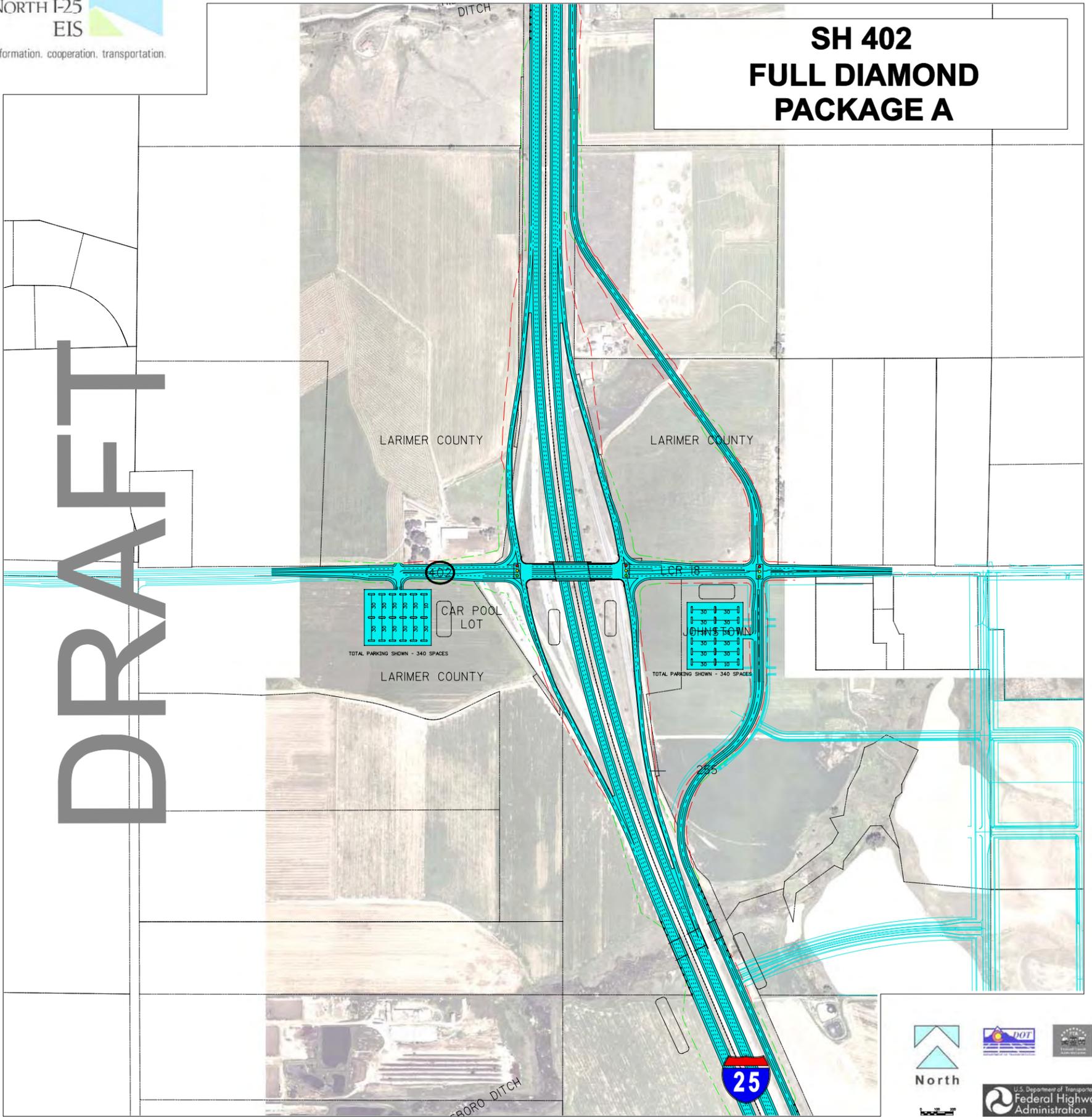


SH 402 FULL DIAMOND PACKAGE A

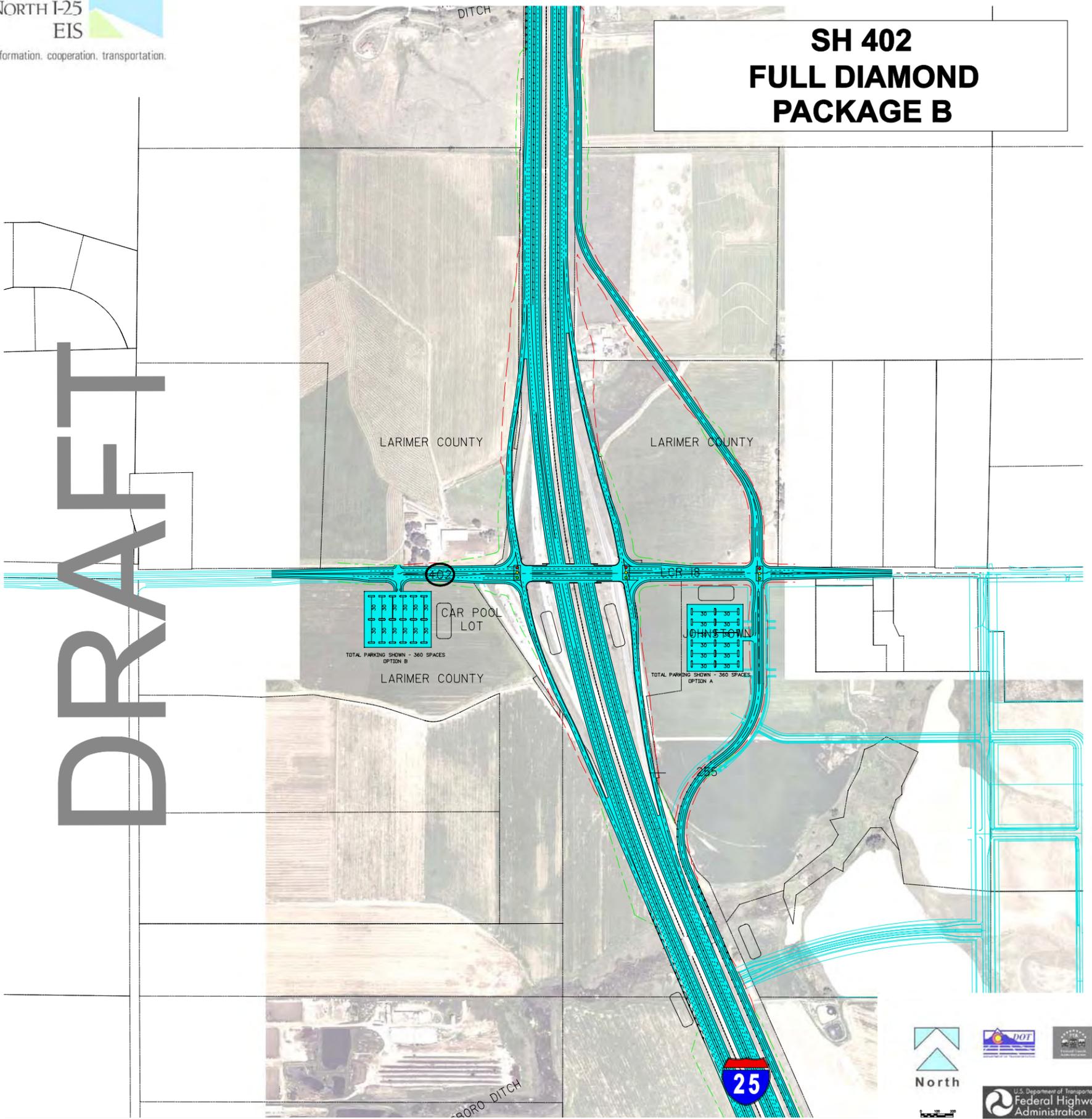
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SH 402 FULL DIAMOND PACKAGE B

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North

Scale 1" = 100'

October 1, 2007



U.S. Department of Transportation
Federal Highway
Administration

SH 402 FULL DIAMOND

SH 402 at I-25 DEIS Interchange Evaluation

August 20, 2007

Introduction

This report describes the existing traffic volumes at this interchange and the adjacent intersections, as well as future traffic conditions with an improved interchange.

Existing Conditions

The SH 402 interchange at I-25 was constructed in 1962. The interchange has a diamond and is similar to several older diamond interchanges (i.e. SH 392, Crossroads) in the corridor. The interchange ramps are one-lane with no dedicated turn lanes at the ramp terminals, but the curb radii at both ramp terminals allow for a right turning vehicle to maneuver around up to two vehicles waiting to turn left onto SH 402. The interchange area includes the following roadways:

SH 402. SH 402 is an east-west two lane arterial roadway that connects I-25 to the rural areas south of Loveland to the west and the rural areas east of the Town of Evans to the east. The land along SH 402 is primarily open fields both east and west of the interstate. The speed limit is 45 mph in the vicinity of the interchange, and there are no turn lanes at the ramp terminals. Both ramp intersections are stop sign-controlled.

East Frontage Road. A frontage road is located on the east side of the interchange, approximately 150 feet east of the northbound ramp intersection. The intersection is stop-sign controlled, and the speed limit on the frontage road in the vicinity of the interchange is 30 mph.

Park-and-Ride Access. An access to an existing park-n-ride lot on the southwest corner of the interchange is located approximately 150 feet west of the southbound ramp intersection. The park-n-ride access intersection is stop sign-controlled.

Figure 2 summarizes the traffic counts collected in August 2004 at this interchange. As shown, average daily traffic on SH 402 is around 14,900 vehicles per day (vpd) west of the interchange and 4,100 vpd east of the interchange. The east side frontage road has daily traffic volumes of ranging from 1,200 north of SH 402 to 3,400 south of SH 402. Daily ramp volumes range between 3,000 and 4,400 vehicles per day, with total volumes generally equal between the north and south directions. At the interchange, turn

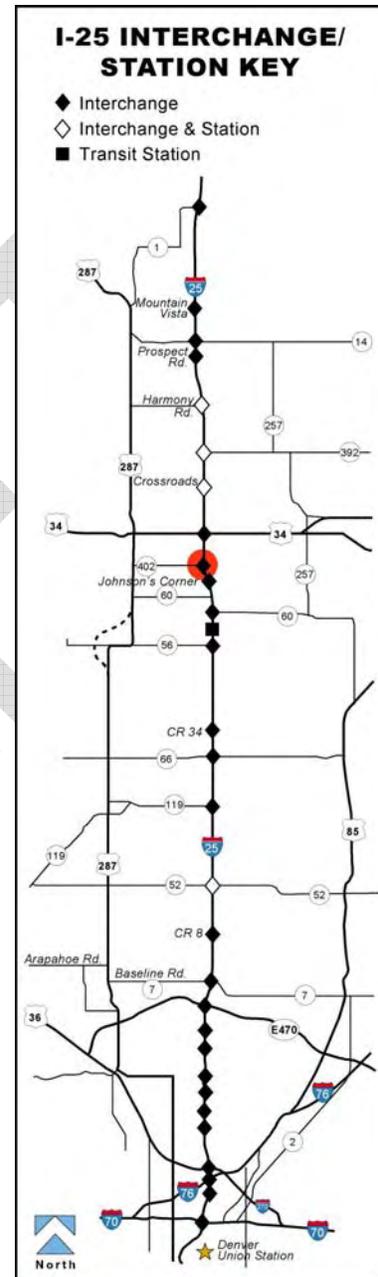


Figure 1. Vicinity Map

SH 402 at I-25 DEIS Interchange Evaluation

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movements to/from the ramps are less than 300 vehicles per hour during the peak periods, with the westbound to northbound movement representing the highest traffic volumes in the morning and the northbound to westbound movement representing the highest volumes in the afternoon.

Traffic Operations

An operational analysis of the interchange was conducted based on methodology developed in the Highway Capacity Manual (Transportation Research Board, 2000). The result of such analysis is a level of service (LOS) rating. Level of service is a qualitative assessment of the traffic flow based on the average stopped delay per vehicles at controlled intersections (i.e. traffic signal, stop-sign).

Levels of service are described by a letter designation ranging from “A” to “F”, with LOS A representing essentially uninterrupted flow, and LOS F representing a breakdown of traffic flow with excessive congestion and delay. Signalized intersection analyses result in a level of service rating for each movement and for the entire intersection but typically only the level of service for the entire intersection is reported. For unsignalized intersections a level of service rating is determined for each turn movement that must yield to another turn movement but an overall level of service rating is not determined for the entire intersection. The following table shows how average stopped delay at controlled intersections equates to levels of service.

Table 1. Equivalent Level of Service to Average Stopped Delay and Density

Level of Service	Average Delay at Signalized Intersections in (sec./veh.)	Average Delay at Stop-Controlled intersections in (sec./veh.)
A	0 to <=10	0 to <=10
B	> 10 to <= 20	> 10 to <= 15
C	> 20 to <= 35	> 15 to <= 25
D	> 35 to <= 55	> 25 to <= 35
E	> 55 to <= 80	> 35 to <= 50
F	> 80	> 50

Figure 2 illustrates existing peak period levels of service at the ramp terminals, adjacent intersections and ramp junctions with I-25. Currently, the northbound movement at the northbound I-25 ramp junction operates at LOS F during both peak periods, but the remaining movements in the vicinity of the interchange operate at LOS D or better.

In addition to the intersection level of service shown in the figure, Table 2 provides additional information for key movements at each intersection to provide further insight into existing operations at the interchange. Key movements are those movements that could have an impact on adjacent intersections or an impact to I-25. For example, east-west movements along SH 402 can queue into adjacent intersections and impede traffic flow at those locations, while vehicles on the ramps could queue back onto the interstate. North-south movements at the east frontage road intersection have not been included in the table because they would not impede traffic flow on SH 402. As shown in the table, the 95th percentile queue lengths for all movements were not greater than the distance between intersections or did not exceed the current storage length provided on the ramps.

SH 402 at I-25 DEIS Interchange Evaluation

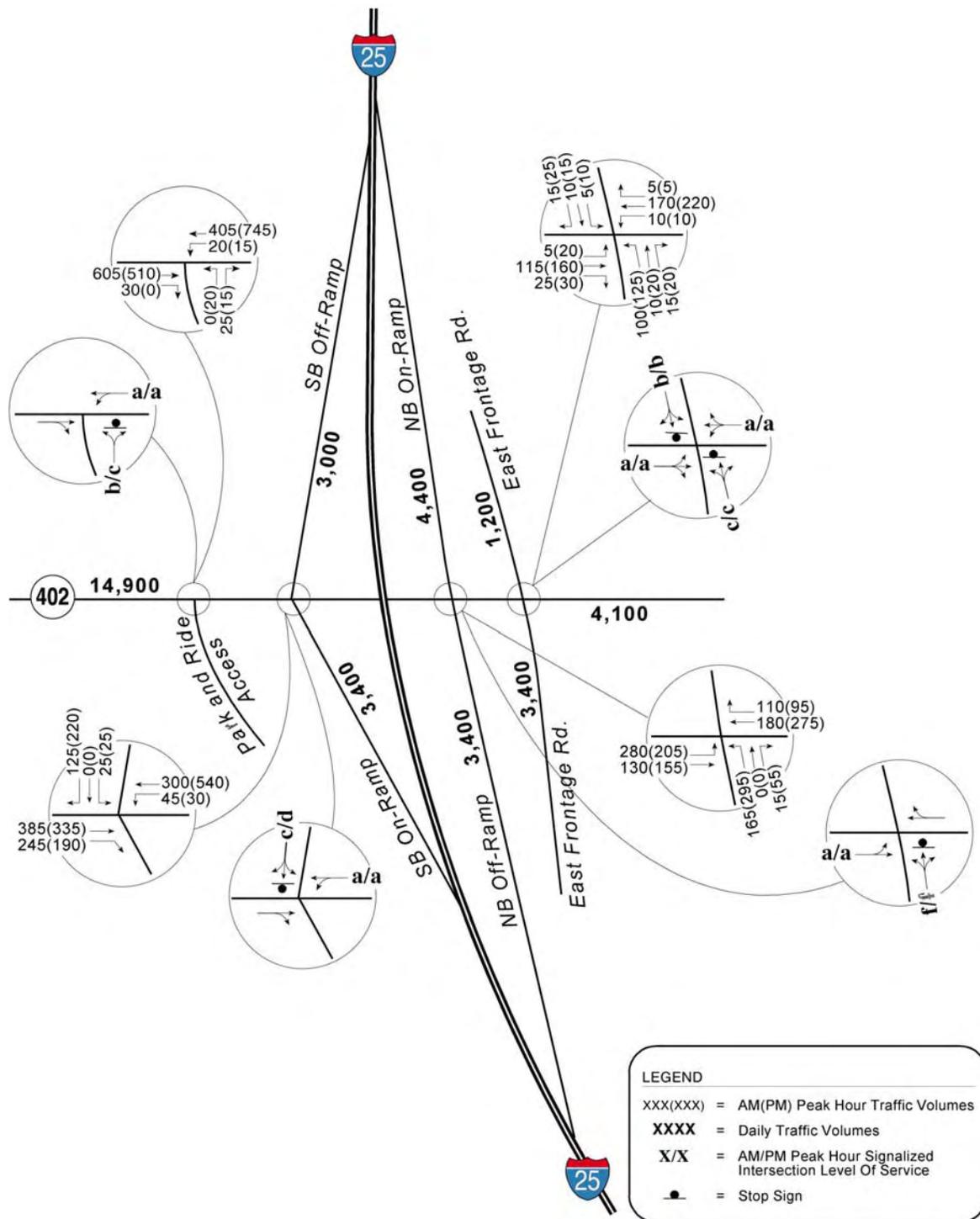


Figure 2. Existing Conditions

Table 2. Existing Level of Service and Queue Lengths for Key Movements

Intersection / Movement	Level of Service		Estimated 95 th Percentile Queue ¹		Intersection Spacing and Storage Length Provisions
	AM	PM	AM	PM	
Park-and-Ride Access					
WB Left/Thru	A	A	50'	30'	Distance to Adjacent Intersection – 150'
Southbound Ramp Terminal					
EB Thru/Right	A	A	10'	10'	
WB Left/Thru	A	A	100'	90'	Distance to Adjacent Intersection – 420'
SB Left/Thru/Right	C	D	110'	140'	Ramp Length – 1,200'
Northbound Ramp Terminal					
EB Left/Thru	A	A	80'	90'	Distance to Adjacent Intersection – 420'
WB Thru/Right	A	A	10'	10'	
NB Left/Right	F	F	150'	480'	Ramp Length – 1,325'
East Frontage Road Intersection					
EB Left/Thru/Right	A	A	10'	20'	Distance to Adjacent Intersection – 150'
¹ The queue lengths given in this table primarily come from SimTraffic with some engineering judgment. SimTraffic gives a queue length for each lane. For example, with dual left-turn lanes SimTraffic estimates a queue for each lane. In the table, for thru movements the queue length is the longest queue observed in any through lane. For multiple turn lanes (i.e. dual lefts), the queue length is the sum of the queues in each lane. For a single turn lane (i.e. right turn), the queue is just the queue for that lane.					

2030 Conditions

2030 traffic projections were developed for the three alternatives being considered:

- 1) No-Action Alternative
- 2) Package A: GPL + CR + CB 85
- 3) Package B: TEL + BRT

These three packages are illustrated in Figures 3 through 5. In developing peak hour turning movements at the ramp terminals and the nearest adjacent intersections, model results were calibrated against existing traffic counts to derive an adjusted model forecast. These adjusted forecasts along with existing turning movement data were used in the NCHRP 255 balancing procedure to develop 2030 peak hour turning movement forecasts. These forecasts were further adjusted, as necessary, to balance between intersections and for reasonableness.

SH 402 at I-25 DEIS Interchange Evaluation

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LEGEND

- ★ Major Structure Rehab by 2030
- Minor Structure Rehab by 2030
- Replace / Rehab Pavement by 2030
- Minor Safety Modifications by 2030
- FasTracks Rail Line

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Figure 3. No Action Alternative

SH 402 at I-25 DEIS Interchange Evaluation



LEGEND

	1 New General Purpose Lane (GPL) in Each Direction
	1 New General Purpose Lane (GPL) + Auxiliary Lane in Each Direction
	Commuter Rail (CR)
	Commuter Bus (CB) Service on US 85
	Feeder Bus Service
	Interchange Upgrades
	Number of Lanes
	Commuter Bus Station / Stop
	Commuter Rail Station
	FasTracks Rail Line
	FasTracks / RTD Transit Station
	Potential Commuter Rail Operational & Maintenance Facility
	Potential Commuter Bus Operational & Maintenance Facility

Congestion Management Measures include:

- Enhanced carpool lot parking capacity and amenities
- Courtesy patrol (Incident management) from SH 14 to SH 7
- Variable messaging signs at all transit stations
- Automated Vehicle Locaters on all transit vehicles - "next bus" technology
- Links to local bike and pedestrian systems at station areas
- Support for development of Transportation Management Organization (TMO)

NOTE:

- Select sections of I-25 would require auxiliary lanes and / or an additional through lane in addition to this 6-lane cross section.
- Where widening is needed between SH 66 and SH 7, the median would be used.
- Commuter Rail Service without a Longmont to North Metro connection will also be evaluated.

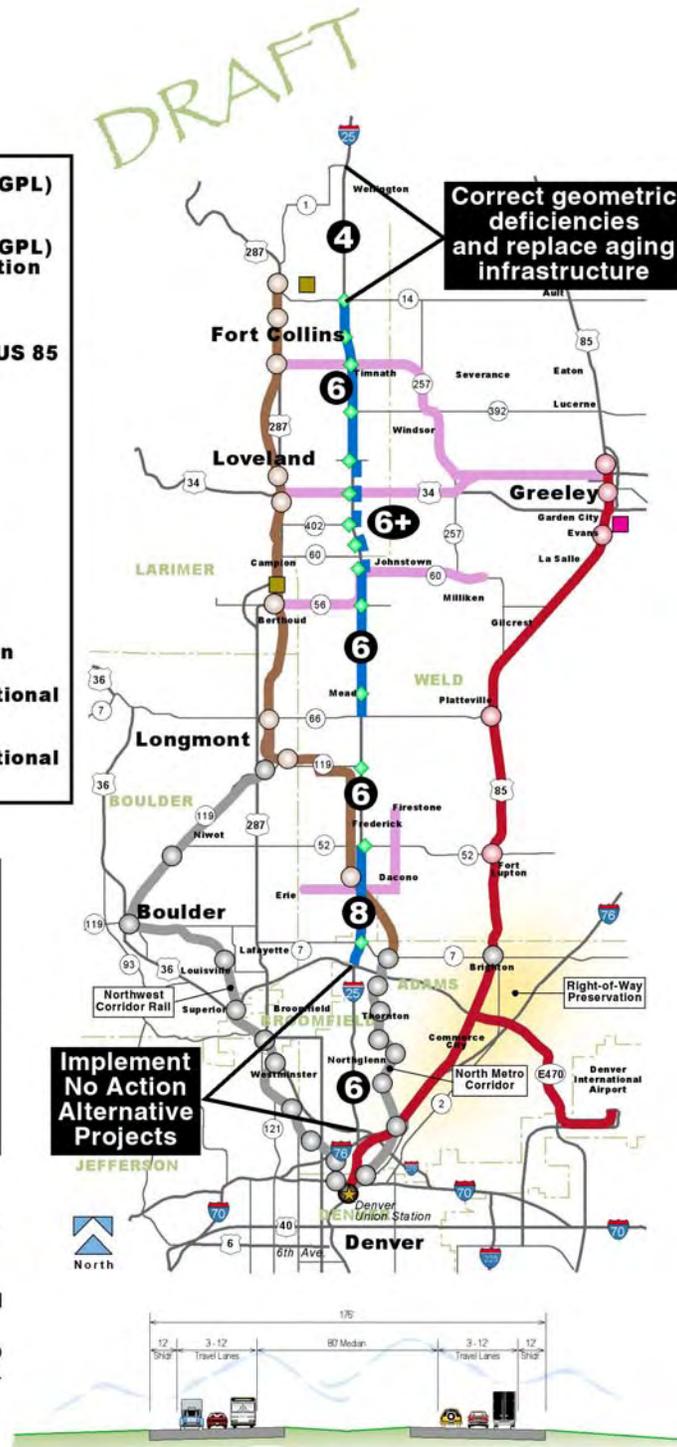


Figure 4. Package A

SH 402 at I-25 DEIS Interchange Evaluation



LEGEND

- **1 Buffer-Separated Tolled Express Lane (TEL) in Each Direction**
- ■ **2 Barrier-Separated Tolled Express Lanes (TEL) in Each Direction**
- **Bus Rapid Transit (BRT) Route (Uses TELs on I-25)**
- **Feeder Bus Service**
- ◆ **Interchange Upgrades**
- ⊗ **Number of Lanes: General Purpose/Tolled Express Lanes**
- **Bus Rapid Transit Station**
- **FasTracks Rail Line**
- **FasTracks / RTD Transit Station**
- **Potential Commuter Bus Operational & Maintenance Facility**

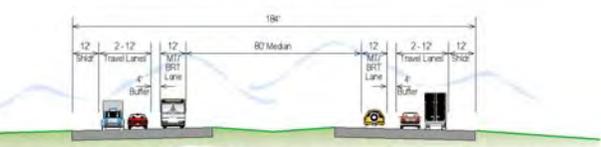
Congestion Management Measures include:

- Enhanced carpool lot parking capacity and amenities
- Courtesy patrol (incident management) from SH 14 to SH 7
- Variable messaging signs at all transit stations
- Automated Vehicle Locators on all transit vehicles - "next bus" technology
- Links to local bike and pedestrian systems at station areas
- Support for development of Transportation Management Organization (TMO)

NOTE:

- A wider barrier and express lanes cross section is included between SH 60 and Harmony Road.
- BRT stations located within an expanded median area.
- Where widening is needed between SH 66 and SH 7, the median would be used.

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NOT TO SCALE

TYPICAL I-25 CROSS SECTION - BUFFERED SEPARATED TOLLED EXPRESS LANES

Figure 5. Package B

2030 No Action Traffic Volumes

Figure 6 depicts 2030 daily and peak hour No Action traffic projections for the SH 402 interchange and adjacent intersections. As shown, daily volume projections on SH 402 range from 20,200 vpd east of the interchange to 42,500 vpd west of the interchange, and ramp volumes range from 8,900 to 13,000 vehicles per day. These volumes show the same patterns as existing counts; the highest traffic flows are to and from the west on SH 402 and to and from the south on the ramps.

2030 Package A Traffic Volumes

Figure 7 depicts 2030 daily and peak hour Package A traffic projections for the SH 402 interchange and adjacent intersections. The volumes in the figure are generally similar to those presented in the No Action Alternative, but are slightly lower east of the interchange because Package A includes the addition of northbound and southbound on ramps at the Johnson Corner interchange, one mile south of SH 402. Daily volume projections on SH 402 range from 15,800 vpd east of the interchange to 42,100 vpd west of the interchange, and ramp volumes range from 9,500 to 13,000 vehicles per day. The volumes patterns show slightly lower flow to and from the east as compared to No Action conditions.

2030 Package B Volumes

Figure 8 depicts 2030 daily and peak hour Package B traffic projections for the SH 402 interchange and adjacent intersections. The volumes in the figure are generally similar to volumes in the No Action Alternative. Daily volume projections on SH 402 range from 20,200 vpd east of the interchange to 42,600 vpd west of the interchange, and ramp volumes range from 8,800 to 12,200 vehicles per day.

2030 No Action Traffic Operations

Interchange Configuration

The North Front Range 2030 Regional Transportation Plan identifies improvements to SH 402 west of the southbound ramp terminal. Since the RTP identifies improvements to SH 402, the improvements have been included in the No Action Alternative. These improvements include an additional through lane in each direction, which begin and end at the southbound ramp terminal, and turn lanes at intersections. The winding allows for a free turn movement from the southbound off-ramp, a right-turn lane to the southbound on ramp and additional through lanes and a left turn lane at the park-n-ride access. In addition to the additional lanes on SH 402, the No Action Alternative also includes traffic signals at the ramp terminals.

Interchange Operations

Figure 6 shows the projected levels of service at the frontage road and ramp intersections on SH 402 under the No Action Alternative. As the figure indicates, the signalized ramp terminals would operate at LOS F during both peak periods, and all side street movements would operate at LOS F in at least one of the peak periods. Table 3 shows the projected queuing for key movements at the interchange and further underscores that the existing interchange configuration would be significantly over capacity with the projected traffic volumes.

SH 402 at I-25 DEIS Interchange Evaluation

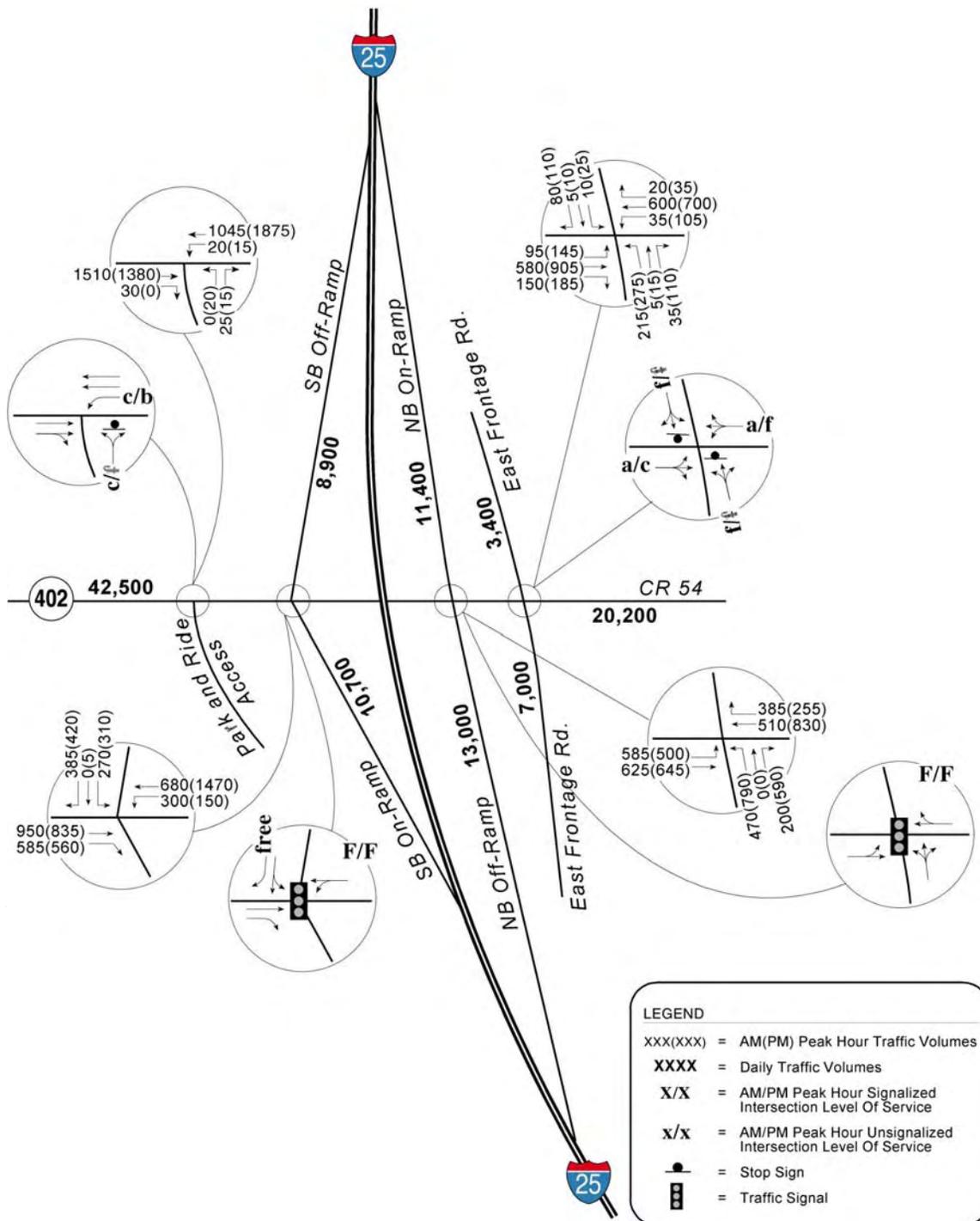


Figure 6. No Action Forecasts and Levels of Service

Table 3. 2030 No Action Level of Service and Queue Lengths for Key Movements

Intersection / Movement	Level of Service		Estimated 95 th Percentile Queue ¹		Intersection Spacing and Storage Length Provisions
	AM	PM	AM	PM	
Park-and-Ride Access					
WB Left	C	B	10'	20'	Distance to Adjacent Intersection – 150'
Southbound Ramp Terminal					
WB Left/Thru	F	F	470'	370'	Distance to Adjacent Intersection – 420'
EB Thru	B	B	150'	150'	Distance to Adjacent Intersection – 150'
EB Right	A	A	30'	50'	Distance to Adjacent Intersection – 150'
SB Left/Thru	F	F	500'	490'	Ramp Length – 1,200'
Northbound Ramp Terminal					
EB Left/Thru	F	F	440'	430'	Distance to Adjacent Intersection – 420'
WB Thru/Right	C	F	160'	180'	Distance to Adjacent Intersection – 150'
NB Left/Thru/Right	F	F	580'	580'	Ramp Length – 1,325'
East Frontage Road Intersection					
EB Left/Thru/Right	A	C	80'	120'	Distance to Adjacent Intersection – 150'
¹ The queue lengths given in this table primarily come from SimTraffic with some engineering judgment. SimTraffic gives a queue length for each lane. For example, with dual left-turn lanes SimTraffic estimates a queue for each lane. In the table, for thru movements the queue length is the longest queue observed in any through lane. For multiple turn lanes (i.e. dual lefts), the queue length is the sum of the queues in each lane. For a single turn lane (i.e. right turn), the queue is just the queue for that lane. ² Due to the high traffic volumes on SH 402, no gaps are available for left turns from the ramps (capacity = 0), so the queues would extend far back onto I-25. ³ Due to the high volume of traffic on SH 402, no gaps are available for left turns from SH 402 onto the I-25 on-ramps, so the queues would extend far back on SH 402.					

2030 Package A Traffic Operations

Interchange Configuration

The proposed configuration for the SH 402 DEIS interchange evaluation is a diamond configuration (Figure 7). The new interchange would increase the distance between the ramps to 600 feet and shift the east frontage road intersection so that it is 850 feet from the northbound ramp terminal. The SH 402 interchange currently is configured with I-25 bridging over SH 402. In the new interchange I-25 will be lowered and SH 402 will be raised so that SH 402 bridges over I-25. The new SH 402 Bridge consists of seven lanes to accommodate dual left-turn lanes and two through lanes in both directions (one of the left turn lanes in each direction would be built back to back). The northbound and southbound off ramps would be constructed with two left turn lanes and a right turn lane. SH 402 itself would be widened to four lanes (plus auxiliary lanes) both east and west of the interchange. All three intersections would be signalized.

Interchange Operations

Figure 7 also shows the levels of service for the ramps and frontage road intersections, along with recommendations for laneage and storage at each location. As shown, all three intersections in the vicinity of the ramp are anticipated to operate at LOS C or better with the forecasted traffic volumes and the enhancements identified.

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SH 402 at I-25 DEIS Interchange Evaluation

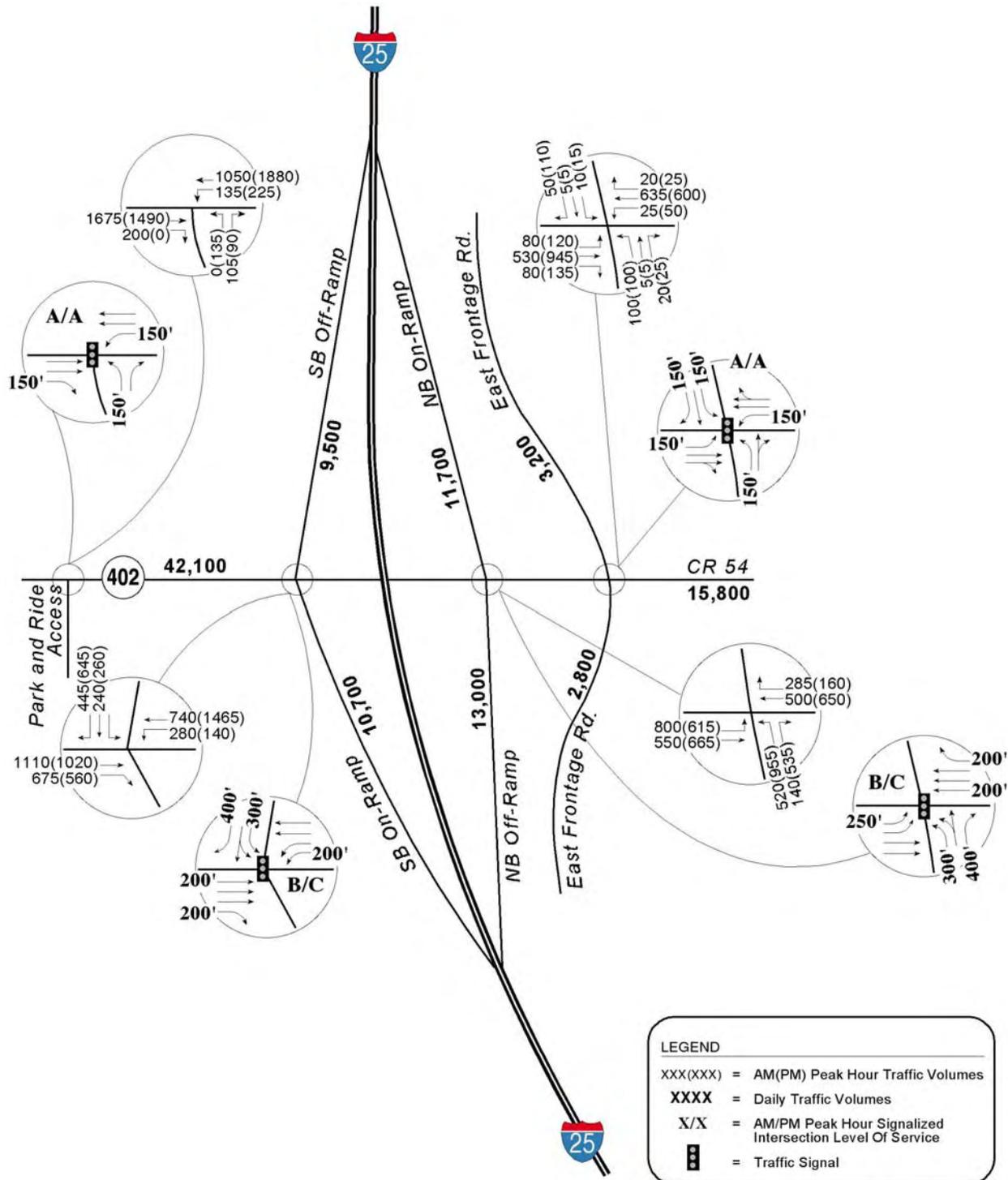


Figure 7. Package A Forecasts and Levels of Service

SH 402 at I-25 DEIS Interchange Evaluation

Table 4 summarizes the levels of service, queue lengths, intersection spacing and designed storage lengths for key movements at the interchange. As shown in the table, specific movement levels of service at this interchange range from LOS A to LOS D. No single movement operates with a substandard level of service; thus, the improvements identified at this interchange appear to provide good operations at both ramp terminals and at the frontage road intersection.

Table 4 also compares SimTraffic estimates of the 95th percentile queue length for key movements to the storage distance available for each. For turning movements, the distance listed is the planned turn lane storage length, while for through movements the length listed is the distance between intersections. The queuing analysis shows that in all cases the estimated 95th percentile queues would be contained within the turn bays or within the space between adjacent intersections. On both the northbound and southbound ramp terminals, the left and right turn queues would be accommodated well within the storage length and would not extend into the I-25 main lanes.

Table 4. 2030 Package A Level of Service and Queue Lengths for Key Movements

Intersection / Movement	Level of Service		Estimated 95 th Percentile Queue ¹		Distance Between Intersections and Storage Length Provisions
	AM	PM	AM	PM	
Park-and-Ride Access					
WB Left	C	B	120'	140'	Storage Provided in Design – 150'
WB Thru	A	A	60'	130'	Distance to Adjacent Intersection – 750'
Southbound Ramp Terminal					
EB Right	A	D	210'	140'	Storage Provided in Design – 200'
WB Left	B	C	490'	330'	Storage Provided in Design – 1,000'
WB Thru	A	B	80'	260'	Distance to Adjacent Intersection – 600'
SB Left	C	B	240'	450'	Storage Provided in Design – 700'
SB Right	D	D	210'	420'	Storage Provided in Design – 400'
Northbound Ramp Terminal					
EB Left	B	C	1,100'	540'	Storage Provided in Design – 1,100'
EB Thru	A	A	200'	200'	Distance to Adjacent Intersection – 600'
WB Thru	C	C	150'	200'	Distance to Adjacent Intersection – 850'
WB Right	B	B	210'	90'	Storage Provided in Design – 200'
NB Left	D	D	450'	550'	Storage Provided in Design – 700'
NB Right	C	D	70'	150'	Storage Provided in Design – 400'
East Frontage Road Intersection					
EB Left	A	A	50'	70'	Storage Provided in Design – 150'
EB Thru	A	A	50'	100'	Distance to Adjacent Intersection – 850'
¹ The queue lengths given in this table primarily come from SimTraffic with some engineering judgment. SimTraffic gives a queue length for each lane. For example, with dual left-turn lanes SimTraffic estimates a queue for each lane. In the table, for thru movements the queue length is the longest queue observed in any through lane. For multiple turn lanes (i.e. dual lefts), the queue length is the sum of the queues in each lane. For a single turn lane (i.e. right turn), the queue is just the queue for that lane.					

Other Carpool Lot Location Options

Two park-and-ride lot locations options are under consideration for this interchange. Option 1, analyzed above, assumes that the access to the existing lot in the southwest quadrant of the interchange would be relocated to 750 feet west of the new southbound ramp intersection, and that the lot would be expanded to 340 spaces. Option 2 assumes that the existing lot would be relocated to the southeast quadrant of the interchange, expanded to 340 spaces, and accessed off of the east frontage road. Under that option, the southbound ramp intersection would operate at LOS C during both peak periods, the northbound ramp intersection would operate at LOS B in the morning and LOS C in the afternoon and the east frontage road intersection would operate at LOS B in both peak periods. Thus, it would appear that both lot locations result in acceptable operations at the interchange. It should be noted, however, that approximately 60 percent of the carpool lot patrons are oriented to and from the east, so the southeast lot location may provide more convenience than the southwest location.

2030 Package B Traffic Operations

Interchange Configuration

The proposed configuration for SH 402 in Package B is the same as in Package A (Figure 7).

Interchange Operations

Figure 8 also shows the levels of service for the ramps and frontage road intersections, along with recommendations for laneage at each location. As shown, all four intersections would operate at LOS C or better with the forecasted traffic volumes and the enhancements identified.

Table 5 summarizes levels of service for key individual turning movements and compares SimTraffic estimates of the 95th percentile queue length for those key movements to the storage distance available for each. The queuing analysis shows that the estimated 95th percentile queues would be contained well within the turn bays or within the space between adjacent intersections during both peak periods. On both the northbound and southbound ramp terminals, left and right turn queues would be accommodated well within the storage length and would not extend into the I-25 main lanes.

SH 402 at I-25 DEIS Interchange Evaluation

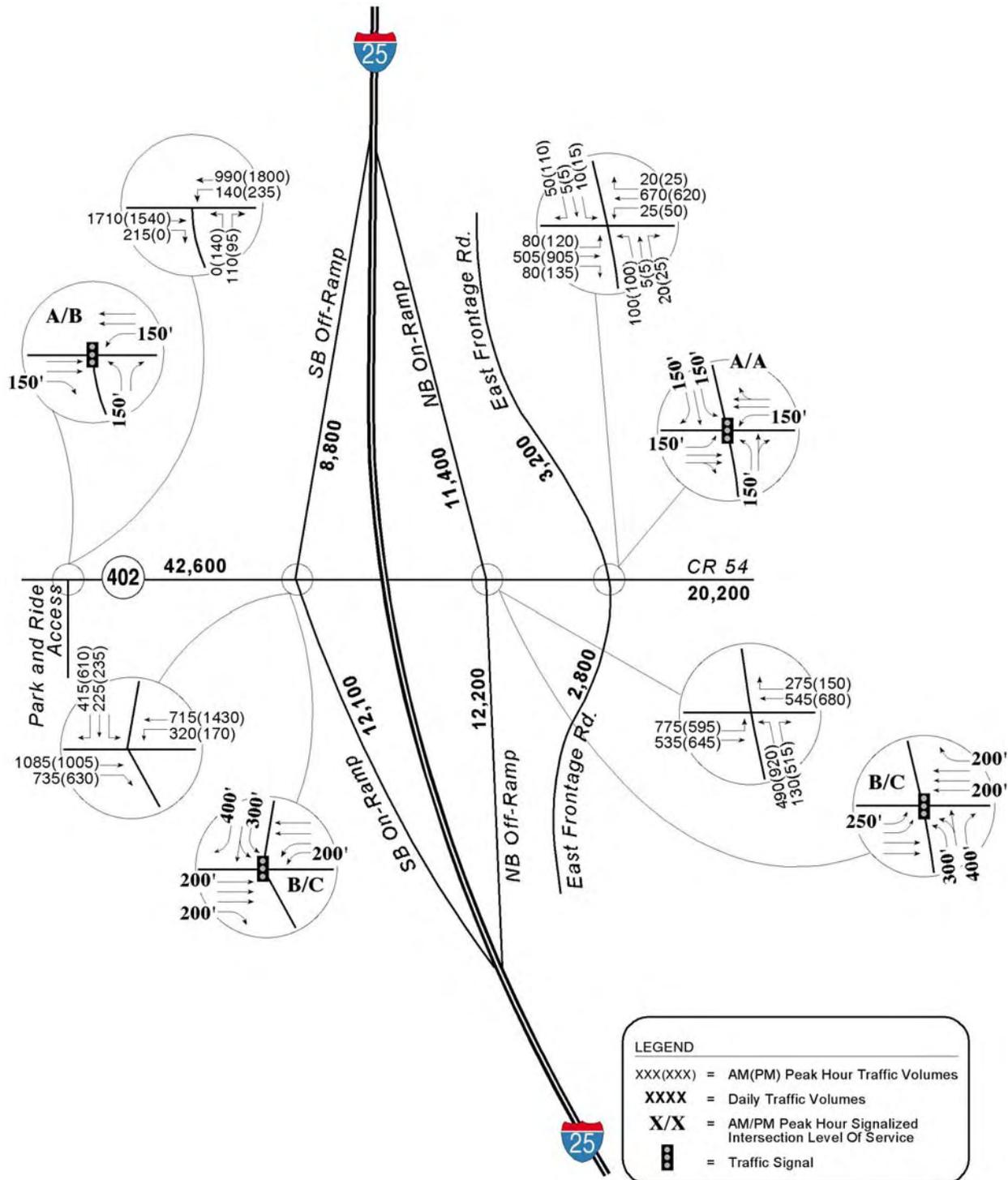


Figure 8. Package B Forecasts and Levels of Service

Table 5. 2030 Package B Level of Service and Queue Lengths for Key Movements

Intersection / Movement	Level of Service		Estimated 95 th Percentile Queue ¹		Distance Between Intersections and Storage Length Provisions
	AM	PM	AM	PM	
Park-and-Ride Access					
WB Left	C	C	160'	180'	Storage Provided in Design – 150'
WB Thru	A	A	70'	260'	Distance to Adjacent Intersection – 750'
Southbound Ramp Terminal					
EB Thru	B	A	790'	510'	Storage Provided in Design – 750'
EB Right	B	D	280'	150'	Storage Provided in Design – 200'
WB Left	C	D	690'	450'	Storage Provided in Design – 1,000'
WB Thru	A	B	120'	250'	Distance to Adjacent Intersection – 600'
SB Left	C	B	240'	400'	Storage Provided in Design – 700'
SB Right	D	D	190'	410'	Storage Provided in Design – 400'
Northbound Ramp Terminal					
EB Left	A	C	930'	630'	Storage Provided in Design – 1,050'
EB Thru	A	B	80'	220'	Distance to Adjacent Intersection – 600'
WB Thru	C	C	240'	210'	Distance to Adjacent Intersection – 850'
WB Right	B	B	180'	110'	Storage Provided in Design – 200'
NB Left	D	D	430'	540'	Storage Provided in Design – 700'
NB Right	C	C	70'	180'	Storage Provided in Design – 400'
East Frontage Road Intersection					
EB Left	A	A	60'	60'	Storage Provided in Design – 150'
EB Thru	A	A	50'	100'	Distance to Adjacent Intersection – 850'
¹ The queue lengths given in this table primarily come from SimTraffic with some engineering judgment. SimTraffic gives a queue length for each lane. For example, with dual left-turn lanes SimTraffic estimates a queue for each lane. In the table, for thru movements the queue length is the longest queue observed in any through lane. For multiple turn lanes (i.e. dual lefts), the queue length is the sum of the queues in each lane. For a single turn lane (i.e. right turn), the queue is just the queue for that lane.					

Other Carpool Lot Location Options

The same two park-and-ride lot location options in Package A are under consideration for Package B, but in this package the lot would be expanded to 360 spaces instead of 340. The above analysis was conducted with the lot located in the southwest quadrant of the interchange (Option 1). Under Option 2 (lot located in the southeast quadrant of the interchange and accessed off of the east frontage road), the southbound ramp intersection would operate at LOS B in the morning and LOS B in the afternoon, the northbound ramp intersection would operate at LOS B in the morning and LOS C in the afternoon and the east frontage road intersection would operate at LOS B in both peak periods. Thus, it would appear that both lot locations result in acceptable operations at the interchange, but like Package A, approximately 60 percent of the carpool lot patrons are oriented to and from the east, so the southeast lot location may provide more convenience than the southwest location.

Alternatives Evaluation Comparison

Traffic Operational Analysis

Table 6 compares the levels of service and delay at the SH 402 interchange for the No Action Alternative and each package. As the table indicates, without improvements at this location, all three intersections would operate at LOS E or F during both peak periods, but with the improvements identified above, all would operate at LOS C or better during both peaks. The levels of service and delays at each intersection are virtually the same for both alternatives, so it would appear that either package would result in adequate operations at this interchange.

Two carpool lot locations are under consideration for this interchange, one in the southwest quadrant of the interchange accessed off SH 402, the other in the southeast quadrant accessed off the frontage road. Both locations result in acceptable operations at the interchange, but since approximately 60 percent of the carpool lot patrons are oriented to and from the east, the southeast lot location may be more convenient than the southwest location.

Table 6. Intersection Level of Service and Delay

Intersection	No Action		Package A		Package B	
	AM Peak	PM Peak	AM Peak	PM Peak	AM Peak	PM Peak
Southbound Ramps	LOS F (>80 sec.)	LOS F (>80 sec.)	LOS B (16 sec.)	LOS C (25 sec.)	LOS B (18 sec.)	LOS C (26 sec.)
Northbound Ramps	LOS F (>80 sec.)	LOS F (>80 sec.)	LOS B (18 sec.)	LOS C (26 sec.)	LOS B (17 sec.)	LOS C (26 sec.)
East Frontage Road ¹	LOS E (66 sec.)	LOS F (>80 sec.)	LOS A (8 sec.)	LOS A (10 sec.)	LOS A (8 sec.)	LOS A (10 sec.)

1. Assumes traffic signals only at this intersection (no turn lane revisions)

LOS X – Level of service

- Average delay in seconds per vehicle