26 crashes were reported – 10 were personal injury. A previous safety study recommended specific improvements to this intersection.	Consider implementing previous safety study recommendations.
5. TH 10 & CR 44 (Upland Ave)	A total of 20 crashes were reported – 11 were personal injury	Complete safety study
6. CSAH 1 (Elk Lake Rd) & CR 33 (Ranch Rd)	A total of 9 crashes were reported – 5 were personal injury	Complete safety study.
7. Jackson Ave & 191st ½ Ave	A total of 7 crashes were reported – 1 was personal injury	Complete safety study
8. Meadowvale Rd & Upland Ave	A total of 4 crashes were reported – 2 were personal injury	Consider safety study if crashes increase.
9. Twin Lakes Pkwy & 175th Ave	A total of 2 crashes were reported – 1 was personal injury	Monitor for increase in crashes.
10. 197th Ave & Ulysses St	A total of 2 crashes were reported – 1 was personal injury	Monitor for increase in crashes.
11. CR 32 (Meadowvale Rd) &	A total of 2 crashes were reported	Monitor for increase in crashes.

SOURCE: 1999-2001 crash data from Mn/DOT, Howard R. Green Company

Table 3 was developed to guide Elk River in determining the order in which road segments with rates above the critical rate should be investigated for potential safety deficiencies. The order was based on the number of non-intersection crashes on each segment. Non-intersection crashes include any crash that does not occur at a public road intersection. That means crashes at private driveway locations are included.

Crashes on the first segment shown in the table will likely go down after the construction of an interchange on TH 169 at CR 33. A safety study for the Elk River High School included a review of the intersection of the School Street segment. The study recommended that School Street be converted to a 3-lane roadway. This change in design would likely reduce crashes on this road segment. Additional study of road segments to confirm where safety deficiencies are present and what could be done to resolve the deficiency should begin with the CSAH 13 (Twin Lakes Road) segment identified.

The last two segments listed in **Table 3** were found to have only four or less crashes in three years. Further investigation of these intersections will not likely result in finding mitigation measures that are feasible to implement. However, all of the segments listed should be monitored to determine if safety problems persist or worsen over time.

TABLE 3
RANKING OF ROAD SEGMENTS FOR FURTHER SAFETY STUDY

Segment	Reason for Ranking	Recommended Action
1. TH 169 from 201st Ave to North City Limits	At total of 105 crashes – 55 were non-intersection crashes. The crash rate for this segment will likely go down after the construction of an interchange at CR 33 (205th Ave).	Monitor after construction of CR 33 interchange to determine if crashes go down.
2. School St from CSAH 1 (Elk Lake Rd) to TH 169	A total of 89 crashes – 19 were non-intersection crashes. A previous safety study recommended specific	Consider implementing previous safety study recommendations.
3. CSAH 13 (Twin Lakes Rd) from Twin Lakes Pkwy to East	A total of 26 crashes were reported – 17 were non-intersection crashes.	Complete safety study
4. CSAH 1 (Elk Lake Rd) from CR 32 (Meadowvale Rd) to North	A total of 18 crashes were reported – 11 were non-intersection crashes.	Complete safety study
5. CR 33 (205th/209th Ave) from CR	A total of 31 crashes were reported – 6 were non-intersection crashes.	Complete safety study
6. CR 33 (Ranch Rd) from West City Limits to CR 77 (Proctor	A total of 17 crashes were reported – 5 were non-intersection crashes.	Complete safety study
7. CR 35 (192nd Ave) from West City Limits to CR 44	A total of 7 crashes were reported – 3 were non-intersection crashes.	Consider safety study.
8. CR 77 (Proctor Rd) from CR 33	A total of 4 crashes were reported – 1 was a non-intersection crash.	Monitor for increase in crashes.
9. CR 40 (Cleveland Ave) from CSAH 13 (Twin Lakes Rd) to	A total of 3 crashes were reported – none were non-intersection crashes.	Monitor for increase in crashes.

SOURCE: 1999-2001 crash data from Mn/DOT, Howard R. Green Company

MEMO

To: Tim Murray, PE

From: Bobby Oare, PE
Chris Albrecht, AICP

Subject: Interchange Geometric Review

Date: August 16, 2002

Howard R. Green Company

As part of the comprehensive planning process for the City of Faribault, a geometric review of the three Interstate-35 interchanges through the City of Faribault was conducted on July 23, 2002. These interchanges included Exit 55 to Lyndale Avenue, Exit 56 to TH 60, and Exit 59 to TH 21. This memorandum discusses the findings of the geometric review.

Interstate-35 Background

Interstate 35 is a divided four-lane freeway running primarily north-south through Minnesota. It is classified as a major arterial and current average daily traffic (ADT) volumes through Faribault are approximately 25,000 vehicles per day. The interstate runs along the westerly edge of the Faribault. The three interchanges that access Faribault are spaced at least one mile apart. The interstate freeway has a posted speed limit of 70 mile per hour (MPH) and has a rural cross-section.

Exit 55 Interchange with Lyndale Avenue/CSAH 48

CSAH 48, locally known as Lyndale Avenue, is a divided four-lane highway approaching the City of Faribault from the south. The highway has a posted speed of 55 MPH and is a rural cross-section. The interchange with Interstate 35 is classified as a system interchange. By definition, this means that it is an interchange between two or more freeways or controlled access roadway facilities. The interchange is a direct connection interchange. This means that the ramps are connections between the two roadways that do not greatly deviate from their intended direction of travel. In the case of this interchange, I-35 northbound to Lyndale Avenue northbound and Lyndale Avenue southbound to I-35 southbound are the two direct connection movements. There is no exit for I-35 southbound, nor is there an entrance for I-35 northbound at this interchange. The interchange is illuminated.

There are 13 critical design elements identified by the Minnesota Department of Transportation (Mn/DOT) and the Federal Highway Administration (FHWA). The geometric reviews of the three interchanges are based on field observations, so it is difficult to know precisely if all design standards are met. The following subsections document the review of those critical design elements, the appropriate design guidelines, and how each interchange compares to the design guidelines based on those field observations.

Design Speed

From the Mn/DOT Road Design Manual (RDM) Table 6-3.04A, the design speed for direct connection ramps such as the ones present at this location would be in the middle range for the highway design speed. Since the highway design speed is 70 MPH, this yields a ramp design speed of 50 MPH minimum. The 50 MPH design speed will impact most of the following design criteria. Since the ramps have a posted speed of 55 MPH, these ramps exceed the design standard.

Ramp Pavement Width

The minimum ramp width from Table 6-3.04C in the RDM is 26 feet wide. This includes a four-foot left shoulder and a six-foot right shoulder. It appears that these ramps meet the design standard.

Ramp Length

Ramp length is broken between acceleration length and deceleration length. The minimum deceleration length is found in Table 6-2.03A while the minimum acceleration length is found in Table 6-2.04B from the RDM. The minimum deceleration length is 340 feet. The deceleration length for I-35 northbound to Lyndale Avenue appears to meet this design standard. The minimum acceleration length is 580 feet. The length should be increased (or decreased) if the mainline has grade over 3%. The acceleration length for Lyndale Avenue southbound to I-35 southbound may be substandard. The ramp does connect to I-35 on an inclined grade, which makes it more difficult to accelerate and merge into mainline traffic. The connections to Lyndale Avenue are direct and ramp length is not an issue.

Horizontal Clearance to Obstruction

Not applicable to ramp design.

Stopping Sight Distance

The minimum Stopping Sight Distance from Table 2-5.9A in the RDM is 475 feet. Stopping sight distance is important so that if traffic is stopped on the ramp, another vehicle has enough time to perceive the problem and stop. It appears that there is adequate stopping sight distance at this interchange and that the design standards are met.

Horizontal Alignment

The minimum curve radius from Table 3-2.03A in the RDM is 849 feet. Since the ramps have a posted speed of 55 MPH, the horizontal curve radius is greater than 849 feet so it appears that the design standards are met.

Grades

The maximum grade from Table 6-3.04B from the RDM is 5%. It appears that the ramp grades at this interchange meet the required design standards.

Vertical Alignment

The minimum “K-Value” for crest and sag vertical curves from Figures 3-4.04A and 3-4.04D in the RDM respectively are 641’/% and 109’/%. The “K-Value” is the rate of vertical curvature per change in grade. It appears that the vertical curves along these ramps for this interchange meet the required design standards.

Cross Slope

The desirable cross slope from Figures 6-3.04A, B, and C in the RDM are 0.02 feet per foot. The design standard for cross slope changed within the past 10 years from 0.015 feet per foot to 0.02 feet per foot. Therefore, since this interchange was likely constructed prior to this change, the cross slopes are likely 0.015 feet per foot. It appears that while the cross slopes do not meet current design standards, they are still within acceptable ranges.

Superelevation

The maximum superelevation rate from Section 3-3 of the RDM is 0.06 feet per foot. It appears that the superelevation rates for all curves on the ramps of this interchange meet the design standards.

Bridge Width

The minimum bridge width from Section 9-2.02 of the RDM for a ramp bridge is 26 feet. There is one bridge for the southbound Lyndale Avenue to southbound I-35 ramp. It appears that the bridge is at least that wide so the bridge width meets the required design standards.

Bridge Structural Capacity

The minimum design load from Section 9-2 of the RDM for all new bridges is a HS-25 design load. It is unknown what is the structural capacity of the existing ramp bridge.

Vertical Clearance

The minimum vertical clearance from Table 9-2.01B of the RDM for a highway under a bridge is 16 feet and four inches. It appears that the vertical clearance for I-35 under the ramp bridge is greater than or equal to the minimum clearance and meets the design standards.

Exit 56 Interchange with Trunk Highway 60

TH 60 is a four-lane highway running east-west through the City of Faribault. The highway has a posted speed of 40 MPH and has a rural cross-section in the vicinity of the interchange with Interstate 35. The median has raised curb and gutter however. The interchange is classified as a service interchange. By definition, that means that it is an interchange between a freeway or controlled access roadway facility and a lower class roadway such as an arterial or collector. The interchange is a folded diamond type of interchange, meaning that the ramps and loops are all on one-side of the minor street (or TH 60). In the case of this interchange, the Cannon River to the north prohibits the use of a more typical diamond interchange at this location. All ramp connections are in place to and from both I-35 and TH 60.

Access to the Faribo Mall is located approximately 1000 feet to the east of the interchange. The mall intersection is controlled by a signal. The signal is inconsistent with driver expectation for traffic from I-35 as the ramp alignments indicate that TH 60 is a more high-speed facility. The closest access to the west is over one-quarter mile to the west and there is no free movement headed in that direction. Another significant access issue is the truck stop access aligned with the west loop/ramp terminus at TH 60. This access adds congestion and safety problems to this intersection due to the large volume of trucks. The median is not wide enough to store an interstate vehicle. The interchange is also illuminated.

The following is a review of those critical design elements, the appropriate design standards, and how this interchange compares to the design standards based on those field observations.

Design Speed

From the Mn/DOT Road Design Manual (RDM) Table 6-3.04A, the design speed for the diagonal ramps near the freeway would be in the middle range for the highway design speed. Since the highway design speed is 70 MPH, this yields a ramp design speed of 50 MPH minimum near the freeway. The design speed for the right-turn ramps is in the low range for the highway design speed. This yields a design speed of 35 MPH minimum near TH 60. Finally, the minimum design speed for loops is 25 MPH. These design speeds will impact most of the following design criteria. Since the TH 60 to I-35 northbound loop has a posted advisory warning speed of 20 MPH, this loop does not meet design standard. All other ramps and loops at this interchange appear to meet the design standards.

Ramp Pavement Width

The minimum ramp width from Table 6-3.04C in the RDM is 26 feet wide. This includes a four-foot left shoulder and a six-foot right shoulder. It appears that these ramps meet the design standard.

Ramp Length

Ramp length is broken between acceleration length and deceleration length. The minimum deceleration length is found in Table 6-2.03A while the minimum acceleration length is found in Table 6-2.04B from the RDM. The minimum deceleration length for the I-35 northbound to TH 60 Ramp is 340 feet. The minimum deceleration length for the I-35 southbound to TH 60 Loop is 550 feet. Both deceleration lengths for this ramp and loop appear to meet this design standard. The minimum acceleration length for the TH 60 to I-35 southbound ramp is 580 feet. The minimum acceleration length for the TH 60 to I-35 northbound loop is 1500 feet. The acceleration length for this loop may be substandard.

Horizontal Clearance to Obstruction

Not applicable to ramp design.

Stopping Sight Distance

The minimum Stopping Sight Distance from Table 2-5.9A in the RDM is 475 feet for 50 MPH and 155 feet for 25 MPH. Stopping sight distance is important so that if traffic is stopped on the ramp, another vehicle has enough time to perceive the problem and stop. It appears that there is adequate stopping sight distance at this interchange and that the design standards are met.

Horizontal Alignment

The minimum curve radius from Table 3-2.03A in the RDM is 849 feet for 50 MPH and 190 feet for 25 MPH. Since the TH 60 to northbound I-35 loop has a posted advisory speed of 20 MPH, the horizontal curve radius is less than 190 feet so it appears that the design standards for this loop are not met. All other ramps and loops appear to meet the design standards.

Grades

The maximum grade from Table 6-3.04B from the RDM is 5%. It appears that the ramp grades at this interchange meet the required design standards.

Vertical Alignment

The minimum "K-Value" for crest and sag vertical curves from Figures 3-4.04A and 3-4.04D in the RDM respectively are 641'/% and 109'/% for 50 MPH and are 18'/% and 26'/% for 25 MPH. The "K-Value" is the rate of vertical curvature per change in grade. It appears that the vertical curves along these ramps for this interchange meet the required design standards.

Cross Slope

The desirable cross slope from Figures 6-3.04A, B, and C in the RDM are 0.02 feet per foot. The design standard for cross slope changed within the past 10 years from 0.015 feet per foot to 0.02 feet per foot. Therefore, since this interchange was likely constructed prior to this change, the cross slopes are likely 0.015 feet per foot. It appears that while the cross slopes do not meet current design standards, they are still within acceptable ranges.

Superelevation

The maximum superelevation rate from Section 3-3 of the RDM is 0.06 feet per foot. It appears that the superelevation rates for all curves on the ramps of this interchange meet the design standards.

Bridge Width

The minimum bridge width from Section 9-2.02 of the RDM for a mainline bridge is 42 feet. There are two mainline bridges for I-35. Each bridge carries two through lanes plus is wider for the loop acceleration and deceleration lanes. It appears that both bridges meet the required design standards.

Bridge Structural Capacity

The minimum design load from Section 9-2 of the RDM for all new bridges is a HS-25 design load. It is unknown what is the structural capacity of the two existing mainline bridges.

Vertical Clearance

The minimum vertical clearance from Table 9-2.01B of the RDM for a highway under a bridge is 16 feet and four inches. It appears that the vertical clearance for TH 60 under the I-35 mainline bridges is greater than or equal to the minimum clearance and meets the design standards.

Exit 59 Interchange with Trunk Highway 21

TH 21 is a divided four-lane highway running north-south through the City of Faribault. The highway has a posted speed of 55 MPH and has a rural cross-section. The median has raised curb and gutter in the vicinity of the interchange. The interchange is classified as a service interchange. By definition, that means that it is an interchange between a freeway or controlled access roadway facility and a lower class roadway such as an arterial or collector. The interchange is a partial cloverleaf type of interchange. This means that the ramps and loops are present in at least one quadrant (southwest quadrant at TH 21). The east side of the interchange resembles more of a typical diamond type of interchange. Development in the northwest quadrant prohibits the use of a more typical diamond interchange at this location. All ramp connections are in place to and from both I-35 and TH 21. Access is located relatively close to the interchange both to the east (approximately 1000 feet) and west (approximately 1350 feet) along TH 21. This closely spaced access along TH 21 adds to safety concerns. The interchange is also illuminated.

The following is a review of those critical design elements, the appropriate design standards, and how this interchange compares to the design standards based on those field observations.

Design Speed

From the Mn/DOT Road Design Manual (RDM) Table 6-3.04A, the design speed for the diagonal ramps near the freeway would be in the middle range for the highway design speed. Since the highway design speed is 70 MPH, this yields a ramp design speed of 50 MPH minimum near the freeway. The design speed for the right-turn ramps is in the low range for the highway design speed. This yields a design speed of 35 MPH minimum near TH 21. Finally, the minimum design speed for loops is 25 MPH. These design speeds will impact most of the following design criteria. There are no posted advisory speed warnings below the expected design speed, therefore all ramps and loops at this interchange appear to meet the design standards.

Ramp Pavement Width

The minimum ramp width from Table 6-3.04C in the RDM is 26 feet wide. This includes a four-foot left shoulder and a six-foot right shoulder. It appears that these ramps meet the design standard.

Ramp Length

Ramp length is broken between acceleration length and deceleration length. The minimum deceleration length is found in Table 6-2.03A while the minimum acceleration length is found in Table 6-2.04B from the RDM. The minimum deceleration length for the I-35 northbound to TH 21 Ramp is 340 feet. The minimum deceleration length for the I-35 southbound to TH 21 Loop is 550 feet. Both deceleration lengths for this ramp and loop appear to meet this design standard. The minimum acceleration length for both the TH 21 to I-35 southbound and TH 21 to I-35 northbound ramps is 580 feet. It appears that the ramp lengths meet the design standards.

Horizontal Clearance to Obstruction

Not applicable to ramp design.

Stopping Sight Distance

The minimum Stopping Sight Distance from Table 2-5.9A in the RDM is 475 feet for 50 MPH and 155 feet for 25 MPH. Stopping sight distance is important so that if traffic is stopped on the ramp, another vehicle has enough time to perceive the problem and stop. It appears that there is adequate stopping sight distance at this interchange and that the design standards are met.

Horizontal Alignment

The minimum curve radius from Table 3-2.03A in the RDM is 849 feet for 50 MPH and 190 feet for 25 MPH. All ramps and loops appear to meet the design standards.

Grades

The maximum grade from Table 6-3.04B from the RDM is 5%. It appears that the ramp grades at this interchange meet the required design standards.

Vertical Alignment

The minimum "K-Value" for crest and sag vertical curves from Figures 3-4.04A and 3-4.04D in the RDM respectively are 641'/% and 109'/% for 50 MPH and are 18'/% and 26'/% for 25 MPH. The "K-Value" is the rate of vertical curvature per change in grade. It appears that the vertical curves along these ramps for this interchange meet the required design standards.

Cross Slope

The desirable cross slope from Figures 6-3.04A, B, and C in the RDM are 0.02 feet per foot. The design standard for cross slope changed within the past 10 years from 0.015 feet per foot to 0.02 feet per foot. Therefore, since this interchange was likely constructed prior to this change, the cross slopes are likely 0.015 feet per foot. It appears that while the cross slopes do not meet current design standards, they are still within acceptable ranges.

Superelevation

The maximum superelevation rate from Section 3-3 of the RDM is 0.06 feet per foot. It appears that the superelevation rates for all curves on the ramps of this interchange meet the design standards.

Bridge Width

The minimum bridge width from Section 9-2.02 of the RDM for a mainline bridge is 42 feet. There are two mainline bridges for I-35. The I-35 southbound bridge carries two through lanes plus is wider for the loop deceleration lanes. The I-35 northbound bridge carries two lanes plus appears to have adequate shoulders across it. It appears that both bridges meet the required design standards.

Bridge Structural Capacity

The minimum design load from Section 9-2 of the RDM for all new bridges is a HS-25 design load. It is unknown what is the structural capacity of the two existing mainline bridges.

Vertical Clearance

The minimum vertical clearance from Table 9-2.01B of the RDM for a highway under a bridge is 16 feet and four inches. It appears that the vertical clearance for TH 21 under the I-35 mainline bridges is greater than or equal to the minimum clearance and meets the design standards.

Further Discussion

Lyndale Avenue/CSAH 48 Interchange

The previous sections indicate that the existing interchanges meet or exceed most, if not all, the applicable design guidelines. The CSAH 48 directional interchange at the south end of Faribault has been, and continues to be a useful exit and entrance to and from I-35 to the south. This is a design that made sense in the 1970's when the interchange was constructed. However, there has been question whether the design still meets the expectations of Mn/DOT, the City of Faribault, and the traveling public. Present-day CSAH 48 has not remained a high speed roadway, as it had prior to the Interstate 35 bypass nearly 30 years ago. Rather it has become and will continue to serve as a business access route, which would indicate slower expected and accepted speeds. However, this alone is not enough reason to reconstruct this interchange as a service interchange.

Mn/DOT and the Federal Highway Administration, who has jurisdiction over the Eisenhower Interstate System, would not support reconstruction of this interchange to be a full access interchange (i.e. additional exit and entrance ramps to the north) unless there were significant changes to the local land use plan and sufficient local supporting roadways in place. For example, CSAH 48 in its present alignment is not conducive to an interchange style other than the directional interchange that exists today. CSAH 48 would need to align more perpendicular to I-35 and also align with a roadway on the west side of I-35. This realignment would allow for a more typical interchange design, such as a standard diamond. This new road on the west side of I-35 could serve both as access to the local land owners and a potential collector to deliver this traffic to I-35.

In addition, and maybe more importantly, the future land use plans for this area west of I-35 and south of TH 60 do not reflect an overall creation of traffic generating land uses. Without a plan for significant growth and a supporting road system with subsequent demand on the transportation network in this area, or a significant diversion of traffic from an existing highway, such as TH 60, there will continue to be little justification for an upgraded southern interchange.

Trunk Highway 60 Interchange

The TH 60 folded diamond interchange also meets or exceeds most, if not all, of the applicable design guidelines. This is also a design that made sense 30 years ago when this area was more rural in nature. However this interchange is now in an urbanizing area, and according to land use plans, will become more urbanized in coming years. With this further urbanization will come concerns with safety. The existing ramps are designed for higher speed movements onto TH 60. Because the land use adjacent to TH 60 is more urban, there is a conflicting message sent to drivers using this interchange. Of particular concern is the I-35 northbound to TH 60 eastbound ramp. This ramp is very close to a signalized intersection. The ramp is such that the driver on the ramp can maintain a higher speed while entering TH 60. This driver has a merge condition onto TH 60 while at the same time approaching a signalized intersection. As traffic volumes grow, the chance for this particular conflict, as well as other conflicts will increase.

As volumes increase, a simple solution to solve some of these potential conflicts would be to remove the free right movements on the ramps. Since all ramp traffic would need to be stopped before entering TH 60, a second improvement that would need to be made would be widening the ramps at the ramp terminals. The widening of the ramps would be necessary to adequately store those vehicles now queued up at the intersection. By aligning the ramp traffic to a single intersection for both the southbound and northbound exit ramps, the interchange would become more urban and therefore more consistent with TH 60. These single intersection points for both the northbound and the southbound exit ramps would also make it easier to accommodate traffic control changes (i.e. signals) if necessary in the future.

Trunk Highway 21 Interchange

The TH 21 partial cloverleaf interchange also meets or exceeds most if not all the applicable design guidelines. Many of the same issues from the TH 60 interchange apply to this interchange as well. This is a rural design interchange in an urbanizing area, which, once again, creates conflicts. A recent Mn/DOT construction project has addressed the ramps on the east side of I-35. As development occurs and traffic volumes increase, the ramps on the west side could be modified to one single intersection and provide additional width at the TH 21 ramp terminal for queuing vehicles. This would create a more urban type of interchange that would fit better with the urbanizing area adjacent to TH 21.

Conclusions

The three Interstate 35 interchanges in the City of Faribault were built in the early 1970's. They were consistent with design guidelines in place at that time and are still consistent with most applicable design guidelines today.

However, the interchanges at TH 60 and TH 21 are beginning to outlive their design life. They were designed as rural interchanges and the land use around them has become increasingly urban. This has led to intersections, some being signalized, closely spaced to the ramp terminals. A more urban style interchange at both of these intersections would be a better fit today and in the future for both the TH 60 and TH 21 interchanges.

The CSAH 48 interchange is also mostly consistent with current design standards. This interchange would require major reconstruction if the city's land use plan were to change significantly to promote growth to the west of I-35 and south of TH 60. Growth and significant traffic generation in and around this area would be a valid reason to consider a full access interchange at this location.

MEMO

To: Mark Koegler, RLA

From: Howard Preston, PE
Chris Albrecht, AICP

Subject: Faribault Operations Analysis

Date: January 24, 2003

As part of transportation planning efforts, a traffic operations analysis was performed for the City of Faribault using existing and forecasted traffic counts. The objective of the operations analysis was to identify corridors and intersections experiencing or expected to experience congestion. The methodology used to identify the locations where congestion might be of concern and a summary of the results are provided in the following paragraph.

Level of Service Summary

The approach to the traffic operations analysis is derived from the established methodologies documented in the *Highway Capacity Manual* (TRB, 2000). The *Highway Capacity Manual* (HCM) contains a series of analysis techniques used to evaluate the operation of transportation facilities under specific conditions. The results of an HCM analysis are typically presented in the form of a letter grade (A-F) that provides a qualitative estimate of the operational efficiency or effectiveness. The letter grade determined by the HCM analysis is referred to as level of service (LOS). By definition, LOS A conditions represent high-quality operations (i.e. motorists experience very little delay or interference) and LOS F conditions represent very poor operations (i.e., extreme delay or severe congestion). In most larger urban areas (for example, the Twin Cities), state and local agencies define the onset of congestion as the LOS D/E boundary. This study used the C/D boundary as the indicator of congestion as directed by the City of Faribault. An graphical explanation of level of service is shown in Figure 1.

LOS at roadway intersections is primarily a function of peak hour turning movement volumes, intersection lane configuration, and traffic control measures. For intersection analysis, HCM defines LOS in terms of the average control delay at the intersection in seconds per vehicle. From the HCM, the LOS for signalized and unsignalized Through-STOP intersections are shown in Table 1 below.

Table 1: Intersection Level-of-Service: Control Delay

LOS	Signalized Intersection	Through-STOP Intersection
A	≤ 10 sec.	≤ 10 sec.
B	10 – 20 sec.	10 – 15 sec.
C	20 – 35 sec.	15 – 25 sec.
D	35 – 55 sec.	25 – 35 sec.
E	55 – 80 sec.	35 – 50 sec.
F	> 80 sec.	> 50 sec.

Source: *2000 Highway Capacity Manual – Exhibits 16-2 and 17-2.*

The threshold values for Through-STOP intersections are slightly less than for signalized intersections because driver expectation of the intersection performance varies for different types of traffic control. For a Through-STOP controlled intersection, the movements that most often experience significant delays include:

- Minor street through traffic
- Minor street traffic turning left onto major street
- Major street left turning traffic onto minor street

Typical strategies to address minor street delays involve installing a traffic signal or prohibiting some of the minor street movements as part of a comprehensive access management plan of the corridor.

Arterial roadway LOS is a function of traffic volume, traffic flow characteristics, roadway cross-sections, traffic signal spacing, and traffic signal timing. For arterial roadway analysis, HCM defines LOS in terms of the average peak hour travel speed along a segment, including delay and stops. Since it was not feasible to either collect travel time data for the study network or model the entire Faribault street system (even just the roadways of interest), it was decided that another method to estimate roadway LOS was needed. The method selected is a chart developed at Howard R. Green Company that relates LOS to daily ADT (see Figure 2). Use of this chart is highly reliable on the assumptions used with the analysis and should not be used in design type situations, but is an appropriate tool for a comprehensive planning study focused on determining more general levels of operation.

Determining Roadway Capacity: Methodology of Modeling Intersections

The methodology for determining average delay per vehicle outlined in the HCM was varied for this analysis. The HCM approach analyzes delay at each intersection as being isolated from other intersections, with the exception of some correction for vehicle platoons. This approach is often classified as “macroscopic” as it does not analyze the individual performance of every vehicle.

With the increase in computer analysis capabilities, a more appropriate methodology of tracing vehicle statistics throughout the modeled network has proven to be more accurate and better suited for certain situations. This technique, called “microscopic” modeling provides a more reasonable estimation of actual traffic operations when intersections are closely spaced such that the zones of influence overlap, or queuing from one intersection bacsk through another intersection. This was a concern for some of the intersections analyzed, especially under forecast conditions.

For the analysis, the roadway characteristics, signal timing parameters, and traffic volumes were entered into Synchro™, a database management and macroscopic traffic analysis software program. To better document the actual traffic characteristics, the data were then transferred to SimTraffic™, a microscopic traffic analysis program. All intersection measures of effectiveness were obtained from SimTraffic™.

Data Collection

A variety of roadway and intersection information was first collected and gathered before the traffic operation analysis could begin. Much of the same information was needed for both the existing and forecast conditions, but for the ADT and turning movement counts, different sources were used.

For the segment analysis, the two key pieces of needed information were ADT and facility type (i.e., number of lanes and presence of turn lanes). The facility type for the existing conditions was gathered via a windshield survey of the city. To determine the facility type for the forecast conditions, the facility type was assumed to remain unchanged except for locations where the City had construction projects planned or underway. For the second piece of information, the ADT volumes were the 2000 ground counts used in the development of the Rice County model. At the time of the analysis, the provided ADT volumes had been collected as part of Mn/DOT's regular count program, had been preliminary smoothed and reviewed by Mn/DOT staff, but had not been finalized for general use. The forecast ADT volumes needed to determine the LOS estimates for the roadway segments were taken from the Rice County model. Using the future land use information developed by HKGi, the model was run to predict the future volumes.

The intersection information needed was peak hour turning movement volumes, lane geometry, and signal phasing information. For the existing condition, both the lane geometry and signal phasing was collected as part of the windshield survey. The peak hour turning movement counts for selected intersections were provided by Mn/DOT. Similar to the roadway facility type, the intersection geometry and signal phasing were assumed to remain unchanged unless the City provided information regarding planned projects at the intersection. The Rice County model used to determine the segment forecast volumes was also the basis for the forecast turning movement volumes. The key assumption to forecasting turning movements was that the relationship between existing approach ADT volumes and peak hour turning movement will remain unchanged. Therefore, using forecast ADT and the relationship between existing ADT and turning movements, the forecast turning movement volumes were estimated.

Results

Using the C/D boundary as the congestion index, three classifications of congestion were determined. Roadways and intersections with a LOS D, E, or F were classified as being congested. With a LOS A or B, an intersection or corridor was classified as being uncongested. Any intersection or corridor with a LOS C was classified as nearing congestion since it was only one letter grade away from the congestion boundary. A summary list of all roadway segments and intersections that were either classified as congested or nearing congested for both the existing and future conditions are identified below.

Existing Conditions

- Roads above congestion index.
    - TH 60 (8th Avenue NW to 4th Avenue NW; River crossing to TH 298/299)
    - 7th Street NW (TH 21 to 1st Avenue NE)
    - 1st Avenue NE (7th Street NE to TH 60)
    - Division Street (Old 4th Street to 1st Avenue W)
    - Willow Street (10th Street SW to TH 60)
    - 2nd Avenue NW (7th Street NW to TH 3)
    - Old 4th Street (Western Avenue to Park Avenue)

- Roads nearing congestion index.
  - TH 60 (TH 21 to 8th Avenue NW; 3rd Avenue NW to 2nd Avenue NW; 4th Street NE to Division Street; TH 298/299 to east city limits)
  - TH 3
  - 7th Street NW (Western Avenue to TH 21)
  - Division Street (1st Avenue W to TH 60)
  - 3rd Street NE (TH 60 to 3rd Ave NE)
  - Prairie Avenue SW (3rd Street SW to Division Street)
  - 9th Avenue SW (10th Street SW to 8th Street SW; 3rd Street SW to Division Street)
- Intersections above congestion index.
  - TH 60 / Irving Avenue
  - TH 21 / 17th Street NW
  - TH 21 / TH 3
  - TH 3 / 2nd Avenue NW
- Intersections nearing congestion index.
  - TH 60 / I-35 NB On-Ramp
  - TH 60 / Western Avenue
  - TH 60 / TH 21
  - TH 60 / TH 298/299

Future Conditions

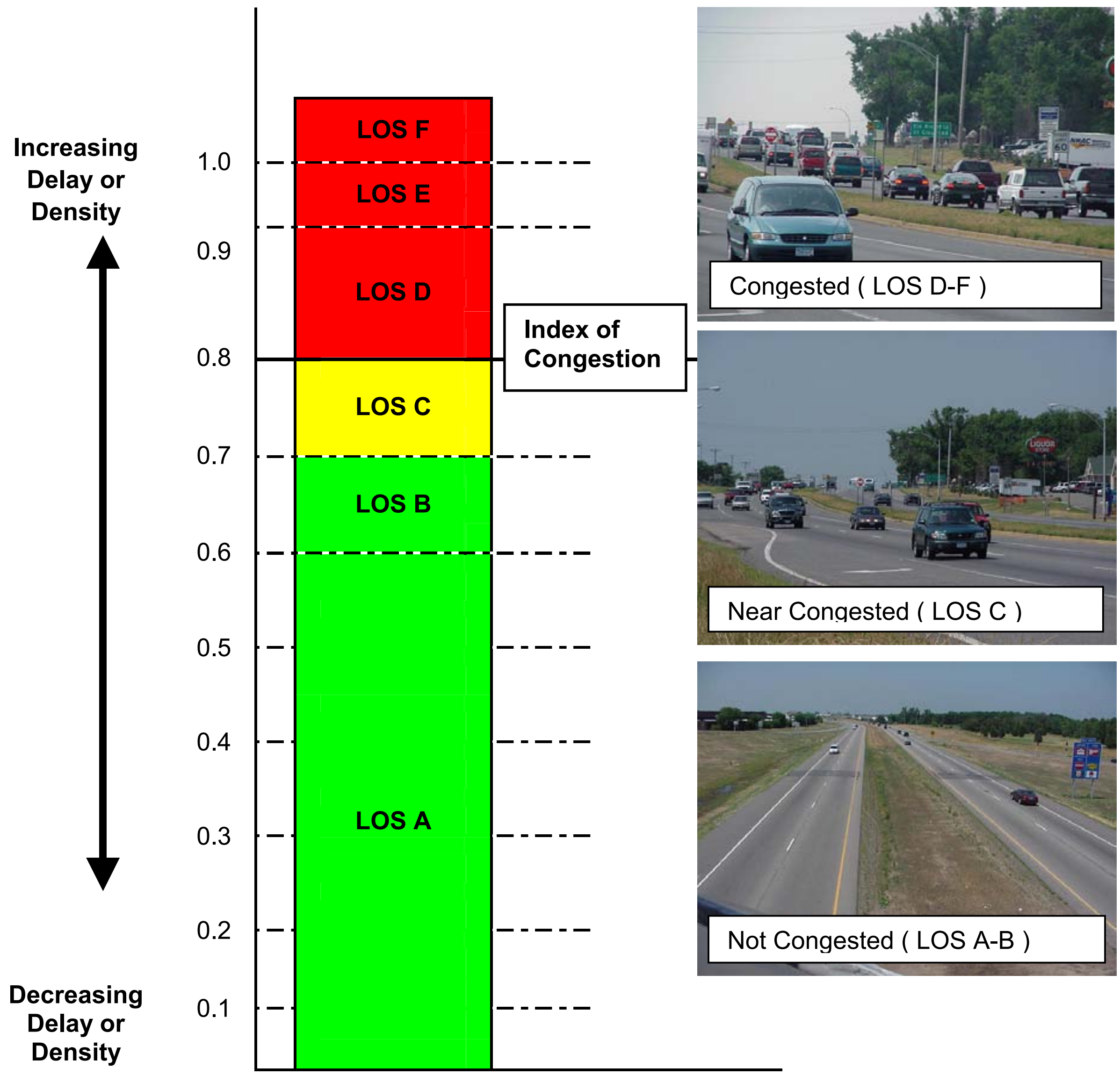
- Roads above congestion index.
  - TH 60 (west city limits to I-35; TH 21 to 1st Avenue NW; 4th Street NW to east city limits)
  - TH 21 (TH 60 to Airport Drive)
  - TH 3
  - 7th Street NW (I-35 to 1st Avenue NE)
  - 1st Avenue NE (7th Street NE to TH 60)
  - Division Street (Old 4th Street to Central Avenue)
  - 3rd Street NE (TH 60 to Shumway Avenue)
  - Willow Street (south city limits to TH 60)
  - 2nd Avenue NW (7th Street NW to TH 3)
  - Old 4th Street (Western Avenue to CSAH 48)
  - Western Avenue (Old 4th Street to TH 60)
  - 9th Avenue SW (17th Street SW to TH 60)
  - Saint Paul Avenue (Ravine Street to east city limits)
  - 17th Street SW (9th Avenue SW to Willow Street)
- Roads nearing congestion index.
  - I-35 (south city limits to CSAH 48; TH 60 to north city limits)
  - TH 60 (I-35 to TH 21; 1st Avenue NW to 1st Avenue NE)
  - CSAH 48 (Division Street to TH 60)
  - Western Avenue (CSAH 11 to 17th Street NW)
  - 17th Street NW (Western Avenue to TH 21)
  - Ravine Street (Shumway Avenue to St. Paul Avenue)
  - Shumway Avenue (TH 60 to St. Paul Avenue)
  - 14th Street NE (Central Avenue to Shumway Avenue)
  - Glenview Trail (Albers Path to Willow Street)
  - 17th Street SW (Prairie Avenue to 9th Avenue SW)

    - Prairie Street SW (Spring Road to Wellington Crescent; 10th Street SW to Division Street)
    - 30th Street (TH 21 to Industrial Drive; Alcorn Trail to TH 3)
- Intersections above congestion index.
    - TH 60 / I-35 NB On-Ramp
    - TH 60 / Western Avenue
    - TH 60 / TH 21
    - TH 60 / Irving Avenue
    - TH 60 / 9TH Avenue NE
    - TH 60 / 1st Avenue NE
    - TH 60 / Willow Street
    - TH 60 / TH 298/299
    - TH 21 / 7th Street NW
    - TH 21 / 17th Street NW
    - TH 21 / TH 3
    - TH 21 / CSAH 46
    - TH 3 / 2nd Avenue NW

Figure 1: Level of Service

HOW TRAFFIC CONGESTION IS DEFINED

THE LEVEL-OF-SERVICE (LOS) CONCEPT



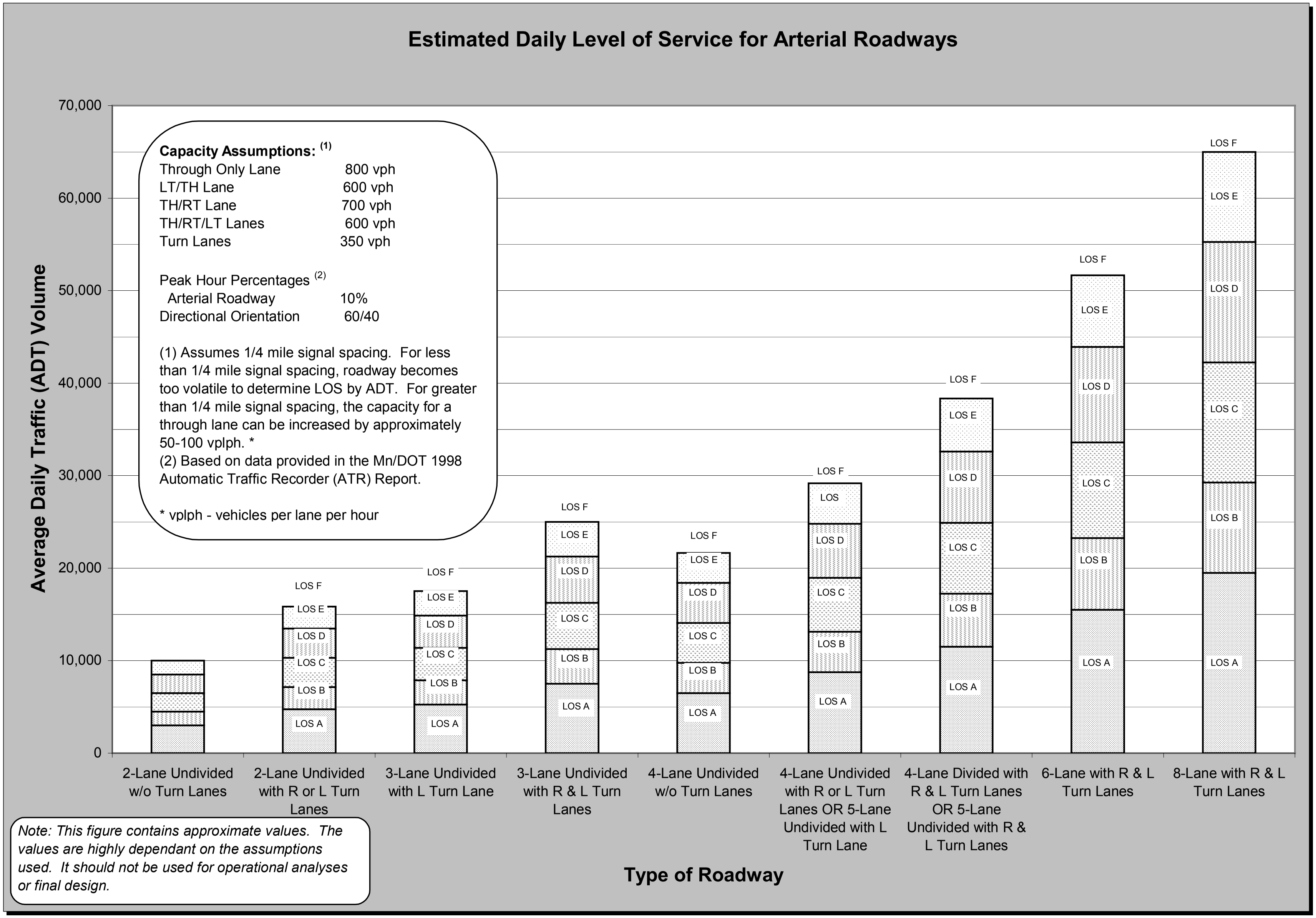
Definition: Level-of-Service (LOS) is an Estimate of the Quality of Traffic Flow.

Source: 2000 Highway Capacity Manual (Transportation Research Board)

Key Factors:
1. Roadway Geometry
2. Traffic Volume Characteristics
3. Intersections / Interchanges

Analysis Type: Segments - Freeway vs. Expressway vs. Urban Arterial, etc…
Intersections - Signalized vs. Unsignalized

Figure 2: ADT versus LOS Bar Charts



MEMO

To: Mark Koegler, RLA

From: Howard Preston, PE
Chris Albrecht, AICP

Subject: Transportation Model Input

Date: January 9, 2003

District 6 staff in Office of Planning at the Minnesota Department of Transportation (Mn/DOT) constructed the Rice County travel demand model between 2000 and 2001. As part of the modeling process, Rice County was divided into 258 traffic analysis zones (TAZs) and 12 external stations. A TAZ is an area in which all of the socioeconomic information is summarized. Each TAZ has a centriod, or where trips are assumed to begin and end. Each TAZ's employment (i.e., number of employees, type of work) and household (i.e., average household size, income, etc.) information is needed to estimate the number of trips that begin and end at each TAZ. External stations are placed at major roadways that lead into or out of the model area. Trips involving external stations are any trips that pass through the model area or have one endpoint (either beginning or ending) outside of the model area.

The creators of the Rice County travel demand model divided employment into the following 13 categories:

- Urban agricultural
- Rural agricultural
- Mining
- Construction
- Manufacturing
- Transportation & Communication
- Wholesale Trade
- Retail Trade
- Finance, Insurance, Real Estate (FIRE)
- Services
- Federal Government
- State Government
- Local Government

Using the Institute of Transportation Engineer's (ITE) Trip Generation Manual, Mn/DOT staff determined the average number of trips to a TAZ that an employee in each category would generate. Therefore, the number of employment based trips were determined using the number of employees in each category and the trip generation rate. To determine the generated trips from the households, the Rice County Model process was based upon the equation used in the travel demand model for the Twin Cities. The general inputs into this category are the average household size, number of vehicles per household, and average household income.

As part of developing the Faribault Comprehensive Plan, HKGi worked in partner with the City of Faribault and Mn/DOT to create a new land use plan for the city. This land use plan had several minor and major differences than the original land use planned used by Mn/DOT staff when developing the travel demand model. Therefore; HKGi then provided the forecasted number of employees by category and number of households in each TAZ based upon the land use plan. Using this information, the model inputs were updated and ran to determine the new traffic forecasts.

With the new land use plan, not all 13 categories of employment were changed from the original inputs. For the TAZs in and around the City of Faribault, the new socioeconomic information is summarized in Table 1 for the nine employment categories which had changes made and also the number of households by TAZ.

Table 1: 2000 and 2021 Socioeconomic Information by TAZ

	2000 - Number of Employees by Sector									2000	2021 - Number of Employees by Sector									2021
TAZ Number	Construction	Manufacturing	Transportation	Wholesale	Retail	FIRE	Services	State Gov.	Local Gov.	Households	Construction	Manufacturing	Transportation	Wholesale	Retail	FIRE	Services	State Gov.	Local Gov.	Households
1	0	0	10	5	0	0	0	0	0	0	0	0	12	5	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	171	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	471	0	0	0	0	0	0	0	0
4	0	600	0	0	0	0	0	0	0	0	0	653	0	0	0	0	0	0	0	0
5	207	100	126	110	0	0	40	10	0	0	285	479	148	130	0	0	40	11	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	342
7	0	0	0	20	0	0	0	0	0	23	0	0	0	20	0	0	0	0	0	100
8	71	550	0	0	0	0	20	0	30	0	93	550	0	19	0	0	20	0	44	23
9	0	0	0	0	0	0	0	0	0	80	0	0	0	0	0	0	0	0	0	80
10	0	8	50	24	33	0	0	0	45	68	0	8	59	24	33	0	0	0	66	80
11	0	0	0	0	0	0	0	0	0	150	0	0	0	0	0	0	0	0	0	235
12	0	0	30	14	0	0	0	0	0	0	0	0	35	21	0	0	0	0	0	150
13	0	0	0	0	0	0	0	0	0	84	0	0	0	0	0	0	0	0	0	0
14	0	0	0	20	11	0	10	0	0	14	0	0	0	20	228	0	168	0	0	50
15	6	0	0	0	11	0	111	0	0	102	8	0	0	0	11	0	133	0	0	14
16	0	0	0	0	0	0	5	0	0	0	0	0	0	0	645	0	5	0	0	0
17	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	515
18	3	0	0	0	0	0	0	0	0	365	4	0	0	0	0	0	0	0	0	626
19	0	0	0	0	0	0	0	0	0	128	0	0	0	0	0	0	0	0	0	557
20	0	0	0	0	0	0	0	0	0	97	0	0	0	0	0	0	0	0	0	228
21	6	0	0	0	11	0	101	0	0	10	8	0	0	0	11	0	101	0	0	0
22	0	0	0	0	0	0	0	0	0	26	0	0	0	0	147	0	217	0	0	6
23	12	0	10	5	1139	25	202	0	0	343	16	0	36	15	4556	116	808	0	0	0
24	0	0	0	0	0	0	51	0	0	294	0	0	0	0	570	0	51	0	0	864
25	0	225	0	0	0	0	0	0	0	30	0	225	0	0	0	0	0	0	0	300
26	0	50	0	0	0	0	0	0	0	0	0	50	0	0	0	0	140	0	0	115
27	12	50	0	0	56	0	81	0	0	0	16	50	0	0	56	0	81	0	0	0
28	0	0	0	60	0	0	51	0	0	37	0	0	0	0	0	0	51	0	0	135
29	12	0	20	9	0	0	40	0	0	37	16	0	24	9	0	0	40	0	0	144
30	0	0	0	0	334	10	51	0	0	29	0	0	0	0	417	15	63	0	0	40
31	0	0	0	0	11	0	70	0	0	55	0	0	0	0	11	0	70	0	0	70
32	12	350	25	12	33	0	0	0	0	52	16	350	29	12	66	0	0	0	0	55
33	0	0	0	0	22	25	51	0	0	94	0	0	0	0	532	29	196	0	0	52
34	0	0	0	0	0	0	0	0	0	233	0	0	0	0	760	0	280	0	0	233
35	0	150	0	0	0	0	0	0	0	14	0	150	0	0	0	0	0	0	0	233
36	0	550	0	0	11	0	60	0	0	28	0	550	0	19	11	0	60	0	0	246
37	0	0	0	0	0	0	0	0	0	110	0	0	0	0	0	0	0	0	0	174
38	0	0	0	0	44	50	51	0	0	16	0	0	0	0	53	70	61	0	0	60
39	6	0	50	24	389	100	101	0	0	35	8	0	59	24	389	118	101	0	0	16
40	0	0	0	0	0	0	20	0	0	207	0	0	0	0	0	0	20	0	0	207
41	0	290	0	0	0	0	101	0	30	24	0	290	0	10	0	0	101	0	44	232
42	0	0	10	5	0	15	222	0	0	0	0	0	12	5	0	18	222	0	0	424
43	0	0	0	0	0	0	0	0	30	113	0	0	0	0	0	0	0	0	44	163
44	0	0	0	0	0	0	0	160	0	0	0	0	0	0	0	0	0	178	0	113
45	0	0	0	0	0	0	0	0	0	132	0	0	0	0	0	0	0	0	0	0
46	3	0	0	0	0	0	100	0	0	31	4	0	0	0	0	0	100	0	0	132
47	0	0	0	0	0	0	10	0	0	179	0	0	0	0	0	0	10	0	0	390
48	0	0	0	0	0	0	152	0	0	71	0	0	0	0	0	0	152	0	0	364
49	0	0	0	0	0	0	607	570	0	598	0	0	0	0	0	0	715	636	0	777
50	0	0	0	0	11	0	0	0	0	114	0	0	0	0	55	0	250	0	0	234
51	4	0	40	19	111	0	202	0	120	228	5	0	47	19	111	0	202	0	176	114
52	0	0	0	0	0	0	101	0	345	56	0	0	0	0	0	0	101	0	505	90
53	0	0	0	0	33	40	101	0	0	180	0	0	0	0	39	56	121	0	0	225
54	0	0	0	0	0	0	20	0	0	85	0	0	0	0	0	0	20	0	0	180
55	0	0	0	0	0	0	0	0	0	288	0	0	0	0	0	0	0	0	0	288
56	0	0	0	0	0	0	71	0	0	95	0	0	0	0	0	0	71	0	0	115
57	0	0	0	0	0	0	0	0	20	40	0	0	0	0	0	0	0	0	29	60
58	0	0	0	0	0	0	0	0	0	107	0	0	0	0	0	0	0	0	0	179
59	0	50	5	12	0	0	10	0	0	0	0	50	6	12	0	0	10	0	0	30
60	0	0	0	0	0	0	0	0	0	56	0	0	0	0	0	0	0	0	0	56
61	0	0	0	20	11	0	20	0	0	407	0	0	0	20	11	0	20	0	0	407
62	0	0	0	0	0	0	10	0	0	245	0	0	0	0	0	0	10	0	0	356
63	0	0	0	0	0	0	0	0	0	363	0	0	0	0	0	0	0	0	0	363
64	0	0	0	0	11	0	120	0	0	430	0	0	0	0	11	0	120	0	0	430
65	0	0	0	0	33	0	10	0	0	254	0	0	0	0	33	0	10	0	0	300
66	0	0	0	0	0	0	0	0	0	190	0	0	0	0	0	0	0	0	0	867
67	0	0	0	0	11	0	708	0	0	179	0	0	0	0	11	0	708	0	0	190
68	0	0	0	0	0	0	0	0	0	117	0	0	0	0	0	0	0	0	0	117
69	0	0	0	0	0	0	263	60	0	77	0	0	0	0	0	0	263	67	0	77
70	0	20	50	24	0	0	10	0	0	0	0	20	59	24	0	0	10	0	0	77
71	9	0	0	0	0	0	0	0	0	53	12	0	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	51	0	0	70	0	0	0	0	0	0	51	0	0	53
73	0	0	0	0	44	0	101	0	0	5	0	0	0	0	44	0	101	0	0	70
74	0	0	0	0	44	6	20	0	0	0	0	0	0	0	44	7	20	0	0	5
75	0	0	0	0	17	0	0	0	0	40	0	0	0	0	133	0	0	0	0	0
137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
225	0	0	0	0	0	0	0	0	0	0	0	1755	0	0	0	0	0	0	0	0
228	0	0	0	0	0	0	0	0	0	0	0	0	0	0	280	0	0	0	0	1869
229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	95
231	0	0	0	0	0	0	0	0	0	0	0	0	0	0	115	0	0	0	0	576
250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1120	0	108	0	0	0
251	0	0	0	0	0	0	0	0	0	37	0	0	0	0	50	0	60	0	0	56
253	0	0	0	0	0	0	150	0	0	0	0	0	0	0	0	0	150	0	0	20
254	0	0	0	0	0	0	0	0	0	0	0	0	0	0	563	0	0	0	0	120
258	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1437

NOTE: Only the employment categories in which changes were made from the original model are presented