APPENDIX A

TRAFFIC ANALYSIS

TRAFFIC ANALYSIS

This appendix provides a summary of existing traffic and capacity conditions, and a comparative analysis of design-year (2030) traffic operations for the No Build and proposed Build Alternatives. Additional existing and future traffic and capacity analysis for existing and forecasted traffic are included in the I-*196/I-96 and M-37/M-44 EA Traffic Analysis* Technical Report which is available upon request. Listed below is a list of the capacity improvements along the I-196, I-96 and M-37/M-44 (East Beltline) corridors that are included in the Build Alternative.

Proposed Capacity Improvements

I-196

- Construct a third through lane in each direction between US-131 and I-96.
- Construct auxiliary weave-merge lanes in each direction between Ionia Avenue/Ottawa Avenue and College Avenue interchanges.
- Construct auxiliary weave-merge lanes in each direction between College Avenue and Fuller Avenue interchanges.
- Construct a ramp from westbound I-196 to northbound US-131BR (Division Avenue).
- Convert existing Division Avenue to one-way northbound between I-196 and Mason Street. Convert existing Ionia Avenue to one-way southbound between Mason Street and I-196.
- Eliminate Hastings Street from the existing north ramp terminal intersection of the I-196/College Avenue interchange.
- Construct additional laneage and storage at the College Avenue and Fuller Avenue interchanges.

I-96

- Construct a third through lane in each direction between M-44 and Cascade Road.
- Construct an eastbound I-196 to westbound I-96 fly-over ramp.
- Construct a eastbound I-96 to westbound I-196 ramp.
- Construct collector-distributor road on eastbound I-96 between I-196 and M-44.
- Construct collector-distributor road on westbound I-96 between M-44 and Leonard Street.
- Reconstruct the eastbound I-96 on-ramp from Leonard Street and construct additional laneage and storage at the I-96/Leonard Street interchange.
- Construct an auxiliary weave-merge lane on eastbound I-96 between M-44 and M-21.
- Widen the existing eastbound I-96 off-ramp to M-21 and provide access to eastbound M-21.
- Construct an eastbound I-96 on-ramp from M-21.
- Construct a westbound I-96 off-ramp to M-21.
- Construct a two-lane on-ramp from Cascade Road to westbound I-96.

M-37/M-44 (East Beltline)

- Construct a third through lane in each direction from north of Knapp Street to M-21.
- Increase capacity and storage of the directional median crossovers at Leonard Street and Knapp Street.
- Improve turning lane capacity at various locations along the corridor.

Traffic Analysis-Base Year (2004) Traffic

Conventional analysis of basic freeway segments, ramp-freeway ramps, weave sections, signalized intersections and unsignalized intersections involves the determination of a "Level of Service" (LOS). Levels of Service range from "A" to "F", similar to an alphabetic grading system, with each level describing a different set of operational characteristics. LOS "A" describes operational performance under light traffic volumes and minimal delay. LOS "F" describes a high degree of congestion with extensive delays and queuing. LOS "D" is commonly considered to be acceptable for peak-hour traffic operations in urbanized areas.

Freeway Segments-Base Year
The existing (2004) peak-hour Levels of Service for the I-196 and I-96 basic freeway segments are depicted in **Table 1**. Capacity analysis worksheets for all existing (2004) basic freeway segment analyses are available on request.

TABLE 1
EXISTING (2004) PEAK-HOUR LEVELS OF SERVICE
BASIC FREEWAY SEGMENTS

Free-way	Segment	AM-Peak Hour				PM-Peak Hour			
		Eastbound		Westbound		Eastbound		Westbound	
		Volume	LOS	Volume	LOS	Volume	LOS	Volume	LOS
I-196	Ionia to College	**4410**	**F**	**3610**	**E**	**4150**	**F**	**3980**	**F**
I-196	College to Fuller	**3860**	**E**	**3770**	**E**	**3880**	**F**	**3760**	**E**
I-196	Fuller to I-96	3210	D	3020	C	3310	D	3340	D
I-96	North of Leonard	3010	C	1530	B	1520	B	3140	D
I-96	Leonard to I-196	2780	C	1410	B	1550	B	2730	C
I-96	I-196 to M-44	Weave Analysis. See Table 2-4.							
I-96	M-44 to M-21	5110	D	3730	C	4050	C	5210	D
I-96	M-21 to Cascade	**4240**	**F**	2490	C	3100	D	**4350**	**F**

Source: URS Corporation, November 2004

As noted above, there are numerous basic freeway segments (shaded areas) which operate at unacceptable Levels of Service. These results reveal the need for additional freeway capacity on I-96 and I-196.

Ramp-Freeway Junctions-Base Year

The existing (2004) peak-hour Levels of Service for the I-196 and I-96 ramp-freeway junctions are depicted in **Table 2**. Some ramps cannot be analyzed by the methods of the *2000 Highway Capacity Manual* because some ramps do not create merge or diverge conditions, but rather involve adding or dropping a freeway lane or creating a weave section. Capacity analysis worksheets for all existing (2004) ramp-freeway junction are available on request.

As shown in **Table 2**, there are numerous ramp-freeway junctions (shaded areas) which operate at unacceptable Levels of Service. Some of the ramps have low volumes, but the merge and/or diverge influence areas have dense volumes of traffic due to the high volumes of traffic on the freeway. These results reveal the need for additional freeway capacity on I-96 and I-196.

TABLE 2
EXISTING (2004) PEAK-HOUR LEVELS OF SERVICE
RAMP-FREEWAY JUNCTIONS

Ramp Location	AM-Peak Hour		PM-Peak Hour	
	Ramp Volume	LOS	Ramp Volume	LOS
Eastbound On-Ramps				
Ionia Avenue On-ramp to EB I-196	**190**	**F**	**680**	**F**
College Avenue On-ramp to EB I-196	**290**	**E**	**460**	**E**
Fuller Avenue On-ramp to EB I-196	250	D	330	D
Leonard Street On-ramp to EB I-96	360	C	280	B
M-44 On-ramp to EB I-96	450	D	400	C
Westbound On-Ramps				
Ionia Avenue On-ramp to WB I-196	280	Add-lane	920	Add-lane
College Avenue On-ramp to WB I-196	720	D	**620**	**F**
Fuller Avenue On-ramp to WB I-196	**1030**	**E**	**1000**	**E**
Leonard Street On-ramp to WB I-96	240	B	650	D
SB M-44 On-ramp to WB I-96	630	Weave	610	Weave
NB M-44 On-ramp to WB I-96	600	C	920	D
M-21 On-ramp to WB I-96	1240	Add-lane	860	Add-lane
Cascade Road On-ramp to WB I-96	1000	C	**1630**	**F**
Eastbound Off-Ramps				
EB I-196 Off-ramp to Ottawa Avenue	420	Drop-lane	230	Drop-lane
EB I-196 Off-ramp to College Avenue	**840**	**F**	**730**	**F**
EB I-196 Off-ramp to Fuller Avenue	**900**	**E**	**900**	**E**
EB I-96 Off-ramp to Leonard Street	590	D	250	B
EB I-96 Off-ramp to M-44	1330	Weave	1210	Weave
EB I-96 Off-ramp to M-21	870	Drop-lane	950	Drop-lane
EB I-96 Off-ramp to WB Cascade Rd	**830**	**F**	420	D
Westbound Off-Ramps				
WB I-196 Off-ramp to Ottawa Avenue	1050	D	**270**	**F**
WB I-196 Off-ramp to College Avenue	**880**	**E**	**400**	**E**
WB I-196 Off-ramp to Fuller Avenue	280	D	580	D
WB I-96 Off-ramp to Leonard Street	120	B	240	C
WB I-96 Off-ramp to M-44	530	C	670	D

Add-Lane: Ramp lane creates an add-on lane and cannot be analyzed by methods of HCM. Drop-Lane: Freeway lane is dropped at off-ramp and cannot be analyzed by methods of HCM. Weave: Ramp is part of a weave segment. See Table 4.

Weave Sections-Base Year

The existing (2004) peak-hour Levels of Service for the two weave sections in the project limits are depicted in **Table 3.** Each weave section operates at Level of Service "E" or "F" in at least one of the peak hours. The weave analyses results are indicative of the bottleneck conditions created by these weave sections during peak hours. Movement-by-movement Levels of Service are shown in the ***I-196/I-96 and M-37/M-44 EA Traffic Analysis*** **Technical Report.** Capacity analysis worksheets for all existing (2004) weave section analyses are available on request.

TABLE 3
EXISTING (2004) PEAK-HOUR LEVELS OF SERVICE
WEAVE SECTIONS

Freeway	Section	Length (feet)	Peak	V a-c	V a-d	V b-c	V b-d	LOS
EB I-96	I-196 to M-44 (Type C Weave)	900	**AM**	**2380**	**400**	**2280**	**930**	**E**
			PM	1320	230	2330	980	D
WB I-96	M-44 to I-196 (Type B Weave)	1400	AM	2640	1160	380	250	D
			PM	**2970**	**2490**	**370**	**240**	**F**
EB I-96	M-44 to M-21	Weave length greater than HCM weave boundaries. Analyzed as freeway segment.						
WB I-96	M-21 to M-44	Weave length greater than HCM weave boundaries. Analyzed as freeway segment.						

V a-c = Freeway-to-freeway volume (mainline through); V a-d = Freeway to Ramp
V b-c = Ramp to Freeway; V b-d = Ramp to Ramp

Signalized Intersections-Base Year

The existing (2004) peak-hour Levels of Service for the signalized intersections within the project limits are depicted in **Table 4**. Movement-by-movement Levels of Service are shown in the *I-196/I-96/M-44 Technical Report*. Capacity analysis worksheets for all existing (2004) signalized intersection analyses are available on request.

TABLE 4
EXISTING (2004) PEAK-HOUR LEVELS OF SERVICE
SIGNALIZED INTERSECTIONS

Signalized Intersection	AM-Peak Hour		PM-Peak Hour	
	Level of Service	Average Delay (sec/veh)	Level of Service	Average Delay (sec/veh)
Ottawa Avenue / Michigan Street	C	23.9	C	34.1
Ionia Avenue / Michigan Street	**E**	**62.9**	**F**	**82.2**
EB I-196 / College Avenue	B	18.8	C	30.5
WB I-196 / College Avenue	D	48.9	C	30.5
EB I-196 / Fuller Avenue	C	29.1	**F**	**83.2**
WB I-196 / Fuller Avenue	D	51.2	D	53.4
EB I-96 / Leonard Street	B	16.9	B	12.9
M-44 / M-21	**E**	**61.3**	**E**	**60.1**
M-44 / Michigan Street	D	40.9	C	26.3
M-44 / EB I-96	C	23.7	**E**	**62.5**
M-44 / WB I-96	B	18.1	D	41.9
M-44 / Leonard Street	D	40.4	**E**	**71.3**
M-44 / Knapp Street	**E**	**77.6**	D	41.0

Source: URS Corporation, November 2004

As shown in **Table 4** on the previous page, six of the thirteen signalized intersections in the study area operate at an unacceptable Level of Service during at least one of the two existing (2004) peak hours.

It should be noted that the Levels of Service depicted at the College Avenue and Fuller Avenue interchanges are worse than shown in **Table 4**. The *Highway Capacity Software* is limited in its ability to analyze congestion, and *the results do not account for the fact that the left-turn movements entering the freeway at those locations back up into the adjacent intersection.*

Each of the M-44 signals which simultaneously stop northbound and southbound traffic (M-21, EB I-96 off-ramp, Leonard Street, and Knapp Street) operate at Level of Service "E" of "F", indicating the need for additional capacity along East Beltline Avenue.

Comparison of Build Alternative and No-Build Alternative

Basic Freeway Segments

A comparison of the results of the various capacity analyses (basic freeway segments, ramp/junction and signalized intersections) is presented in the following tables for the Build and the No-Build Alternatives. Future traffic volumes were forecasted using the Grand Rapids MPO model sub-set of the MDOT Statewide Model coupled with a review of historical growth in the project area.

Major differences between the alternatives include increased traffic induced by the additional capacity provided in the Build Alternative. In addition, traffic volumes on I-96 west of the I-196 junction are greater under the Build Alternative due to the redistribution of trips and attraction of new trips associated with construction of the proposed new, eastbound I-96 to westbound I-196 and eastbound I-196 to westbound 1-96, freeway-to-freeway ramps at the I-96/I-196 interchange. This additional traffic is caused by travel pattern changes for both freeway to freeway and freeway interchange access routes. Freeway trip length, especially for the Plainfield Avenue, Leonard Street, and Fuller Avenue interchanges, will be shortened by using the new freeway to freeway ramps. As a result, some trips currently using US-131 to access I-196 interchanges, are projected to use I-96 to access I-196 via the new ramps when completed. As shown in **Tables 5 and 6**, the Build Alternative operates at an acceptable Level of Service for the freeway segments in the project area.

TABLE 5
DESIGN YEAR (2030) MORNING PEAK-HOUR LEVELS OF SERVICE
BASIC FREEWAY SEGMENTS
NO-BUILD AND BUILD ALTERNATIVE COMPARISON

Free way	Segment	2030 No Build				2030 Build Alternative			
		Eastbound		Westbound		Eastbound		Westbound	
		Volume	LOS	Volume	LOS	Volume	LOS	Volume	LOS
I-196	Ionia to College	**5440**	**F**	**4460**	**F**	Weave Analysis. See Table 4			
I-196	College to Fuller	**4760**	**F**	**4660**	**F**	5130	D	5120	D
I-196	Fuller to I-96	**3970**	**E**	**3740**	**E**	4580	C	4430	C
I-96	M-44 to M-21	**6440**	**F**	4710	D	6930	C	4930	C
I-96	M-21 to Cascade	**5340**	**F**	3140	D	5990	C	3590	B

Source: URS Corporation, November 2004

TABLE 6
DESIGN YEAR (2030) EVENING PEAK-HOUR LEVELS OF SERVICE
BASIC FREEWAY SEGMENTS
NO-BUILD AND BUILD ALTERNATIVE COMPARISON

Freeway	Segment	2030 No Build				2030 Build Alternative			
		Eastbound		Westbound		Eastbound		Westbound	
		Volume	LOS	Volume	LOS	Volume	LOS	Volume	LOS
I-196	Ionia to College	**5130**	**F**	**4900**	**F**	Weave Analysis. See Table 4			
I-196	College to Fuller	**4800**	**F**	**4630**	**F**	5180	D	5090	D
I-196	Fuller to I-96	**4090**	**E**	**4120**	**E**	4710	D	4840	D
I-96	M-44 to M-21	4960	D	**6570**	**F**	5400	B	6880	D
I-96	M-21 to Cascade	**3760**	**E**	**5480**	**F**	4360	B	6110	C

Source: URS Corporation, November 2004

Ramp Freeway Junctions

As shown in **Table 7**, some ramps cannot be analyzed by methods of the *2000 Highway Capacity Manual* because some ramps do not create merge or diverge conditions but involve adding or dropping a freeway lane or creating a weave section. The Build Alternative operates at an acceptable Level of Service during design year (2030) peak hours.

TABLE 7
DESIGN YEAR (2030) PEAK-HOUR LEVELS OF SERVICE
RAMP-FREEWAY JUNCTIONS
NO-BUILD AND BUILD ALTERNATIVE COMPARISON

Ramp Location	AM-Peak Hour		PM-Peak Hour	
	No Build	Build	No Build	Build
Eastbound On-Ramps				
Ionia Avenue On-ramp to EB I-196	**F**	Weave	**F**	Weave
College Avenue On-ramp to EB I-196	**F**	Add-lane	**F**	Add-lane
Fuller Avenue On-ramp to EB I-196	**E**	D	**F**	D
Leonard Street On-ramp to EB I-96	D	Add lane	B	Add lane
M-44 On-ramp to EB I-96	**F**	Add lane	D	Add lane
M-21 On Ramp to EB I-96	N/A	Add lane	N/A	Add lane
Westbound On-Ramps				
Ionia Avenue On-ramp to WB I-196	Add-lane	Add lane	Add-lane	Add lane
College Avenue On-ramp to WB I-196	**F**	Weave	**F**	Weave
Fuller Avenue On-ramp to WB I-196	**F**	Add lane	**F**	Add lane
SB M-44 On-ramp to WB I-96	Weave	Weave	Weave	Weave
NB M-44 On-ramp to WB I-96	D	Weave	**F**	Weave
M-21 On-ramp to WB I-96	Add-lane	Add lane	Add-lane	Add lane
Cascade Road On-ramp to WB I-96	D	Add lane	**F**	Add lane
Eastbound Off-Ramps				
EB I-196 Off-ramp to Ottawa Avenue	Drop-lane	Drop-lane	Drop-lane	Drop-lane
EB I-196 Off-ramp to College Avenue	**F**	Weave	**F**	Weave
EB I-196 Off-ramp to Fuller Avenue	**F**	Drop-lane	**F**	Drop-lane
EB I-96 Off-ramp to M-44	N/A	Drop-lane	N/A	Drop-lane
EB I-96 Off-ramp to M-44	Weave	Drop-lane	Weave	Drop-lane
EB I-96 Off-ramp to M-21	Drop-lane	Drop-lane	Drop-lane	Drop-lane
EB I-96 Off-ramp to WB Cascade Rd	**F**	Drop-lane	**E**	Drop-lane
Westbound Off-Ramps				
WB I-196 Off-ramp to Ottawa Avenue	**F**	Weave	**F**	Weave
WB I-196 Off-ramp to College Avenue	**F**	Drop-lane	**F**	Drop-lane
WB I-196 Off-ramp to Fuller Avenue	**E**	D	**F**	D
WB I-96 Off-ramp to Leonard Street	B	Weave	D	Weave
WB I-96 Off-ramp to M-44	D	C	**F**	D
WB I-96 Off-ramp to M-21	N/A	Drop-lane	N/A	Drop-lane

Add-Lane: Ramp lane creates an add-on lane and cannot be analyzed by methods of HCM.
Drop-Lane: Freeway lane is dropped at off-ramp and cannot be analyzed by methods of HCM.
Weave: Ramp is part of a weave segment. See Table 4. Source: URS Corporation, November 2004

Weaving Sections

The proposed improvements of the Build Alternative create two new weave sections—along I-196 (in each direction) between the Ottawa Avenue and College Avenue interchanges. The improvements eliminate the existing weave along eastbound I-96 between I-196 and M-44. The existing weave along westbound I-96 between M-44 and I-196 still exists in the Build Alternative, but the volumes within the weave are reduced as I-96 "through" traffic is eliminated from the weave. **Table 8** shows each weave section operates at an acceptable Level of Service under design year (2030) peak hour traffic volumes for the Build Alternative.

TABLE 8
DESIGN YEAR (2030) PEAK-HOUR LEVELS OF SERVICE
RAMP-FREEWAY JUNCTIONS
NO-BUILD AND BUILD ALTERNATIVE COMPARISON

Freeway	Section		No Build	Build
EB I-196	Ionia to College	AM	N/A	D
		PM		D
WB I-196	College to Ionia	AM	N/A	D
		PM		D
EB I-196	College to Fuller	Weave length greater than HCM weave boundaries. Analyzed as freeway segment.		
WB I-196	Fuller to College	Weave length greater than HCM weave boundaries. Analyzed as freeway segment.		
EB I-196	I-196 to M-44	AM	**F**	N/A
		PM	**F**	
WB I-96	M-44 to I-196	AM	**E**	C
		PM	**F**	C
EB I-96	M-44 to M-21	Weave length greater than HCM weave boundaries. Analyzed as freeway segment.		
WB I-96	M-21 to M-44	Weave length greater than HCM weave boundaries. Analyzed as freeway segment.		
EB I-96	M-21 to Cascade	Weave length greater than HCM weave boundaries. Analyzed as freeway segment.		
WB I-96	Cascade to M-21	Weave length greater than HCM weave boundaries. Analyzed as freeway segment.		

Signalized Intersections

The comparison of signalized intersection capacities and levels of services shown in **Tables 9** and **10** confirm that all signalized intersections in the project area operate at an acceptable LOS under the Build Alternative. More detailed information on turning movements for existing, Build and No Build Alternatives are provided in the **I-*196/I-96 and M-37/M-44 EA Traffic Analysis* Technical Report.**

TABLE 9
DESIGN YEAR (2030) MORNING PEAK-HOUR LEVELS OF SERVICE
SIGNALIZED INTERSECTIONS
NO-BUILD AND BUILD ALTERNATIVE COMPARISON

Signalized Intersection	No-Build		Build Alternative	
	Level of Service	Average Delay (sec/veh)	Level of Service	Average Delay (sec/veh)
Ottawa Avenue / Michigan Street	C	34.0	C	30.7
Ionia Avenue / Michigan Street	**F**	**82.2**	D	48.0
EB I-196 / College Avenue	C	22.2	D	41.7
WB I-196 / College Avenue	**F**	**99.6**	C	20.6
EB I-196 / Fuller Avenue	**F**	**131.3**	C	28.1
WB I-196 / Fuller Avenue	**F**	**105.1**	C	26.1
EB I-96 / Leonard Street	C	29.5	C	21.3
WB I-96 / Leonard Street			D	43.8
M-44 / M-21	**F**	**164.6**	D	52.9
M-44 / Michigan Street	**F**	**168.2**	B	16.5
M-44 / EB I-96	**F**	**80.9**	D	47.0
M-44 / WB I-96	D	50.3	D	53.2
M-44 / Leonard Street	**F**	**141.6**	D	48.7
M-44 / Knapp Street	**F**	**192.5**	C	27.4

Note: Movement-by-movement LOS values are depicted on Figures 3-1a, 3-1b, 3-2a, 3-2b, 4-16a, 4-16b, 4-16c, 4-17a, 4-17b, and 4-17c.
Source: URS Corporation, November 2004

TABLE 10
DESIGN YEAR (2030) AFTERNOON PEAK-HOUR LEVELS OF SERVICE
SIGNALIZED INTERSECTIONS
NO-BUILD AND BUILD ALTERNATIVE COMPARISON

Signalized Intersection	No Build		Build Alternative	
	Level of Service	Average Delay (sec/veh)	Level of Service	Average Delay (sec/veh)
Ottawa Avenue / Michigan Street	C	32.9	C	30.7
Ionia Avenue / Michigan Street	**F**	**124.4**	D	48.0
EB I-196 / College Avenue	D	54.7	D	41.7
WB I-196 / College Avenue	**E**	**61.8**	C	20.6
EB I-196 / Fuller Avenue	**F**	**148.0**	C	28.1
WB I-196 / Fuller Avenue	**F**	**117.0**	C	26.1
EB I-96 / Leonard Street	B	16.4	C	21.3
WB I-96 / Leonard Street			D	43.8
M-44 / M-21	**F**	**269.3**	D	52.9
M-44 / Michigan Street	**F**	**172.9**	B	16.5
M-44 / EB I-96	**F**	**212.0**	D	47.0
M-44 / WB I-96	**F**	**181.1**	D	53.2
M-44 / Leonard Street	**F**	**257.9**	D	48.7
M-44 / Knapp Street	**F**	**95.5**	C	27.4

Note: Movement-by-movement LOS values are depicted on Figures 3-1a, 3-1b, 3-2a, 3-2b, 4-16a, 4-16b, 4-16c, 4-17a, 4-17b, and 4-17c.

Source: URS Corporation, November 2004

Signalized Intersections-Base Year

The existing (2004) peak-hour Levels of Service for the signalized intersections within the project limits are depicted in **Table 4**. Movement-by-movement Levels of Service are shown in the *I-196/I-96/M-44 Technical Report*. Capacity analysis worksheets for all existing (2004) signalized intersection analyses are available on request.

TABLE 4
EXISTING (2004) PEAK-HOUR LEVELS OF SERVICE
SIGNALIZED INTERSECTIONS

Signalized Intersection	AM-Peak Hour		PM-Peak Hour	
	Level of Service	Average Delay (sec/veh)	Level of Service	Average Delay (sec/veh)
Ottawa Avenue / Michigan Street	C	23.9	C	34.1
Ionia Avenue / Michigan Street	**E**	**62.9**	**F**	**82.2**
EB I-196 / College Avenue	B	18.8	C	30.5
WB I-196 / College Avenue	D	48.9	C	30.5
EB I-196 / Fuller Avenue	C	29.1	**F**	**83.2**
WB I-196 / Fuller Avenue	D	51.2	D	53.4
EB I-96 / Leonard Street	B	16.9	B	12.9
M-44 / M-21	**E**	**61.3**	**E**	**60.1**
M-44 / Michigan Street	D	40.9	C	26.3
M-44 / EB I-96	C	23.7	**E**	**62.5**
M-44 / WB I-96	B	18.1	D	41.9
M-44 / Leonard Street	D	40.4	**E**	**71.3**
M-44 / Knapp Street	**E**	**77.6**	D	41.0

Source: URS Corporation, November 2004

As shown in **Table 4** on the previous page, six of the thirteen signalized intersections in the study area operate at an unacceptable Level of Service during at least one of the two existing (2004) peak hours.

It should be noted that the Levels of Service depicted at the College Avenue and Fuller Avenue interchanges are worse than shown in **Table 4**. The *Highway Capacity Software* is limited in its ability to analyze congestion, and *the results do not account for the fact that the left-turn movements entering the freeway at those locations back up into the adjacent intersection.*

Each of the M-44 signals which simultaneously stop northbound and southbound traffic (M-21, EB I-96 off-ramp, Leonard Street, and Knapp Street) operate at Level of Service "E" of "F", indicating the need for additional capacity along East Beltline Avenue.

APPENDIX B

TRAFFIC CRASH ANALYSIS

TRAFFIC CRASH ANALYSIS

Crash statistics were provided by MDOT for the most recent five-year span (1999-2003). Crash data was provided for freeway segments, ramps, and ramp terminals on I-196 and I-96 and the boulevard segment of M-44/M-37.

I-196 and I-96

Freeway Segment Crash Analysis

A crash analysis was completed for each freeway segment along I-196 and I-96 in the study area. The total number of crashes by freeway segment, a breakdown of crashes by type, and an overall crash rate for each freeway segment is depicted in Table B-1.

As shown in Table B-1, 1,525 crashes occurred within the study area freeways from 1999 to 2003. A total of 327 (21%) of these crashes resulted in injuries. There were three reported fatalities during the five-year period. A double fatality occurred on westbound I-196 between Ottawa Avenue and US-131—a rear-end crash which occurred at dusk just east of the I-196 westbound on-ramp from Ionia Avenue. One fatality involved a pedestrian and occurred on eastbound I-196 between US-131 and Ottawa Avenue. The pedestrian fatality occurred at night in the vicinity of the diverge point of the I-196 eastbound off-ramp to Ottawa Avenue.

Freeway segments that experienced higher than average crash rates as compared to statewide averages are shaded in Table B-1. Three segments on I-196 and one segment on I-96 experience higher than average crash rates compared to other similar facilities in the state from 1999-2003. These segments are on I-196 between Ottawa Avenue and College Avenue (both eastbound and westbound segments), westbound I-196 between College Avenue and Fuller Avenue, and eastbound I-96 between Leonard Street and I-196.

The higher-than-average crash rate on I-196 between Ottawa Avenue and College Avenue are partly attributed to the heavy traffic volumes on the segment and peak-hour traffic congestion. Both eastbound and westbound at this segment had a high level of Rear-End crashes – 65% eastbound and 81% westbound. High levels of rear-end crashes are common on congested freeways. Also, the 4% uphill grade on eastbound I-196 on this segment reduces travel speed and capacity, particularly for large trucks, which creates rear-end crashes.

The higher-than-average rate on westbound I-196 between College Avenue and Fuller Avenue are partly attributed to the heavy traffic volumes associated with peak-hour traffic congestion. The segment had a very high level of rear-end crashes (87%). High levels of rear-end crashes are common on congested freeways.

The higher-than-average crash rate on eastbound I-96 between Leonard Street and I-196 can be attributed to the curvature of this segment, the high number of lane changes associated with the subsequent merge with I-196, and the weave movement needed to exit at M-44.

TABLE B-1
CRASH ANALYSIS SUMMARY (1999-2003)
I-196 AND I-96 FREEWAY SEGMENTS

Freeway	Section		Type of Crash						Crash Rate*
			Total	Rear--End	Side-Swipe	Fixed Object	Angle	Other	
I-196 (1)	US-131 to Ottawa Avenue	EB	118	75	19	14	2	8	364
		WB	70	38	10	10	0	12	181
I-196 2-Lane	Ottawa Avenue to College Avenue	EB	153	100	22	18	1	12	**262**
		WB	141	114	8	6	0	13	**297**
I-196 2-Lane	College Avenue to Fuller Avenue	EB	79	54	9	4	0	12	132
		WB	212	185	10	3	0	14	**311**
I-196 2-Lane	Fuller Avenue to I-96	EB	138	67	23	22	5	21	117
		WB	133	53	14	36	4	26	113
I-96 2-Lane	Leonard Street to I-196	EB	45	6	4	13	0	22	**221**
		WB	32	4	6	4	2	16	181
I-96 (1)	I-196 to M-44	EB	126	58	22	17	3	26	293
		WB	106	34	23	15	8	26	218
I-96 3-Lane	M-44 to M-21	EB	97	29	14	17	6	31	175
		WB	75	14	22	11	1	27	130
TOTALS:			1525	831	206	190	32	266	
Percent:			100%	55%	14%	12%	2%	17%	

* - Per 100 million vehicle miles traveled

Notes: 1. The statewide average crash rate is 206 crashes per 100 million VMT for 4-lane divided, limited-access urban highways.
2. The statewide average crash rate is 438 crashes per 100 million VMT for 6-lane divided, limited-access urban highways.

(1) 4-Lane Eastbound, 3-Lane Westbound

Source: Michigan Department of Transportation, November 2004

Freeway Crash Countermeasures

Various countermeasures are incorporated into the Build Alternative which will decrease the potential for traffic crashes for the high-crash segments listed in TableB-1 and for the entire study area. These countermeasures include: Construction of additional freeway capacity to minimize congestion and unexpected traffic back-ups; construction of weave-merge lanes between Ottawa Avenue and College Avenue and between College Avenue and Fuller Avenue to increase ramp-freeway merge capacity; and construction of collector-distributor roads on I-96 between I-196 and M-44 to eliminate weave movements.

Additional countermeasures which could be erected prior to full build-out include: Construction of a "choice" lane at the eastbound I-96 exit to M-44, providing the outside through lane the choice of staying on I-96 or exiting at M-44. A choice lane would reduce the number of lane changes required by an eastbound I-96 motorist who desires to exit at M-44. Only one lane change would be required if a "choice" lane were constructed, whereas this maneuver currently requires a two-lane change.

Erection of a permanent variable message sign on westbound I-196 at Plymouth Avenue warning of traffic backups ahead at Fuller Avenue or College Avenue. Static signing on eastbound I-196 warning motorists of SLOW TRUCKS climbing the hill between Ottawa Avenue and College Avenue.

Ramp Crash Analysis

A crash analysis was completed for each ramp along I-196 and I-96 in the study area. The total number of crashes by ramp and a breakdown of crashes by type are depicted in Table B-2.

As shown in Table B-2, 109 crashes occurred on study area ramps from 1999 to 2003. A total of 28 (26%) of these crashes resulted in injuries. There were two reported fatalities on study area ramps in the five-year period. One fatality involved a one-vehicle rollover crash on the westbound I-96 loop exit ramp to Leonard Street. The other fatality involved a one-vehicle rollover crash on the eastbound I-96 off ramp at the merge point with eastbound M-21.

The majority of ramps (14 of 23 ramps) averaged less than one crash per year. MDOT does not compute crash rates for freeway ramps. Total crashes over the five-year period ranged from zero crashes at three ramps to 12 crashes at both the I-196 westbound Ionia Avenue on-ramp and the I-96 eastbound M-21 off-ramp.

TABLE B-2
CRASH ANAYLSIS SUMMARY (1999-2003)
I-196 AND I-96 RAMPS

Interchange	Ramp Type	Total	Rear-End	Side-swipe	Fixed Object	Angle	Other	Crashes per Year
Ottawa Avenue/ I-196	EB Off - Slip	2	2	0	0	0	0	0.4
	WB Off - Loop	10	2	1	2	2	3	2.0
Ionia Avenue/ I-196	EB On - Loop	0	0	0	0	0	0	0.0
	WB On - Slip	12	0	1	6	2	3	2.4
College Avenue/ I-196	EB Off - Slip	2	1	0	0	0	1	0.4
	EB On - Slip	4	3	0	0	0	1	0.8
	WB Off - Slip	2	0	0	0	0	2	0.4
	WB On - Slip	0	0	0	0	0	0	0.0
Fuller Avenue/ I-196	EB Off - Slip	1	1	0	0	0	0	0.2
	EB On - Slip	3	1	0	1	1	0	0.6
	WB Off - Slip	2	0	0	1	0	1	0.4
	WB On - Slip	0	0	0	0	0	0	0.0
Leonard Street/ I-96	EB Off - Slip	2	2	0	0	0	0	0.4
	EB On - Slip	1	0	0	0	1	0	0.2
	WB Off - Loop	10	0	0	3	0	7	2.0
	WB On - Slip	9	0	2	2	0	5	1.8
M-44/I-96	EB Off - Slip	9	4	0	2	0	3	1.8
	EB On - Loop	3	1	0	0	1	1	0.6
	WB Off - Slip	4	2	0	1	0	1	0.8
	SB>WB On - Slip	3	1	0	1	0	1	0.6
	NB>WB On - Loop	8	3	1	2	0	2	1.6
M-21/I-96	EB Off - Slip	12	1	0	5	0	6	2.4
	WB On - Slip	10	2	0	1	0	7	2.0
TOTALS:		109	26	5	27	7	44	
Percent:		100%	24%	5%	25%	6%	40%	

* - Per 100 million vehicle miles traveled Source: Michigan Department of Transportation, November 2004

Ramp Crash Countermeasures

Various countermeasures are incorporated into the Build Alternative which will decrease the potential for traffic crashes on the freeway ramps in the study area. These countermeasures include: Increased storage for off-ramp approaches; Lengthening of acceleration and deceleration lanes where possible; and Improved signage and attenuation for all ramp movements which require a significant decrease in speed in order to navigate the ramp (westbound I-196 at Ottawa Avenue and westbound I-96 at Leonard Street).

Ramp Terminal Crash Analysis

A crash analysis was completed for each ramp terminal intersection at the I-96 and I-196 interchanges within the study area. The total number of crashes per intersection by year, the average number of crashes per intersection, and the crash rate for each intersection is depicted in Table B-3.

As shown in Table B-3, the Ottawa Avenue/Michigan Street intersection has by far the highest crash rate (4.84 crashes per MEV), more than double the next highest rate. This ramp terminal has an unusual design with two off ramps and one local street merging only 300 feet before the signal with a resultant five-lane southbound approach at the intersection. Turn restrictions are posted for some movements at the intersection: "No Left Turn" for eastbound off-ramp traffic and "No Right Turn" for westbound off-ramp traffic. A total of 150 of the 272 crashes (55%) are on the southbound approach to the intersection. A review of crash types indicates that primarily two types of crashes occur on the southbound leg: angle crashes (41% of total) and side-swipe crashes (39%). These types of crashes are common at intersections like the Ottawa Avenue/Michigan Street intersection, where a high number of merges and lane changes occur.

While no average intersection crash rate statistics are compiled in West Michigan, the intersection crash rates were compared to average rates compiled by the Southeast Michigan Council of Governments (SEMCOG)—the local Metropolitan Planning Organization overseeing transportation decisions in the seven counties comprising the Detroit metropolitan area.

SEMCOG computes an average crash rate of 1.4 crashes per million-entering vehicles (MEV) at urban signalized intersections with an ADT of 20,000 to 30,000 vehicles per day, and an average crash rate of 1.2 crashes per MEV for signalized intersections with an ADT of greater than 30,000 vehicles per day. The average crash rate for unsignalized intersections with an ADT of 20,000 to 30,000 vehicles per day is 0.5 crashes per MEV. Assuming these average crash rates apply to West Michigan, Table B-3 reveals that six of the eight signalized ramp terminal intersections exceed the average rate and each of the unsignalized ramp terminal intersections exceed the average rate.

TABLE B-3
CRASH ANAYLSIS SUMMARY (1999-2003)
RAMP TERMINAL INTERSECTIONS

Intersection	Traffic Control	Number of Crashes							Crash Rate (per MEV*)
		1999	2000	2001	2002	2003	Total	Average (crashes/yr)	
Ottawa Ave / Michigan St	Signal	48	66	54	58	46	272	54.4	**4.84**
Ionia Ave / Michigan St	Signal	37	42	29	25	18	151	24.2	**2.49**
EB I-196 / College Ave	Signal	12	7	10	22	3	54	10.8	1.16
WB I-196 / College Ave	Signal	12	10	12	15	16	65	13.0	**1.54**
EB I-196 / Fuller Ave	Signal	28	21	27	18	9	103	20.6	**1.78**
WB I-196 / Fuller Ave	Signal	10	6	9	12	1	38	7.6	0.62
EB I-96 / Leonard St	Stop Sign (1)	6	9	3	5	n/a	23	5.8	**0.73**
WB I-96 / Leonard St	Stop Sign	4	3	3	7	12	29	5.8	**0.66**
EB I-96 / M-44	Signal	25	36	20	36	26	143	28.6	**1.51**
WB I-96 / M-44	Signal	19	13	17	21	19	89	17.8	**1.97**

* MEV = million entering vehicles Source: Michigan Department of Transportation, November 2004
(1) Unsignalized intersection from 1999 through 2002. This ramp terminal became signalized in 2003 and experienced 10 crashes that year.

Ramp Terminal Intersection Countermeasures

Various countermeasures are incorporated into the Build Alternative which will decrease the potential for traffic crashes at ramp-terminal intersections in the study area. These countermeasures include: Increased storage for off-ramp and surface street turn bays; Optimized traffic signal timing, including incorporation of all-red clearance phases; Turn prohibitions for turn movements with limited sight distance, and Improved lane definition through pavement markings.

East Beltline

Crash data for the East Beltline was also analyzed from approximately 300 feet south of M-21 to 300 feet north of Knapp Street. During the period from 1999 to 2003 there were 1,119 crashes resulting in 371 injuries and two fatalities (see Table B-4). Both fatalities occurred in 1999 just south of the Knapp Street intersection.

The segment from I-96 south to south of M-21 displayed a much higher crash rate than the statewide average for the same type of roadway, as shaded on Table B-4. This higher-than-average crash rate is also most likely due to heavy traffic volumes on the segment and peak hour congestion. The majority of crashes were rear-end crashes (65%), which is a common indicator of heavy congestion.

TABLE B-4
CRASH ANAYLSIS SUMMARY (1999-2003)
M-37 / M-44

	Total	**Rear--End**	**Side-Swipe**	**Fixed Object**	**Angle**	**Other**	
S of M-21 to I-96	412	286	29	12	35	50	**743**
I-96 to N of Knapp	707	445	56	19	106	81	428
TOTAL	1119	731	85	31	141	131	
Percent	100%	65%	7%	3%	13%	12%	

* - Per 100 million vehicle miles traveled

Notes: 1. The statewide average crash rate is 206 crashes per 100 million VMT for 4-lane divided, limited-access urban highways. 2. The statewide average crash rate is 438 crashes per 100 million VMT for 6-lane divided, limited-access urban highways. 3. The statewide average crash rate is 450 crashes per 100 million VMT for 4-lane divided urban free-access trunkline. (1) 4-Lane Eastbound, 3-Lane Westbound Source: Michigan Department of Transportation, November 2004

M-37/M-44 Crash Countermeasures

There are several countermeasures incorporated into the Build Alternative which should help to reduce congestion and increase traffic flow on M-37/M-44 (East Beltline). These countermeasures include:

1. Construction of additional (third) through lane to help reduce congestion.
2. Construction of additional left turn lane at select crossover locations.
3. Construction of right turn lanes at select driveway and cross-street locations.