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Technical Memo

To: Steve Gramm, SDDOT	
From: Rick Laughlin, HDR	Project: I-190/Silver St. Study, Phase II
CC:	
Date: 7/20/11	Job No: HDR 137390, Work order PD-02-09, Amendment 3, Agreement 410445

RE: Traffic Analysis

This memorandum documents the traffic analysis conducted for the second phase of the Interstate 190/Silver Street study in Rapid City, SD. The results of the traffic analysis have also been carried forward for use in the Interchange Justification Report (IJR) and Environmental Assessment (EA) being prepared for this study.

Lane Demand

The number and types of lanes needed to provide at least Level of Service D were determined using traffic forecasts and Synchro software. The traffic forecasts were based on output from the regional travel demand model maintained by the City of Rapid City. While a similar analysis was conducted for a much larger area in Phase 1, this memorandum is confined to the IJR study area.

The analysis shows that no additional mainline lanes will be required on I-190, with all sections of I-190 running at LOS "A" or "B" with the existing 4-lane configuration. The mainline levels of service are summarized in the following table:

TABLE: INTERSTATE MAINLINE LOS

			2030 CONDITIONS									
	2010		NO-BUILD		ALT. 1		ALT. 1A		ALT. 2A		ALT. 3A	
SECTION	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
NB OMAHA TO SILVER OFF	A	A	B	C	B	B	B	B	B	B	B	B
NB SILVER OFF TO ANAMOSA	A	A	B	B								
NB SILVER OFF TO SILVER ON					B	B	B	B	B	B	B	B
NB SILVER ON TO I-90					B	B	B	B	B	B	B	B
NB ANAMOSA TO I-90	A	A	B	B								
SB I-90 TO SILVER OFF	A	A	B	B	B	B	B	B	B	B	B	B
SB SILVER OFF TO SILVER ON	A	A	B	A	A	B	A	B	A	B	A	B
SB SILVER ON TO OMAHA	A	A	B	B	B	B	B	B	B	B	B	B

The ramps at the I-190/Silver Street interchange and at Interstate 90 are also expected to operate well with the existing single-lane configuration. The ramp levels of service are summarized in the following table:

TABLE: INTERSTATE RAMP LOS

	2030 CONDITIONS											
	2010		NO-BUILD		ALT. 1		ALT. 1A		ALT. 2A		ALT. 3A	
RAMP	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
SILVER OFF NB	A	B	B	B	B	A	B	A	B	B	B	B
ANAMOSA ON NB	A	B	B	B								
SILVER ON NB					A	A	A	A	A	A	A	A
I-90 OFF NB	A	A	A	A	A	A	A	A	A	A	A	A
I-90 OFF WB	A	A	A	A	A	A	A	A	A	A	A	A
I-90 ON WB	A	A	A	A	A	A	A	A	A	A	A	A
I-90 ON SB	A	A	B	B	A	A	A	A	A	A	A	A
SILVER OFF SB	A	A	B	A	A	A	A	A	A	A	A	A
SILVER ON SB	A	A	B	A	A	A	B	B	B	B	A	B

The study area intersections are expected to continue to operate at acceptable levels of service into the future, with a few changes related to the implementation of each of the future interchange alternatives. The intersection operations are summarized in the following table:

TABLE: INTERSECTION LOS

			2030 CONDITIONS									
	2010		NO-BUILD		ALT. 1		ALT. 1A		ALT. 2A		ALT. 3A	
INTERSECTION	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
CROSSROAD/I-190 SB	A	A	A	A	B	B	B	B			A	A
CROSSROAD/I190 NB	A	A	C	B	B	B	B	B			B	B
CROSSROAD/I-190 COMMON									B	B		
NORTH ST./MT. RUSHMORE RD.	C	B	C	C	B	A	B	A	B	A	B	A
OMAHA ST./MT. RUSHMORE RD.	C	D	D	D	D	D	D	D	D	D	D	D
OMAHA ST./I-190/WEST BLVD.	C	C	C	C	C	C	C	C	C	C	C	C

The lane demand for each study area intersection is shown in the following table for each interchange alternative. The lane demand is also shown in the interchange alternative graphics included later in this memorandum. The code used in the table is outlined below:

L = left turn lane

T = thru lane

R = right turn lane

LT = combined left/thru lane

RT = combined right/thru lane

(lanes are separated by commas)

LANE DEMAND

I-190/SILVER STREET STUDY AREA INTERSECTIONS

EXISTING CONDITIONS				
INTERSECTION	SOUTHBOUND	WESTBOUND	NORTHBOUND	EASTBOUND
I-190/SILVER	LTR	L, TR	LT,R	LT,T
MT. RUSHMORE/NORTH	LTR	LT, TR	LT,R	LT,TR
MT. RUSHMORE/OMAHA	L,T,T,R	L,L,T,T,TR	L,L,T,T,R	L,L,T,T,T,R
I-190/OMAHA	L,L,T,T,R	L,L,T,T,T,R	L,T,T,R	L,L,T,T,T,R
ALTERNATIVE 1				
INTERSECTION	SOUTHBOUND	WESTBOUND	NORTHBOUND	EASTBOUND
I-190/SILVER	L,R	L,L,T,TR	L,R	L,T,TR
MT. RUSHMORE/NORTh	L,TR	LT, TR	LT,R	LT,TR
MT. RUSHMORE/OMAHA	L,T,T,R	L,L,T,T,TR	L,L,T,T,R	L,L,T,T,T,R
I-190/OMAHA	L,L,T,T,R	L,L,T,T,T,R	L,T,T,R	L,L,T,T,T,R
ALTERNATIVE 1a				
INTERSECTION	SOUTHBOUND	WESTBOUND	NORTHBOUND	EASTBOUND
I-190/SILVER	L,R	L,L,T,TR	L,R	L,T,TR
MT. RUSHMORE/NORTH	L,TR	LT, TR	LT,R	LT,TR
MT. RUSHMORE/OMAHA	L,T,T,R	L,L,T,T,TR	L,L,T,T,R	L,L,T,T,T,R
I-190/OMAHA	L,L,T,T,R	L,L,T,T,T,R	L,T,T,R	L,L,T,T,T,R
ALTERNATIVE 2a				
INTERSECTION	SOUTHBOUND	WESTBOUND	NORTHBOUND	EASTBOUND
I-190/SILVER	L,R	L,L,T,TR	L,R	L,T,TR
MT. RUSHMORE/NORTH	L,TR	LT, TR	LT,R	LT,TR
MT. RUSHMORE/OMAHA	L,T,T,R	L,L,T,T,TR	L,L,T,T,R	L,L,T,T,T,R
I-190/OMAHA	L,L,T,T,R	L,L,T,T,T,R	L,T,T,R	L,L,T,T,T,R
ALTERNATIVE 3a				
INTERSECTION	SOUTHBOUND	WESTBOUND	NORTHBOUND	EASTBOUND
I-190/SILVER	L,R	T,TR	L,R	L,T,TR
MT. RUSHMORE/NORTH	L,TR	LT, TR	LT,R	LT,TR
MT. RUSHMORE/OMAHA	L,T,T,R	L,L,T,T,TR	L,L,T,T,R	L,L,T,T,T,R
I-190/OMAHA	L,L,T,T,R	L,L,T,T,T,R	L,T,T,R	L,L,T,T,T,R

Safety Analysis

A search of the crash reduction factors related to interchange configuration was conducted as part of this study. While there were many crash reduction factors related to improving the length of ramps, those factors would apply equally well to any of the interchange alternatives under consideration. The crash reduction factors indicate that extending ramps by about 100 feet results in about a 10% reduction in future crashes, while providing a long ramp instead of a short ramp results in about a 40% reduction in future crashes.

Two studies were found that relate specifically to clover-leaf ramps such as the one envisioned in Alternative 3a. One study found a crash reduction of about 45% by replacing a clover-leaf ramp with a straight ramp, while the other found a crash reduction of about 23% by replacing a straight ramp with a clover-leaf ramp. The actual affect on crash rates can depend greatly on the design of the clover-leaf ramp and environmental factors. In this case, the approach to the loop ramp is on a city street with lower speeds, but the loop has a fairly tight radius. Crash statistics examined in Phase 1, however, indicated a significant incidence of crashes related to winter weather driving conditions. On balance, it appears that Alternative 3a may see a slightly higher crash rate than the other alternatives.

The preferred alternative identified during the Environmental Assessment process will be the subject of a Road Safety Audit as part of the overall study and the audit findings will serve as input to the final design.

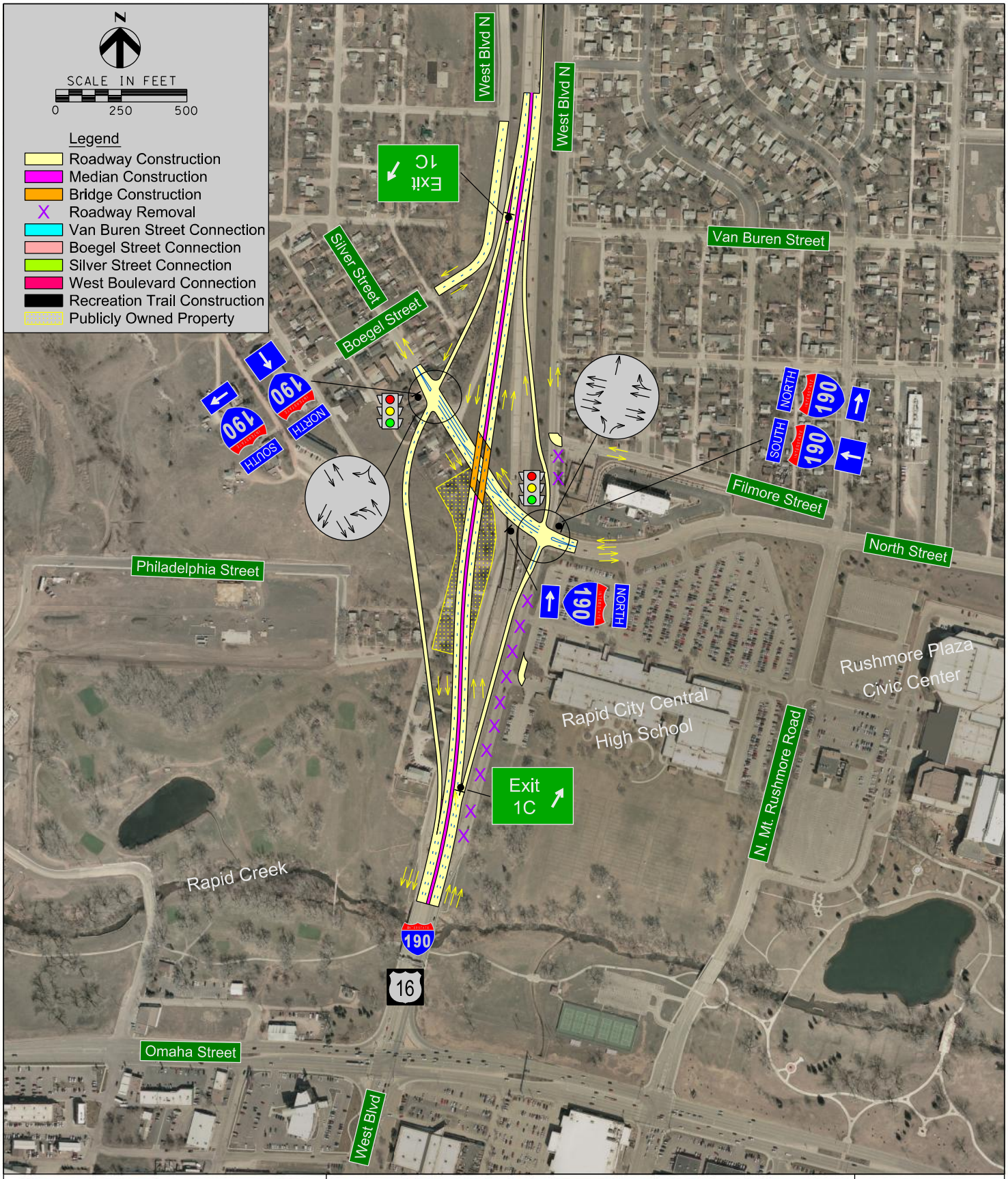
Neighborhood Connections

A number of alternative local street connections have been examined to address the cross-street alignment change proposed in several of the interchange alternatives. Specifically, Alternatives 1a, 2a, and 3a show connection of North Street to Philadelphia Street, rather than the existing North Street to Silver Street connection. The change would require extension of at least one local street south to Philadelphia Street to allow neighborhood traffic to continue to use the I-190 interchange. The local street connections would either result in an intersection within about 590' of the center of the interchange or an intersection within about 1230' of the center of the interchange. For purposes of this memorandum, the nearer intersection will be called the West/Silver extension and the farther intersection will be called the Boegel/Van Buren extension.

Peak hour traffic forecasts were prepared for these two intersections based on data available from the Rapid City regional traffic forecasting model. Please note that most forecasting models, including the Rapid City model, have difficulty providing forecasts for local street intersections due to the larger network structure employed. The model is also based on generalized forecasts of future land uses and does not discern differences between the interchange alternatives as long as all the alternatives provide acceptable service.

The forecasts, however, support reasonable belief that either of the intersections will operate at acceptable level of service and not unduly interfere with interchange operations. Either intersection will operate at level of service A during the AM and PM peak hours with stop sign control. Queues at the intersections and the adjacent leg of the interchange are all minimal and no queue interference is anticipated.

Volume/Level of Service summaries and SYNCHRO analysis reports are attached to this memorandum to document analysis conditions and results.



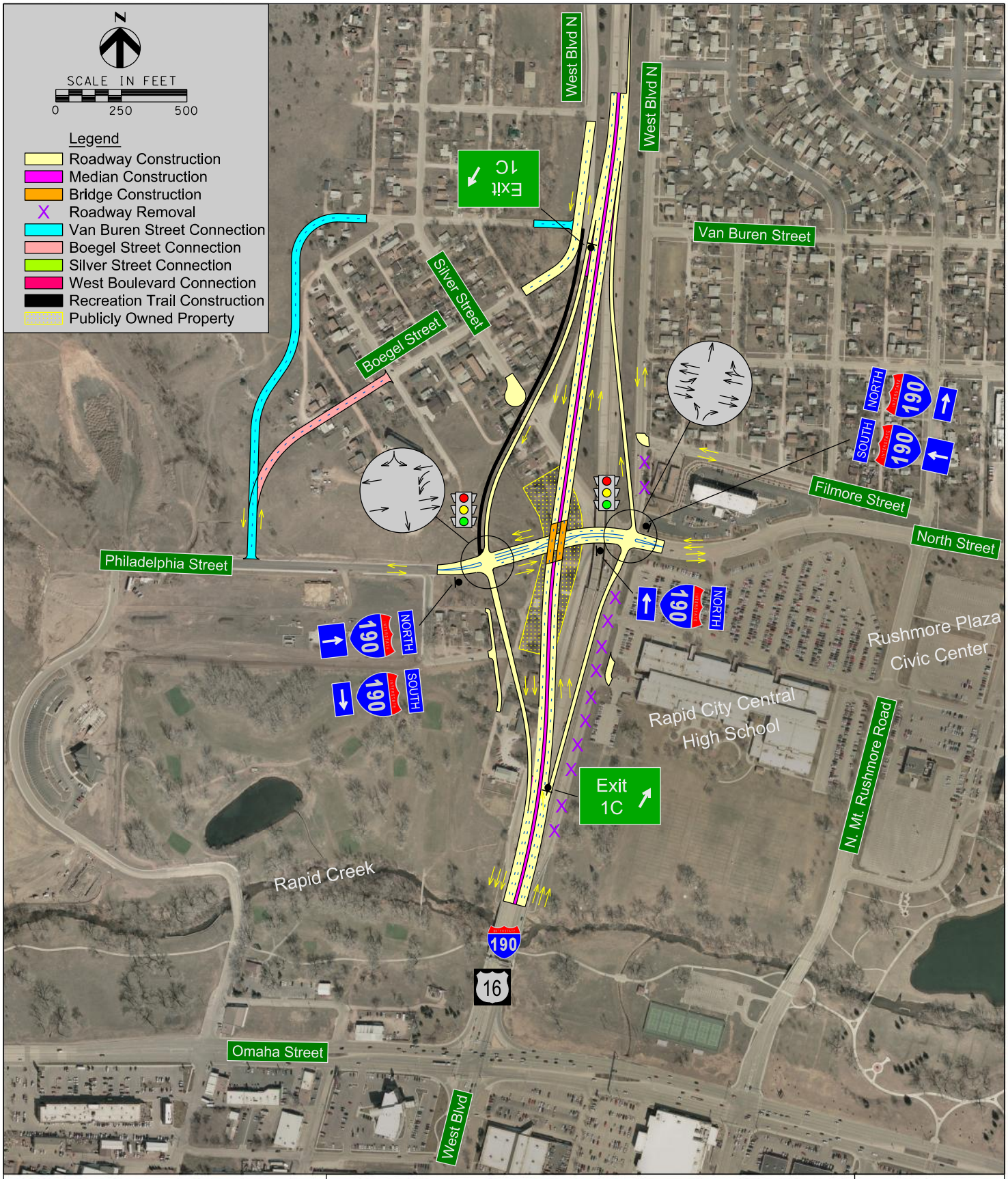
Interchange Alternative 1

Philadelphia Street Connection Options

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

Figure 1

July 1, 2011



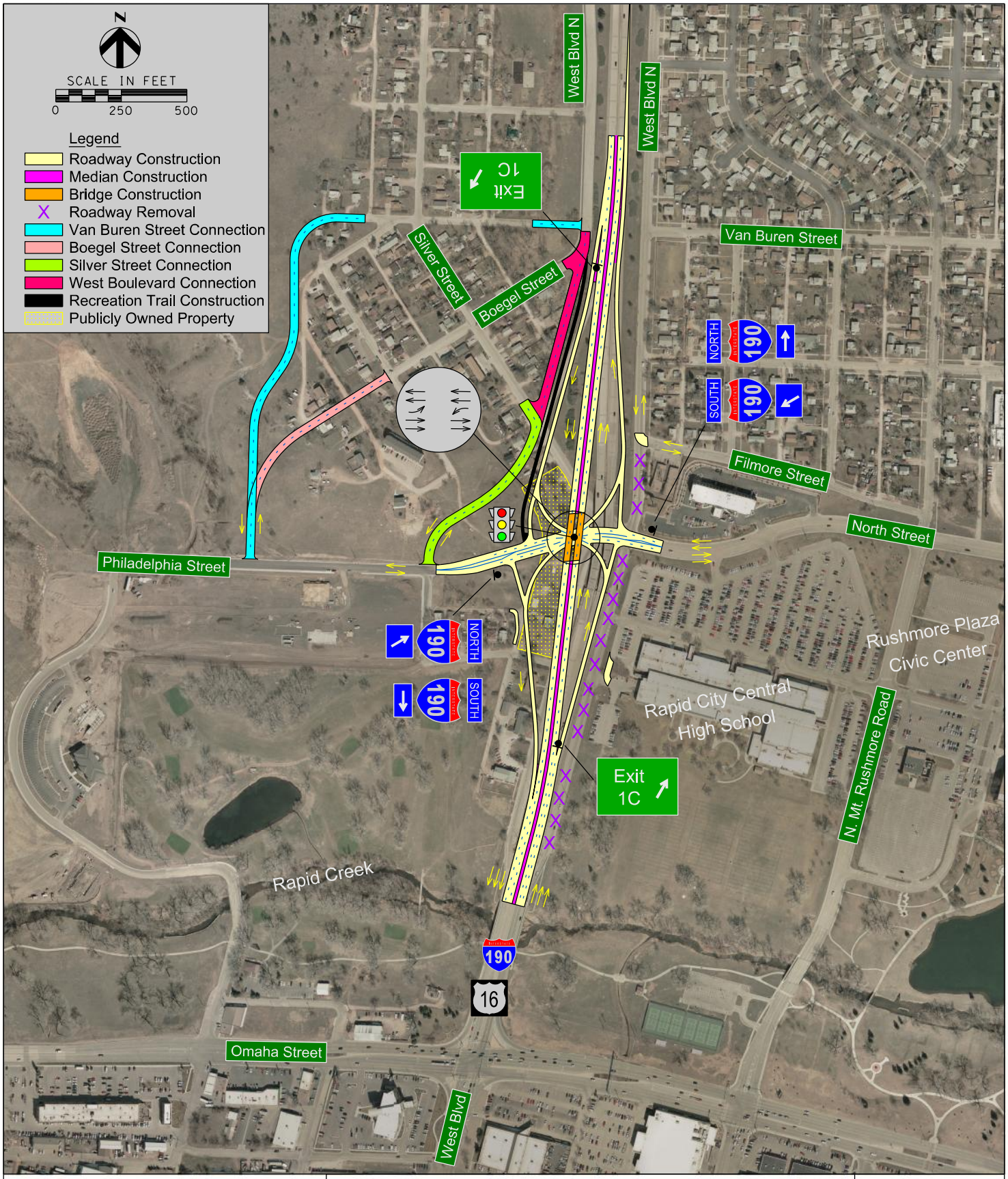
Interchange Alternative 1a

Philadelphia Street Connection Options

Figure 2

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

July 1, 2011



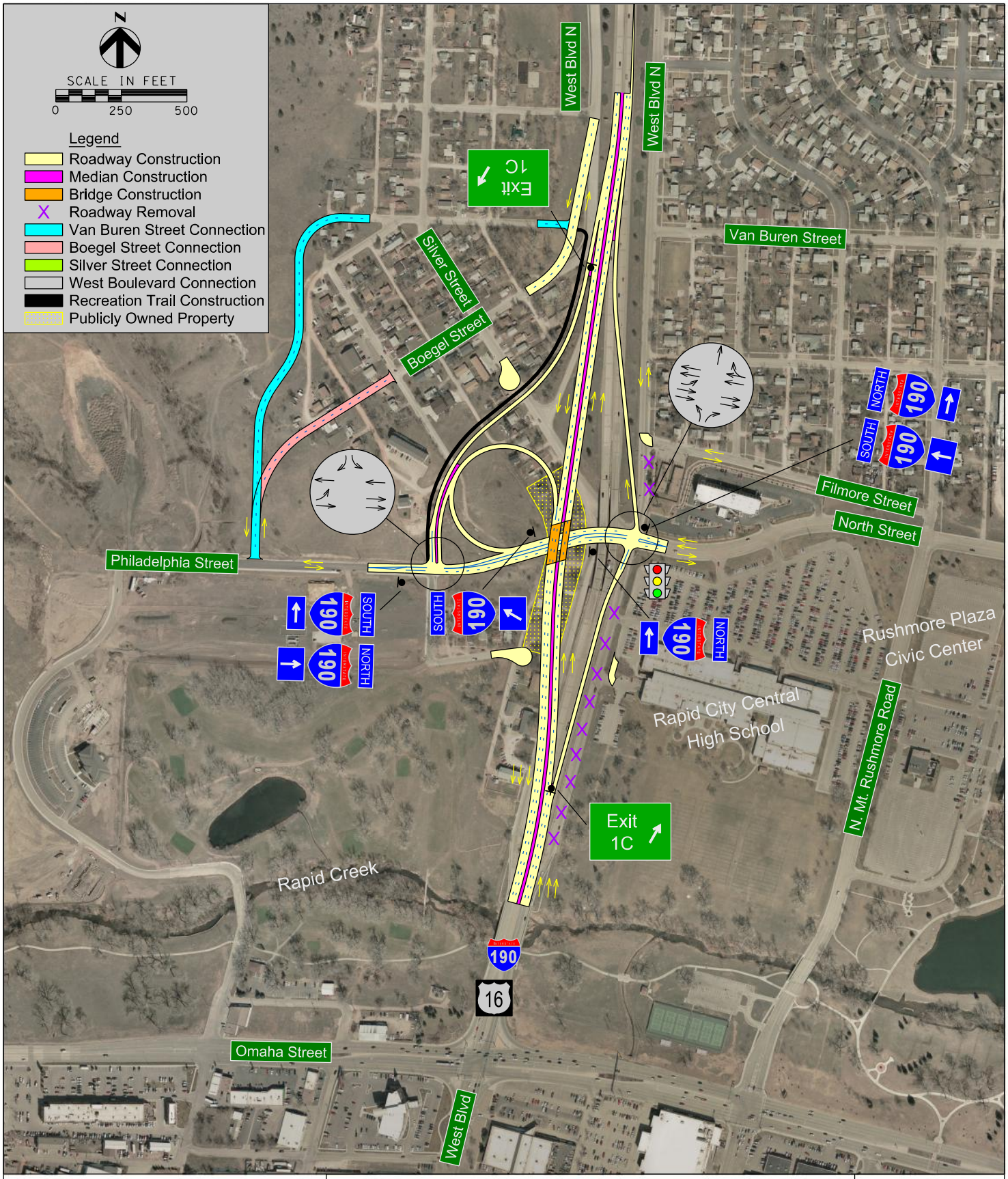
Interchange Alternative 2a

Philadelphia Street Connection Options

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

Figure 3

July 1, 2011



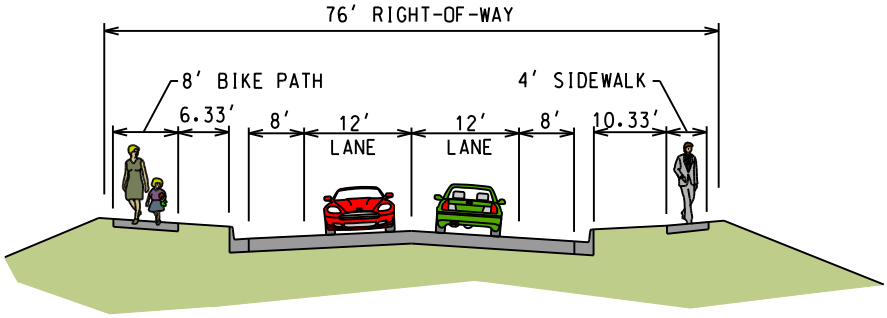
Interchange Alternative 3a

Philadelphia Street Connection Options

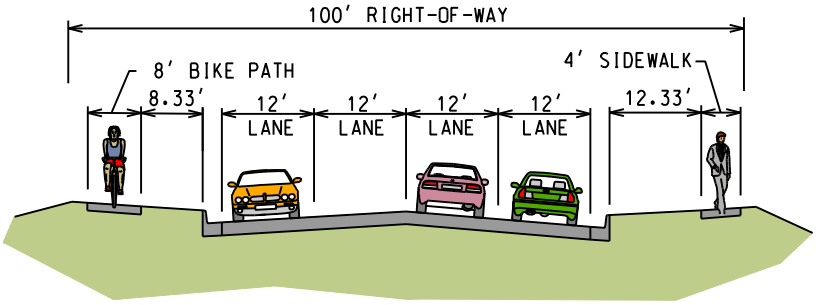
Figure 4

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

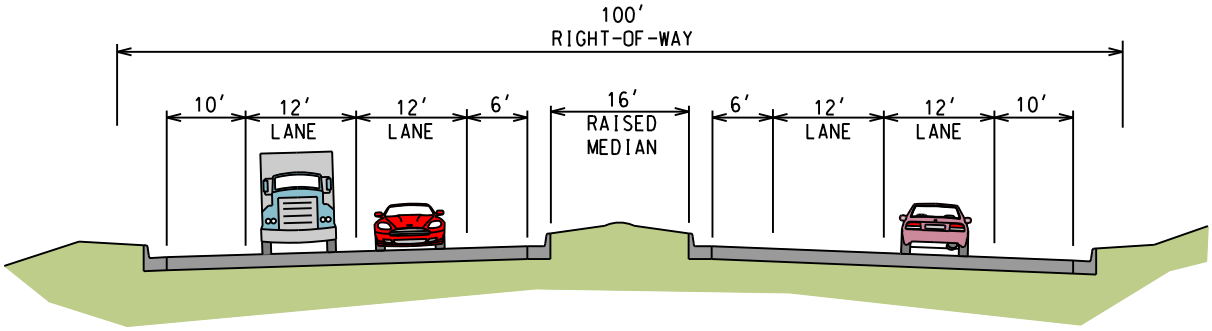
July 1, 2011



Urban Collector



Urban Arterial

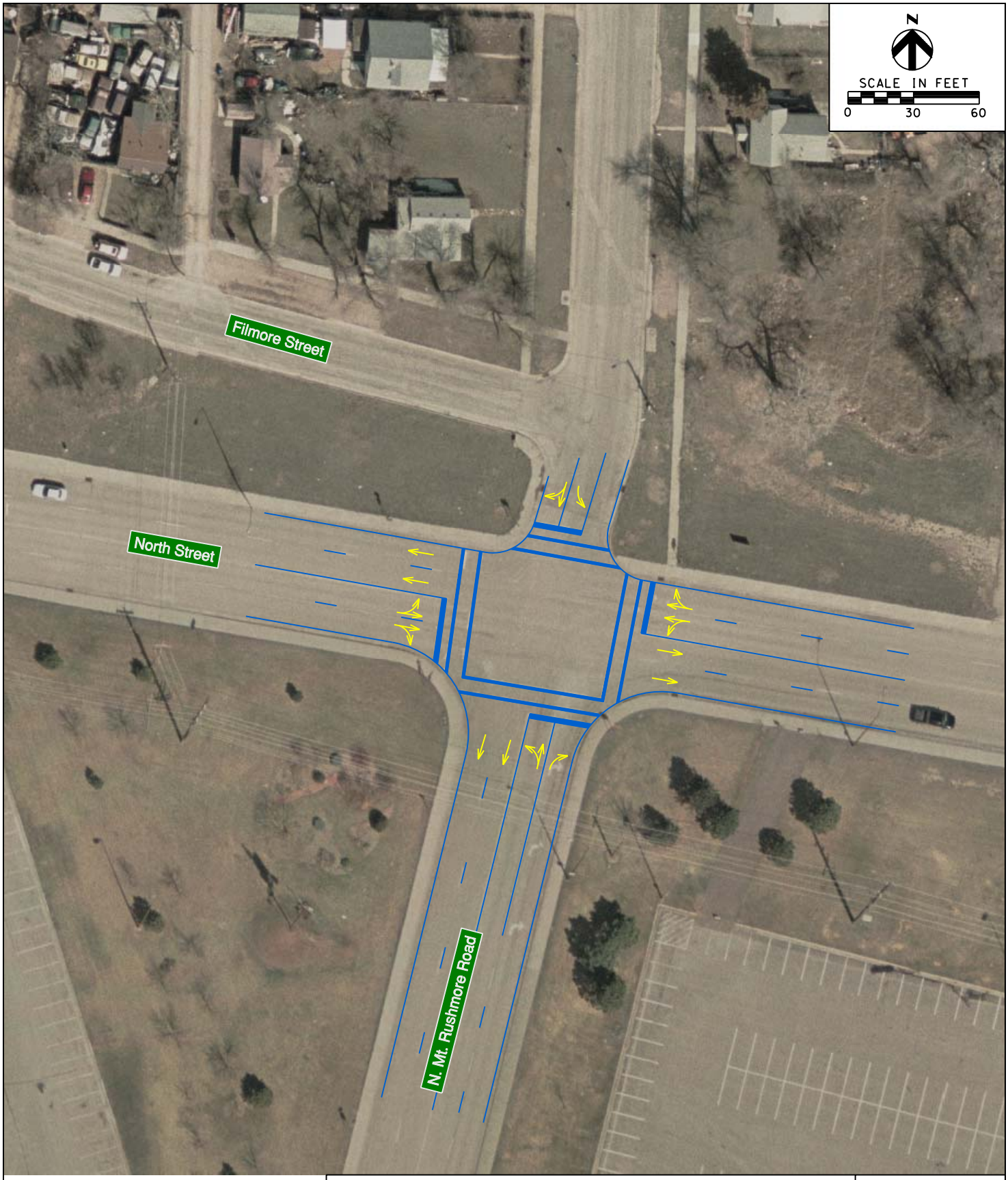


i-190

Typical Sections

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

June 15, 2011



North Street / Mt. Rushmore Road

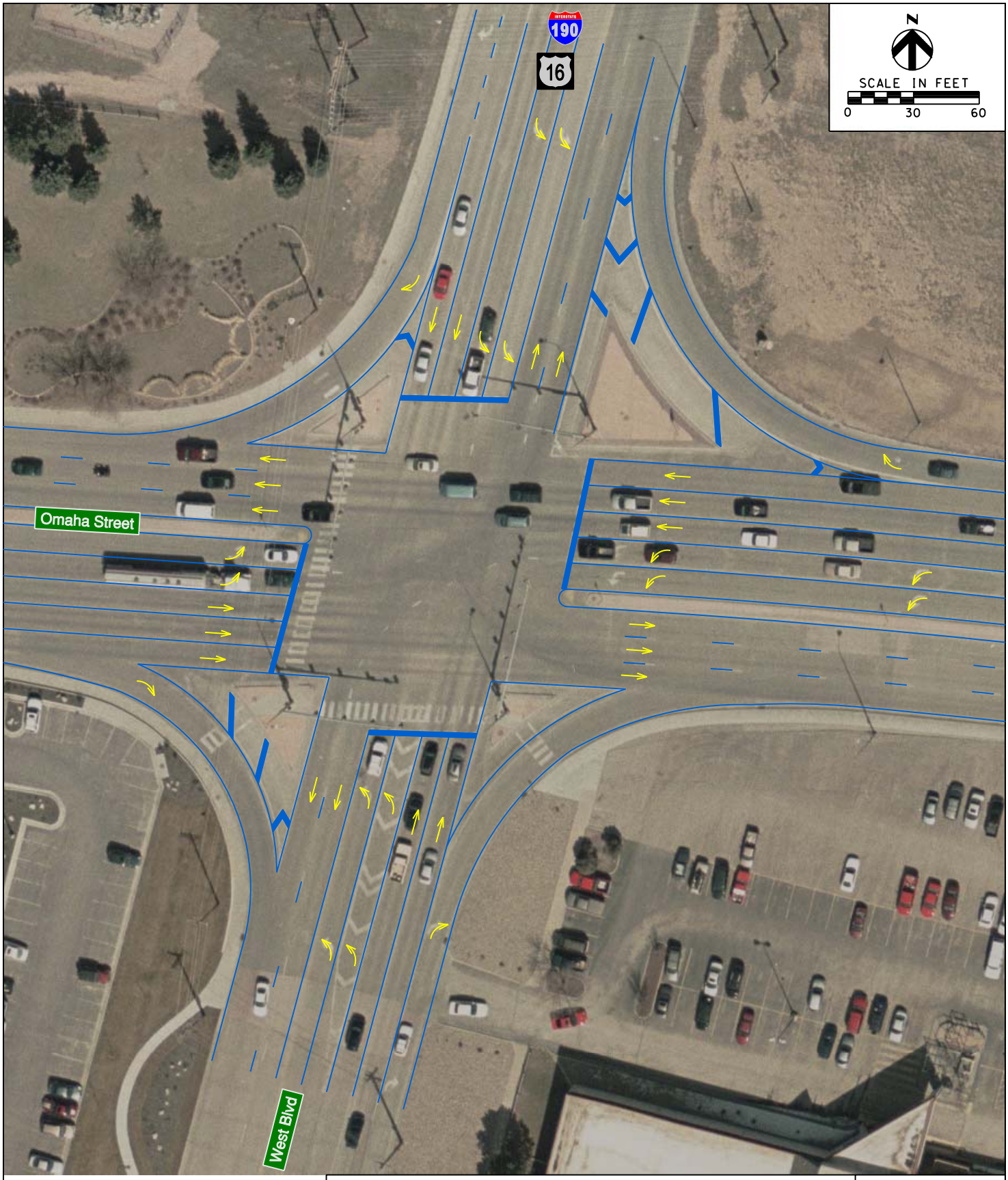
Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

June 15, 2011

Omaha Street / Mt. Rushmore Road

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

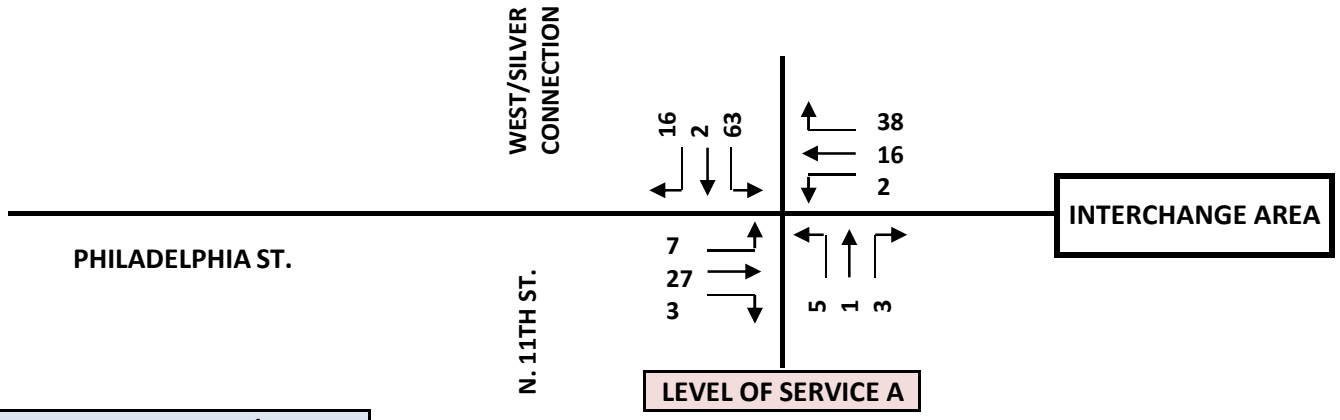
June 15, 2011



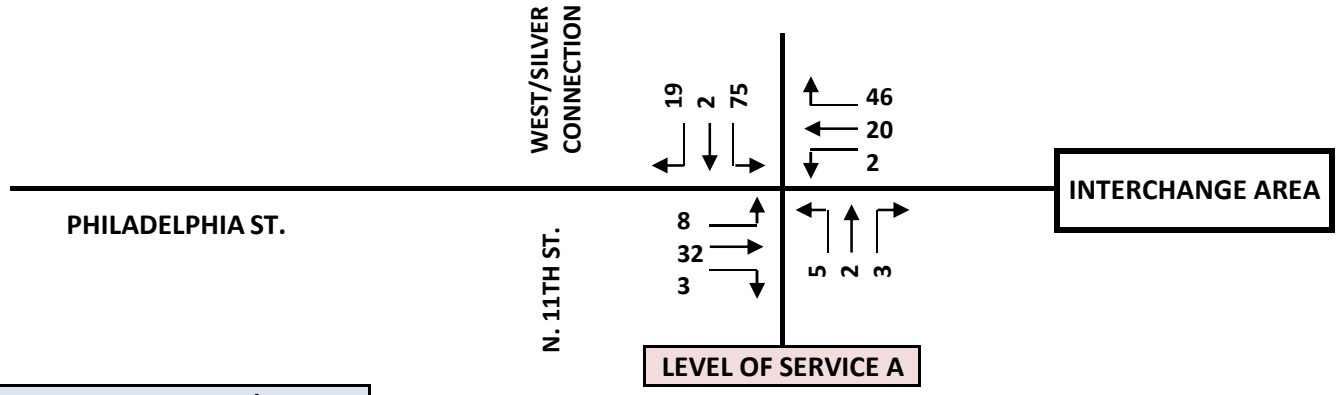
Omaha Street / West Blvd. (I-190)

Interstate 190/Silver Street Interchange Study
Rapid City, South Dakota

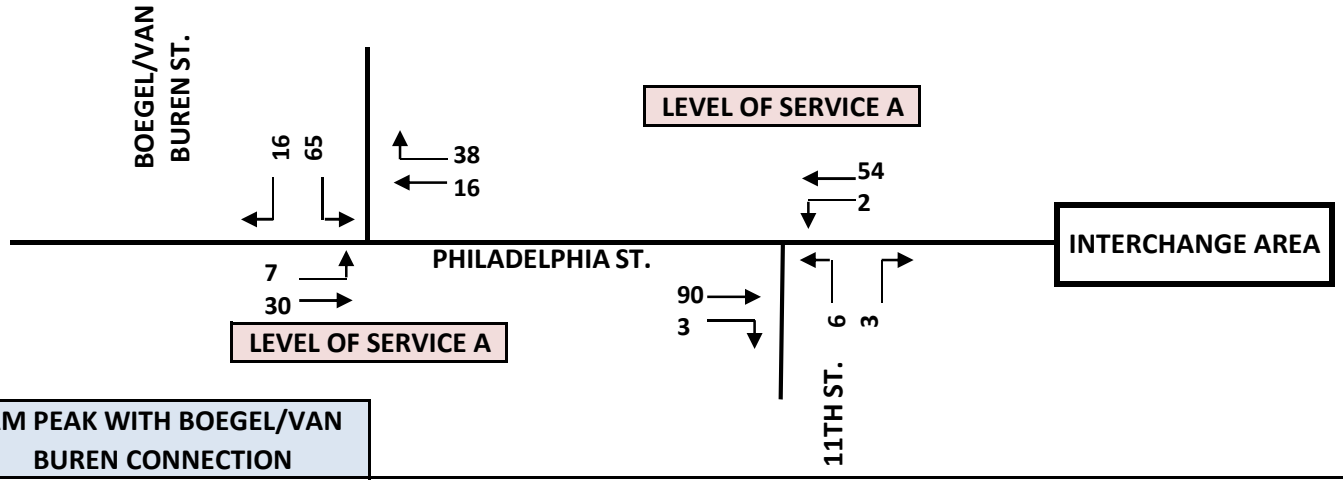
June 15, 2011



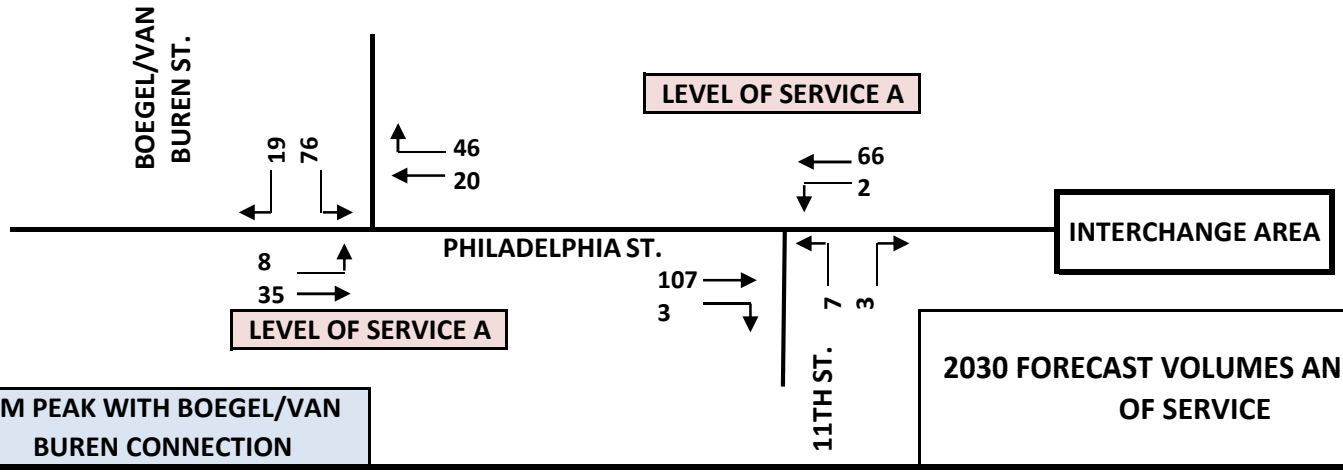
AM PEAK WITH WEST/SILVER CONNECTION



PM PEAK WITH WEST/SILVER CONNECTION



AM PEAK WITH BOEGEL/VAN BUREN CONNECTION



PM PEAK WITH BOEGEL/VAN BUREN CONNECTION

2030 FORECAST VOLUMES AND LEVEL OF SERVICE

HCM Unsignalized Intersection Capacity Analysis
6: Silver Street & West/Silver Connection

7/19/2011

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	7	27	3	2	16	38	5	1	3	63	2	16
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	8	29	3	2	17	41	5	1	3	68	2	17
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)					590							
pX, platoon unblocked												
vC, conflicting volume	59			33			86	109	31	91	90	38
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	59			33			86	109	31	91	90	38
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	100			100			99	100	100	92	100	98
cM capacity (veh/h)	1545			1579			878	776	1043	886	795	1034

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1	SB 2
Volume Total	8	33	2	59	10	68	20
Volume Left	8	0	2	0	5	68	0
Volume Right	0	3	0	41	3	0	17
cSH	1545	1700	1579	1700	913	886	1000
Volume to Capacity	0.00	0.02	0.00	0.03	0.01	0.08	0.02
Queue Length 95th (ft)	0	0	0	0	1	6	1
Control Delay (s)	7.3	0.0	7.3	0.0	9.0	9.4	8.7
Lane LOS	A		A		A	A	A
Approach Delay (s)	1.4		0.3		9.0	9.2	
Approach LOS					A	A	

Intersection Summary			
Average Delay	4.9		
Intersection Capacity Utilization	18.1%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
6: Silver Street & West-Silver Connection

7/19/2011

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	8	32	3	2	20	46	5	2	3	75	2	19
Sign Control		Free			Free			Stop			Stop	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	9	35	3	2	22	50	5	2	3	82	2	21
Pedestrians												
Lane Width (ft)												
Walking Speed (ft/s)												
Percent Blockage												
Right turn flare (veh)												
Median type		None			None							
Median storage veh)												
Upstream signal (ft)					590							
pX, platoon unblocked												
vC, conflicting volume	72			38			102	130	36	108	107	47
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	72			38			102	130	36	108	107	47
tC, single (s)	4.1			4.1			7.1	6.5	6.2	7.1	6.5	6.2
tC, 2 stage (s)												
tF (s)	2.2			2.2			3.5	4.0	3.3	3.5	4.0	3.3
p0 queue free %	99			100			99	100	100	91	100	98
cM capacity (veh/h)	1528			1572			855	755	1036	862	778	1023

Direction, Lane #	EB 1	EB 2	WB 1	WB 2	NB 1	SB 1	SB 2
Volume Total	9	38	2	72	11	82	23
Volume Left	9	0	2	0	5	82	0
Volume Right	0	3	0	50	3	0	21
cSH	1528	1700	1572	1700	878	862	993
Volume to Capacity	0.01	0.02	0.00	0.04	0.01	0.09	0.02
Queue Length 95th (ft)	0	0	0	0	1	8	2
Control Delay (s)	7.4	0.0	7.3	0.0	9.2	9.6	8.7
Lane LOS	A		A		A	A	A
Approach Delay (s)	1.4		0.2		9.2	9.4	
Approach LOS					A	A	

Intersection Summary			
Average Delay	4.9		
Intersection Capacity Utilization	20.6%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
6: Silver Street & Boegel-Van Buren Connection

7/19/2011

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	7	30	16	38	65	16
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	8	33	17	41	71	17
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	59				86	38
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	59				86	38
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	100				92	98
cM capacity (veh/h)	1545				911	1034

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	8	33	59	88
Volume Left	8	0	0	71
Volume Right	0	0	41	17
cSH	1545	1700	1700	933
Volume to Capacity	0.00	0.02	0.03	0.09
Queue Length 95th (ft)	0	0	0	8
Control Delay (s)	7.3	0.0	0.0	9.3
Lane LOS	A			A
Approach Delay (s)	1.4		0.0	9.3
Approach LOS				A

Intersection Summary			
Average Delay	4.7		
Intersection Capacity Utilization	17.1%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
9: Silver Street & 11th St.

7/19/2011

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	90	3	2	54	6	3
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	98	3	2	59	7	3
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				700		
pX, platoon unblocked						
vC, conflicting volume			101		162	99
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			101		162	99
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			100		99	100
cM capacity (veh/h)			1491		827	956

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	101	2	59	10
Volume Left	0	2	0	7
Volume Right	3	0	0	3
cSH	1700	1491	1700	866
Volume to Capacity	0.06	0.00	0.03	0.01
Queue Length 95th (ft)	0	0	0	1
Control Delay (s)	0.0	7.4	0.0	9.2
Lane LOS		A		A
Approach Delay (s)	0.0	0.3		9.2
Approach LOS				A

Intersection Summary			
Average Delay	0.6		
Intersection Capacity Utilization	14.9%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Lane Configurations						
Volume (veh/h)	8	35	20	46	76	19
Sign Control		Free	Free		Stop	
Grade		0%	0%		0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	9	38	22	50	83	21
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type		None	None			
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	72				102	47
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	72				102	47
tC, single (s)	4.1				6.4	6.2
tC, 2 stage (s)						
tF (s)	2.2				3.5	3.3
p0 queue free %	99				91	98
cM capacity (veh/h)	1528				891	1023

Direction, Lane #	EB 1	EB 2	WB 1	SB 1
Volume Total	9	38	72	103
Volume Left	9	0	0	83
Volume Right	0	0	50	21
cSH	1528	1700	1700	915
Volume to Capacity	0.01	0.02	0.04	0.11
Queue Length 95th (ft)	0	0	0	10
Control Delay (s)	7.4	0.0	0.0	9.4
Lane LOS	A			A
Approach Delay (s)	1.4		0.0	9.4
Approach LOS				A

Intersection Summary			
Average Delay	4.7		
Intersection Capacity Utilization	18.7%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (veh/h)	107	3	2	66	7	3
Sign Control	Free			Free	Stop	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	116	3	2	72	8	3
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type	None			None		
Median storage veh)						
Upstream signal (ft)				740		
pX, platoon unblocked						
vC, conflicting volume			120		194	118
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol			120		194	118
tC, single (s)			4.1		6.4	6.2
tC, 2 stage (s)						
tF (s)			2.2		3.5	3.3
p0 queue free %			100		99	100
cM capacity (veh/h)			1468		794	934

Direction, Lane #	EB 1	WB 1	WB 2	NB 1
Volume Total	120	2	72	11
Volume Left	0	2	0	8
Volume Right	3	0	0	3
cSH	1700	1468	1700	831
Volume to Capacity	0.07	0.00	0.04	0.01
Queue Length 95th (ft)	0	0	0	1
Control Delay (s)	0.0	7.5	0.0	9.4
Lane LOS		A		A
Approach Delay (s)	0.0	0.2		9.4
Approach LOS				A

Intersection Summary			
Average Delay	0.6		
Intersection Capacity Utilization	15.8%	ICU Level of Service	A
Analysis Period (min)	15		