I-5 Optimization Study

Final Report

DKS

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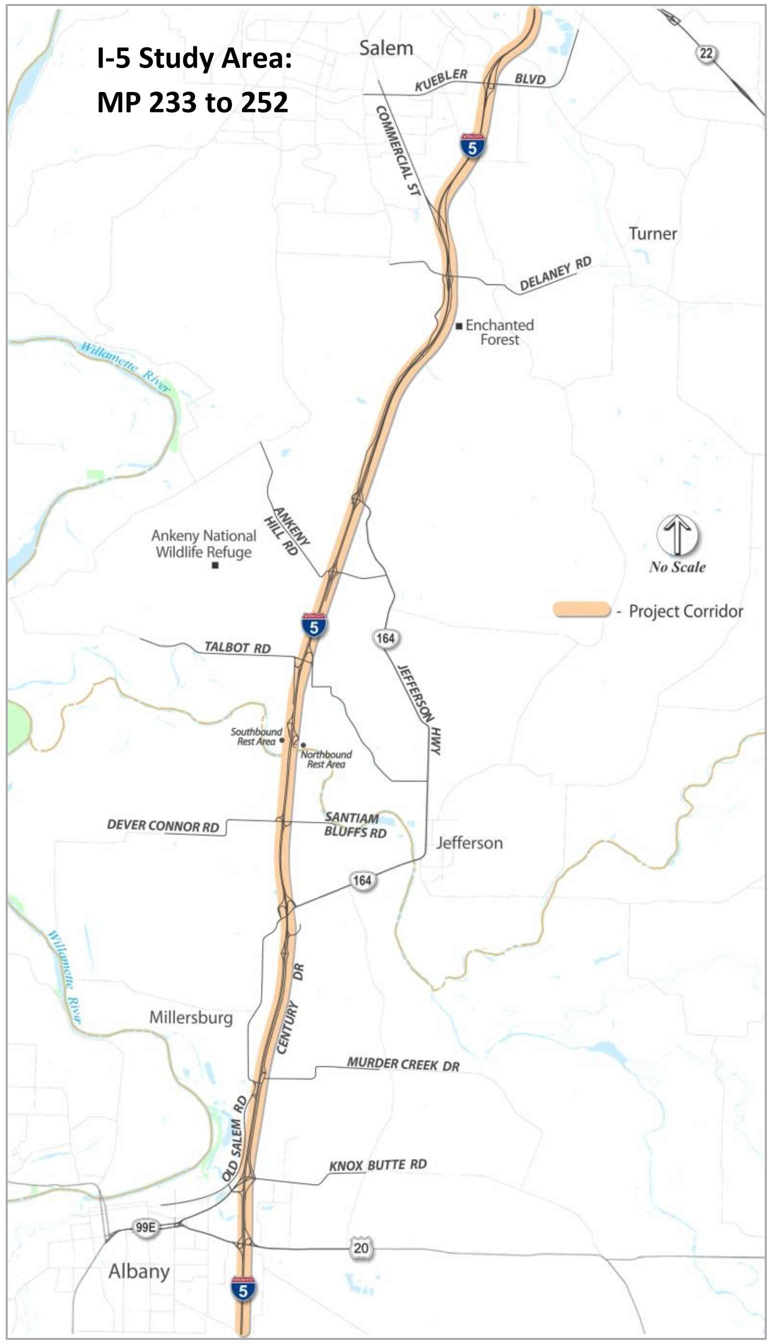
1. CHAPTER 1 – EXECUTIVE SUMMARY

About the Project

The I-5 Optimization Project identifies low cost, operational improvements to address safety and mobility over the next five years. The Interstate 5 (I-5) corridor between Salem and Albany experiences unreliable travel times, congestion, and delays caused primarily by non-recurring events.

The ODOT internal project team evaluated strategies that could be implemented quickly with a relatively low cost to improve the corridor operations. Four system management strategies offer the greatest potential benefits and return on investment for the study corridor and are recommended for implementation: traffic surveillance, ramp metering, incident information signs, and variable speeds signs.



The study area includes 19 miles of I-5 through Oregon, between Salem (mile post 252) and mid-Albany (mile post 233). This section of I-5 typically carries between 60,000 and 70,000 vehicles per day, of which 13 to 18 percent are freight vehicles.

Key Corridor Needs

A review of existing conditions along the corridor identified several corridor needs:

1. **The project needs to find ways to address delay from non-recurring events.** Non-recurring congestion (such as crashes, weather events, special events, and road debris) cause the greatest amount of delay along the study corridor.

2. **The project needs to find ways to reduce weather related crashes, particularly at the north end of the study corridor.** At the north end of the study corridor there tends to be more weather related crashes than along the rest of the corridor. This section is hillier and has more horizontal curves than to the south.

3. **The project needs to find ways to reduce crash clearance times.** The average duration for a non-fatal crash with a lane closure is about 80 minutes, while the average duration for a fatal crash is just over three hours.

4. **The project needs to find ways to improve freight travel time reliability.** This section of I-5 is classified as a freight route, and carries approximately 13 to 18 percent heavy vehicle traffic. Travel time reliability is critical for efficient freight movement during all times of the day (not just peak hours).

5. **The project needs to find ways to reduce the congestion caused by passenger vehicles and heavy trucks traveling at different speeds.** Speed differential between passenger vehicles and heavy trucks ranges from six to twelve percent, depending on the location.

The Goals and Objectives

The project team identified three primary goals with multiple objectives. Chapter 3 includes specific targets for each of the objectives listed here.

Goal 1: Improve Safety

Objectives:

- Reduce rear end crashes
- Reduce fixed object and side-swipe crashes
- Reduce weather related crashes
- Clear all lane blocking incidents within a 90 minute clearance goal

Goal 2: Improve Commuter Mobility

Objectives:

- Reduce fixed object and side-swipe crashes
- Reduce weather related crashes
- Clear all lane blocking incidents within 90 minutes

Goal 3: Improve Freight Mobility

Objectives:

- Make travel times more reliable during peak hours
- Make travel times more reliable during non-peak hours
- Reduce freight related crashes

Maintenance Strategies to Improve Operations

Along with the four recommended strategies in this I-5 Optimization Project, ODOT completed an internal evaluation of 12 additional strategies that the Region 2 Maintenance and Operations group will pursue:

HIGH PRIORITY

- Evaluate and optimize the incident response vehicle program
- Inlaid pavement markings and reflectors

HIGH/MEDIUM PRIORITY

- Corridor operations team
- Demand management strategies
- Higher visibility markings and signage
- Mile marker signs

MEDIUM PRIORITY

- Dry run towing
- Hourly towing contract
- Incentivizing clearing heavy vehicle incidents

Recommended Strategies and Suggested Phasing

The I-5 Optimization Project recommends four transportation system management and operations strategies (see Figure 1-1) to achieve the corridor objectives. Installing the four strategies together delivers the highest benefit-cost ratio because each can share a fiber communications backbone for communications to the Traffic Operations Center, which reduces overall project costs. However, if funding is not available to install all four strategies together, we recommend the following project order.

1	**Traffic Surveillance**	**Estimated Initial Capital Cost: $630,000**	**B/C Ratio: 6.6**
	Summary: Install four new pan-tilt-zoom (PTZ) cameras and upgrade two existing cameras to PTZ cameras at the locations shown in Figure 1-1.		
	Benefits: Reduces incident duration by up to 10%.		
2	**Ramp Metering**	**Estimated Initial Capital Cost: $380,000**	**B/C Ratio: 5.6**
	Summary: Install a ramp meter at the Knox Butte/OR 99E interchange (Exit 234) to meter northbound traffic. Use the existing ODOT adaptive ramp metering system to activate the meter when mainline volumes exceed the programmed threshold.		
	Benefits: Reduces crashes by 36% near the on-ramp, improves freeway capacity by 10%, and reduces fuel consumed by 10%.		
3	**Incident Information Signs**	**Estimated Initial Capital Cost: $1,440,000**	**B/C Ratio: 3.1**
	Summary: Install dynamic message signs (DMS) to provide real-time information to drivers including incident information and travel times Figure 1-1 shows the proposed sign locations.		
	Benefits: Reduce injury crashes by 5%, and reduce delay.		
4	**Variable Speeds w/ Weather Responsive**	**Estimated Initial Capital Cost: $8,650,000**	**B/C Ratio: 0.9**
	Summary: Install variable speeds with a weather responsive system on a seven-mile segment at the north end of the study area. Automatically change the speed based on current congestion and weather conditions. This cost estimate assumes fiber installation, which is conservative. With other communication options, the project cost will likely decrease.		
	Benefits: Reduce all crashes by 7% and reduce weather related crashes by up to 18%.		

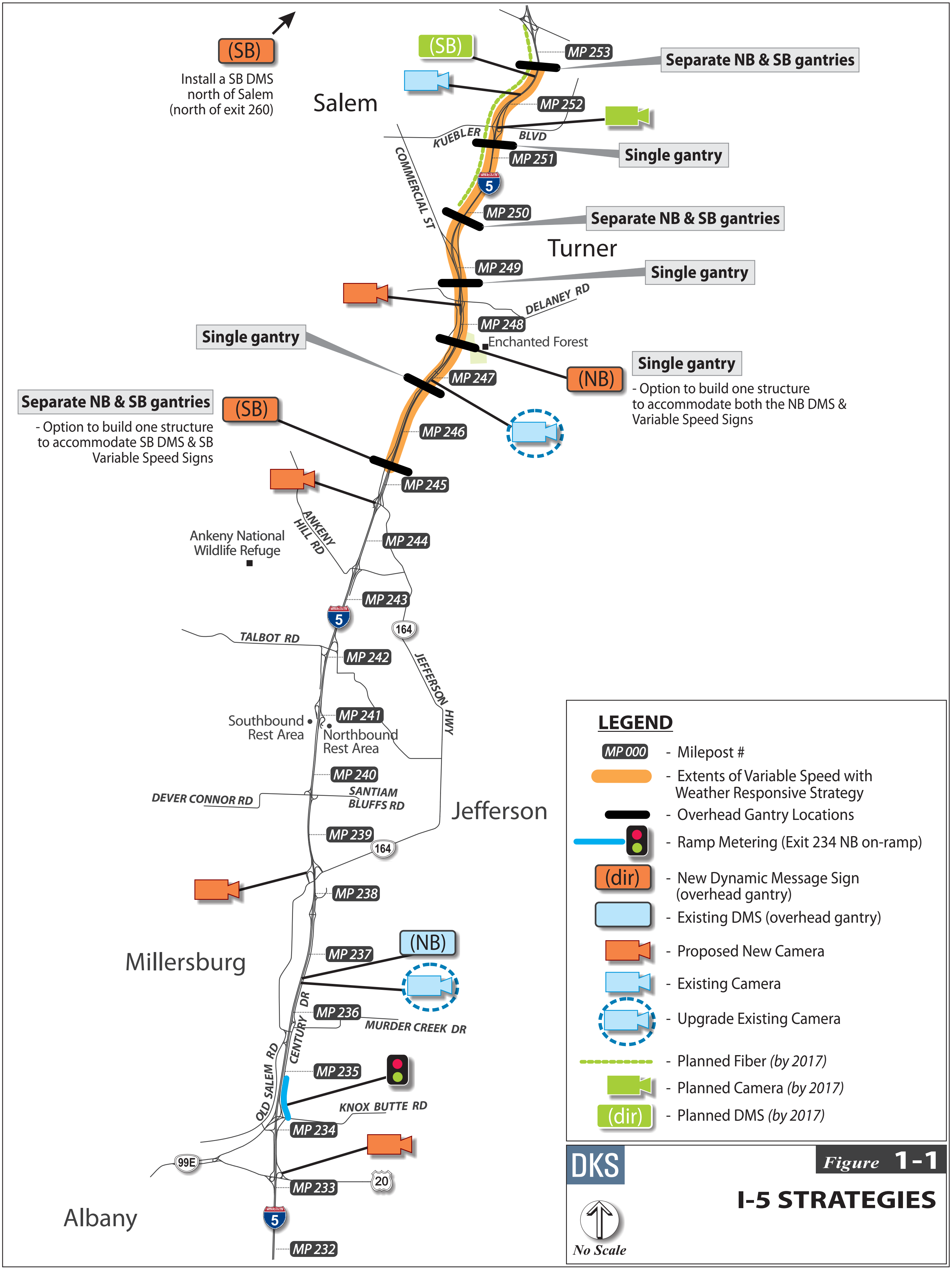


Figure 1-1

I-5 STRATEGIES

Next Steps

The project team identified additional considerations that should be evaluated as the project moves into design. These items deal with detailed design elements, project add-ons that can provide great value for a small cost increase, and policy based decisions that require larger ODOT discussion. These items are identified for each strategy in Figure 1-2.

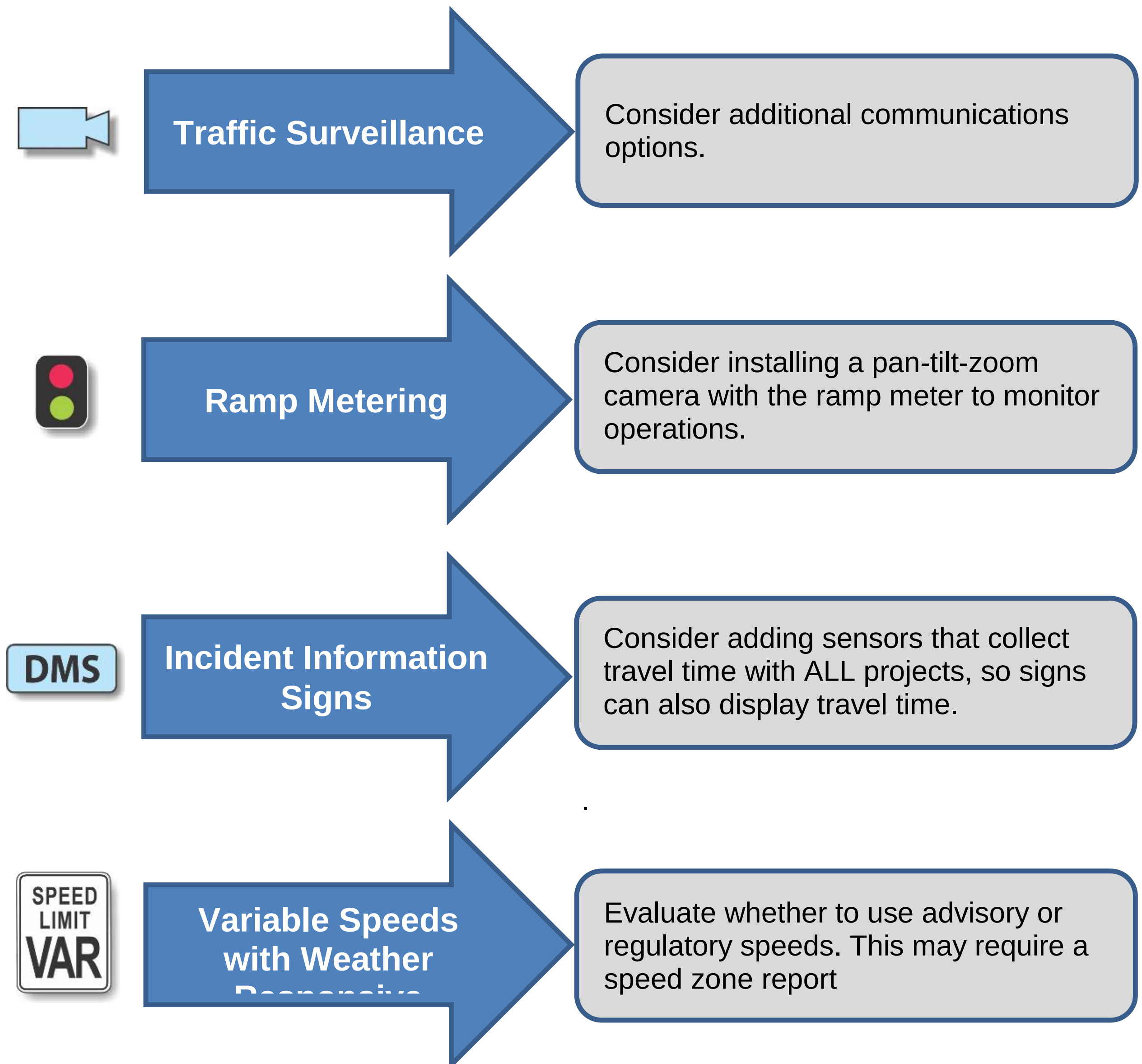


Figure 1-2: Strategy Next Steps

2. CHAPTER 2 – EXISTING CONDITIONS

This portion of the report documents the existing conditions along approximately 19 miles of Interstate 5 (I-5) through Oregon, between Salem (just north of Interchange 252 at Kuebler Boulevard) and mid-Albany (Exit 233 at Highway 20).

In order to better assess the most appropriate management strategies for this freeway segment, the current conditions of the freeway must be understood. The existing conditions memorandum reviews key findings, general study area characteristics, traffic volumes, speed differentials, congestion and delay, crash and incident data, observed problems, and other relevant information.

2.1 Key Findings

The key findings include:

Delay Related Findings

- Non-recurring congestion such as crashes and special events rather than recurring congestion cause the greatest amount of delay along the study corridor.
- Review of the operational data identified 30 percent of the delay experienced by drivers is the result of crashes, and six percent is due to weather conditions. The remaining 64 percent results from special events, maintenance/ construction activities, non-collision based incidents (i.e. road debris), and some recurring congestion.
- The average duration for a non-fatal crash with a lane closure is about 80 minutes, while the average duration for a fatal crash is just over three hours.
- Based on planning time index data from 2013, northbound congestion appears to be worse than southbound congestion. And Fridays and Sundays appear to experience the greatest congestion compared to other days of the week.

Crash and Safety Related Findings

- The most common types of crashes are rear ends, fixed object, and side-swipe by overtaking.
- At the north end of the study corridor there tend to be more weather related crashes than along the rest of the corridor. This northern section also has more graded sections and horizontal curves than to the south.
- There are spikes in crashes at a few areas along the study corridor:
    - At the north end near Kuebler Boulevard
    - In the curves by the Enchanted Forest area
    - Near mile post 243 (Ankeny Hill area)
    - Near mile post 237 (Millersburg area)

- Speed differential between passenger vehicles and heavy trucks ranges from six to twelve percent, depending on the location.

Traffic Volume Related Findings

- Based on a linear growth rate, the northern end of the study corridor (where there are three lanes in each direction) will reach congested conditions in approximately year 2030 for typical weekday traffic. At the southern end of the study area where there are two lanes in each direction congested conditions will be reached by approximately 2018 for weekday traffic.
- Traffic volumes through this study corridor remain steady with little to no growth over the past ten years.

2.2 Study Area Characteristics

The study area encompasses approximately 19 miles of I-5 from the southern end of Salem to mid-Albany. This section of I-5 is part of the National Highway System and is also an Oregon Highway Plan freight route. Salem and Albany are both considered urban areas with populations of approximately 160,000 people and 50,000 people respectively[1]. Millersburg is another populated area just north of Albany with a population just over 1,000 people. Between Salem and Millersburg/Albany the land use is considered rural. The study area is shown in Figure 2-1.

This stretch of I-5 is typically two lanes in each direction with annual average daily traffic (AADT) around 60,000 to 70,000 vehicles. There are a few segments with a third auxiliary lane between interchanges, but for the most part, I-5 has two lanes of traffic in each direction south of the Kuebler Boulevard Interchange (south end of Salem).

Figure 2-2 shows the lane geometry, spacing between interchanges, and p.m. peak hour volumes from the year 2000 along the study area segment. Since traffic volumes along this corridor remained steady over the past ten years, the 2000 volumes were used to understand general traffic patterns, but updated volumes were used for all analysis purposes. The p.m. peak hour volumes are from the I-5 State of the Interstate Report from the year 2000[2]. There are several interchanges in the middle of the study area that did not meet ODOT criteria to complete a more detailed screening analysis, so peak hour volumes are not available for those interchanges (as noted on the Figure). Data shows that the traffic volumes along this stretch of I-5 have been relatively steady over the past decade (see the “Current and Past Traffic Volume Trends” section of this memorandum).

2010 US Census data

[2] ODOT I-5 State of the Interstate Report, 2000. Version 1.0. Appendix P.

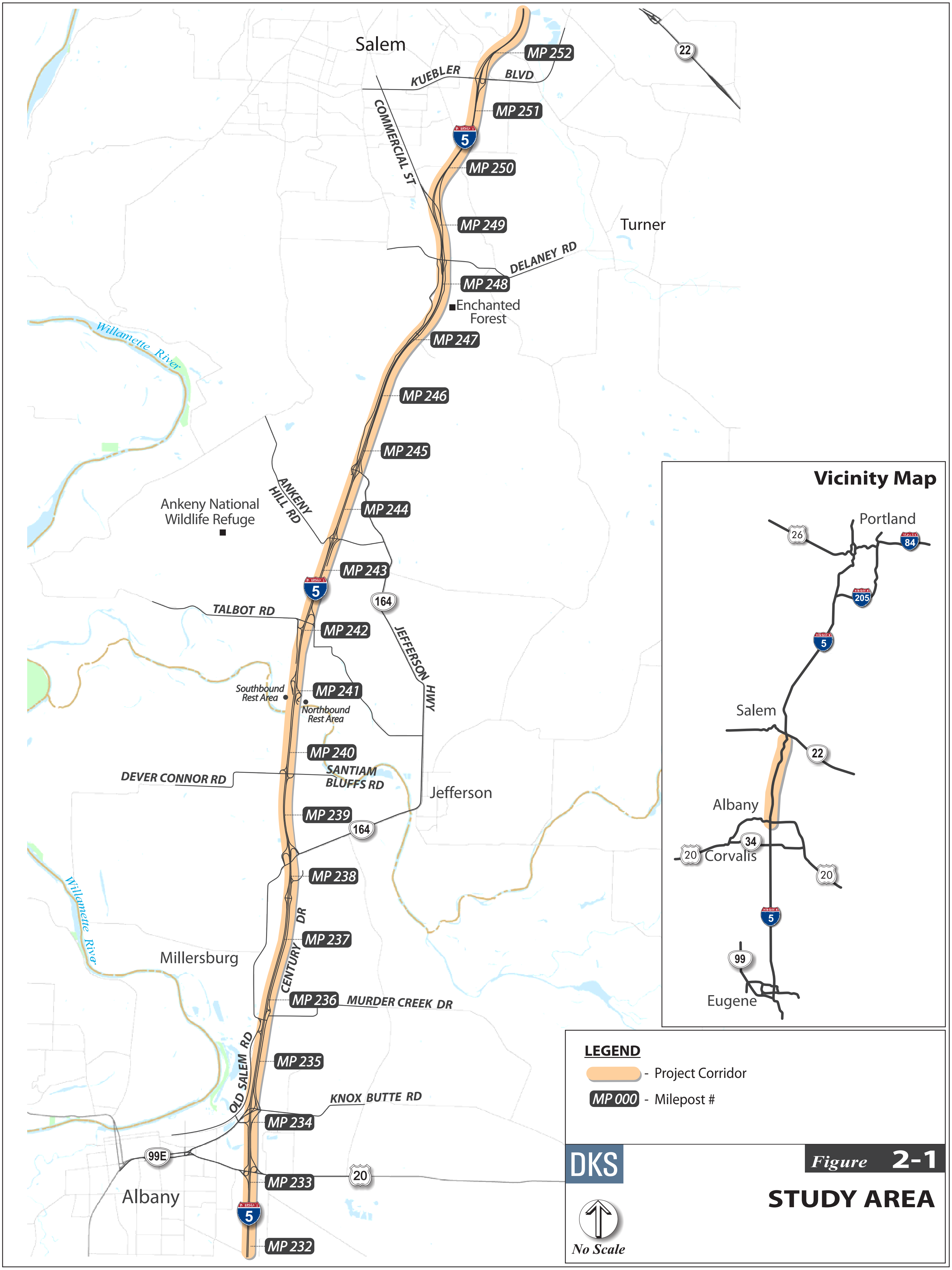


Figure 2-1
STUDY AREA

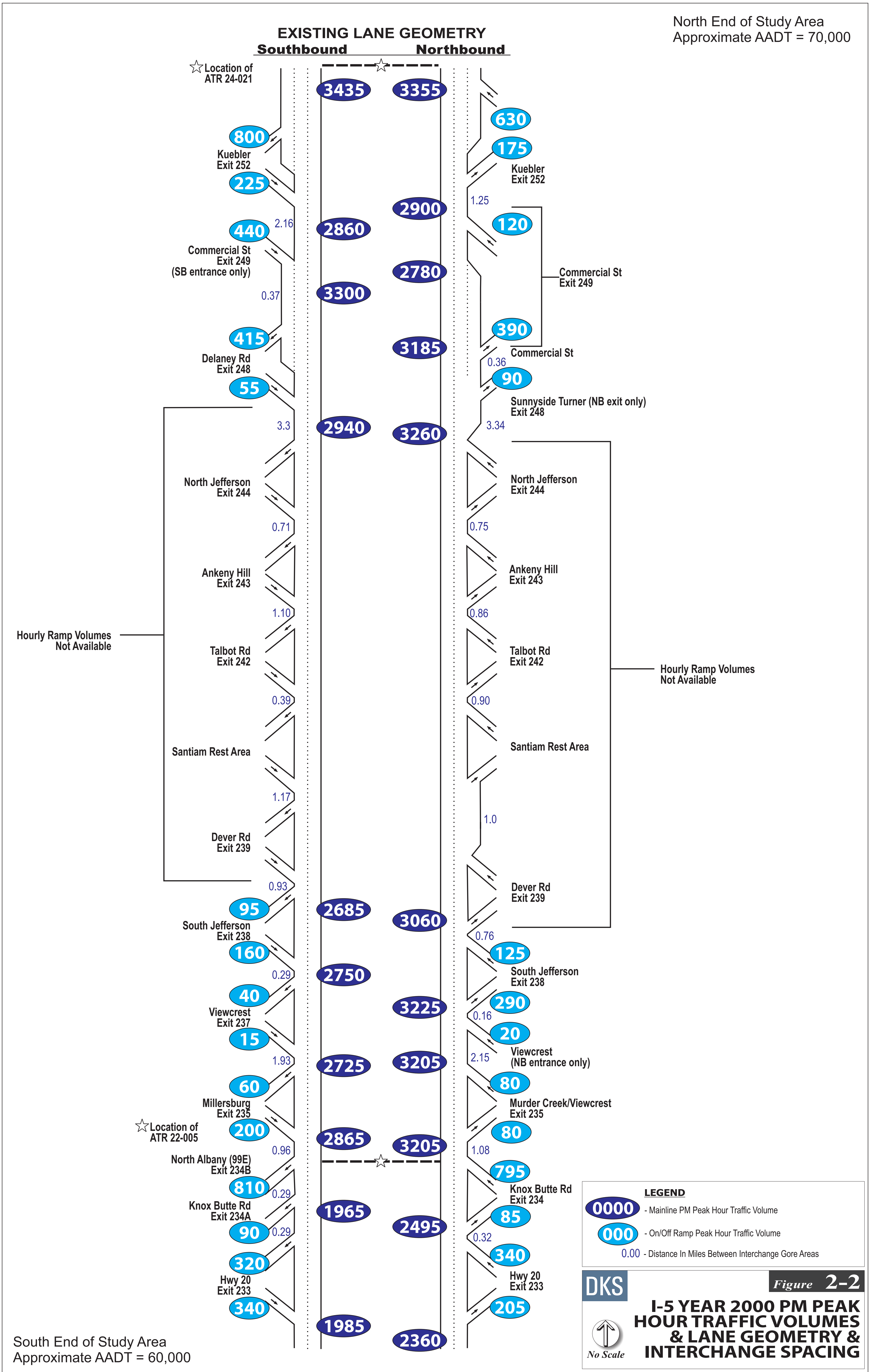


Figure 2-2

I-5 YEAR 2000 PM PEAK HOUR TRAFFIC VOLUMES & LANE GEOMETRY & INTERCHANGE SPACING

The ODOT interchange spacing standard is 3 miles in urban areas and 6 miles in rural areas[3]. Most of the interchanges through the study area do not meet this standard. There are five locations in particular where the spacing between the entrance lane and exit are less than 0.4 miles:

- Southbound between Interchanges 249 entrance (Commercial Street) and Interchange 248 exit (Delaney Road) – 0.37 miles
- Southbound between Interchange 242 entrance (Talbot Road) and the Santiam Rest Area exit – 0.39 miles
- Southbound between Interchange 238 entrance (South Jefferson) and Interchange 237 exit (Viewcrest) – 0.29 miles
- Northbound between Interchange 233 entrance (Highway 20) and Interchange 234 exit (Knox Butte) – 0.32
- Northbound between Interchange 237 entrance (Viewcrest) and Interchange 238 exit (South Jefferson) – 0.16 miles

An active project, the I-5 South Jefferson to US 20 Environmental Assessment[4], is evaluating ways to improve accessibility, mobility and safety along that six mile stretch of I-5 (between mile post 233 and mile post 239). That project will address interchange modifications in an attempt to achieve interchange spacing standards.

Figure 3 shows the geometric components along the study corridor including areas with substandard shoulder widths, clear zone infringements, median types, and areas with steeper terrain.

The terrain varies with some rolling hills and horizontal curves, as well as long level straight segments. The steepest grades occur toward the north end of the study corridor. Between mile points 246 and 249 grades of almost five percent are present. Most of I-5 through the study area has a design speed of 70 miles per hour. At the north end, near Salem at mile post 250.6, the design speed decreases to 60 miles per hour.

The right side standard shoulder width on a freeway is ten feet, based on the ODOT highway design manual, or twelve feet when directional design truck volumes are greater than 250 trucks per hour. The left side shoulder is dependent on the number of lanes, truck volumes, and whether the design meets 4R or 3R standards. The 4R standards (which are more stringent) apply to new construction. The 3R standards apply to repaving and rehabilitation projects. Based on 4R standards the left shoulder should be six feet wide for a two lane section and ten feet wide for a three or more lane section. Based on these 4R standards, there are a few sections where the left or right shoulders do not meet standards as shown in Figure 2-3.

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[3] ODOT Highway Design Manual, 2012, Chapter 5.

[4] Project website: http://www.oregon.gov/ODOT/HWY/REGION2/pages/i-5_southjefferson_home.aspx

Figure 2-4 shows the existing ITS equipment along the corridor. There are three cameras, a weather station, and a dynamic message sign. The three cameras are located at approximate mile posts 237,247, and 252. The camera near mile post 247 is accompanied by a weather station. There is a dynamic message sign for northbound traffic near mile post 237, and a planned dynamic message sign in the southbound direction near Millersburg[5]. Highway advisory radio also operates along this stretch of I-5.

[5] Central Willamette Valley ITS Plan. Prepared for ODOT, Prepared by DKS Associates and IBI Group. December 2010

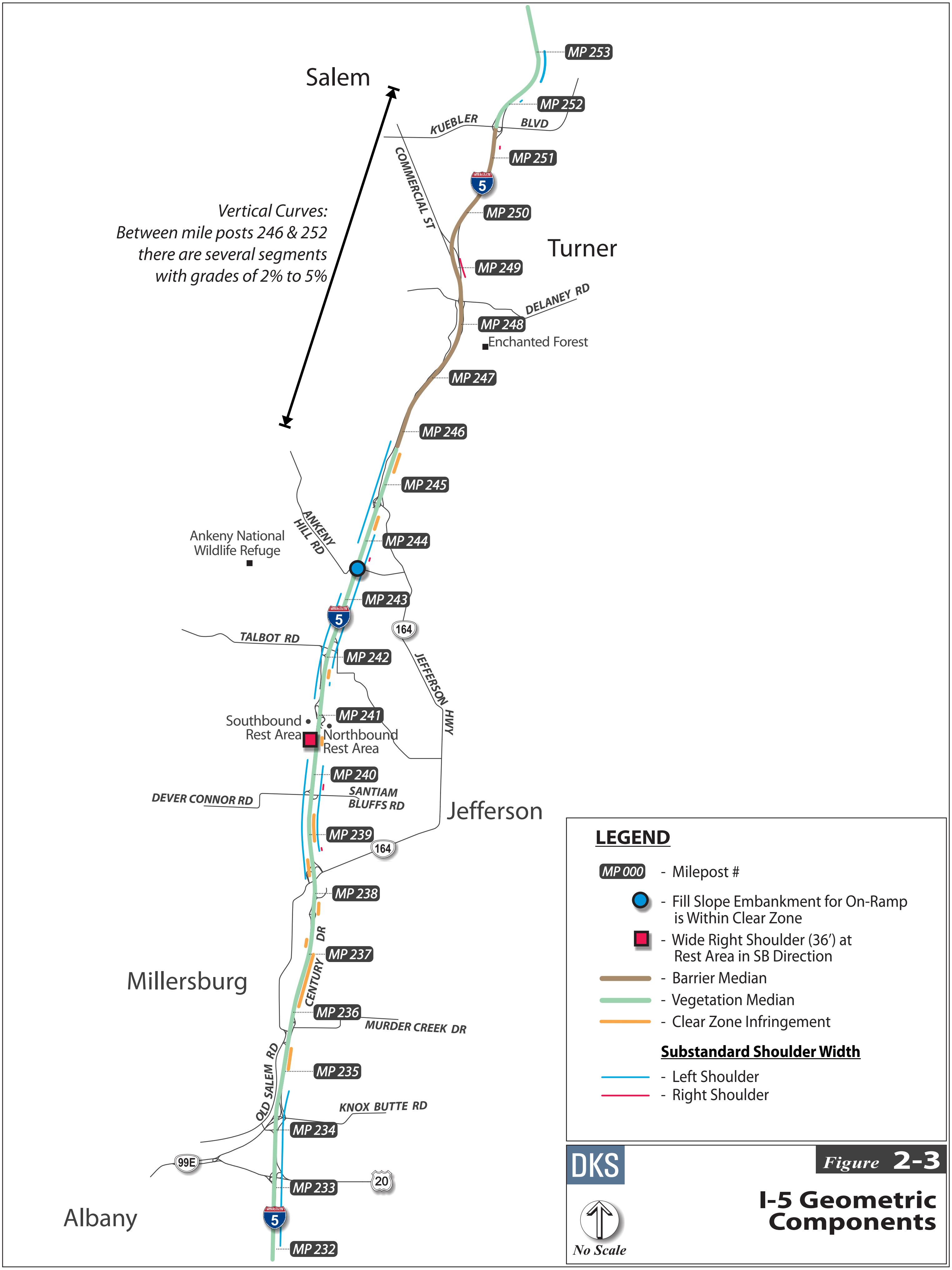

Figure 2-3
I-5 Geometric Components

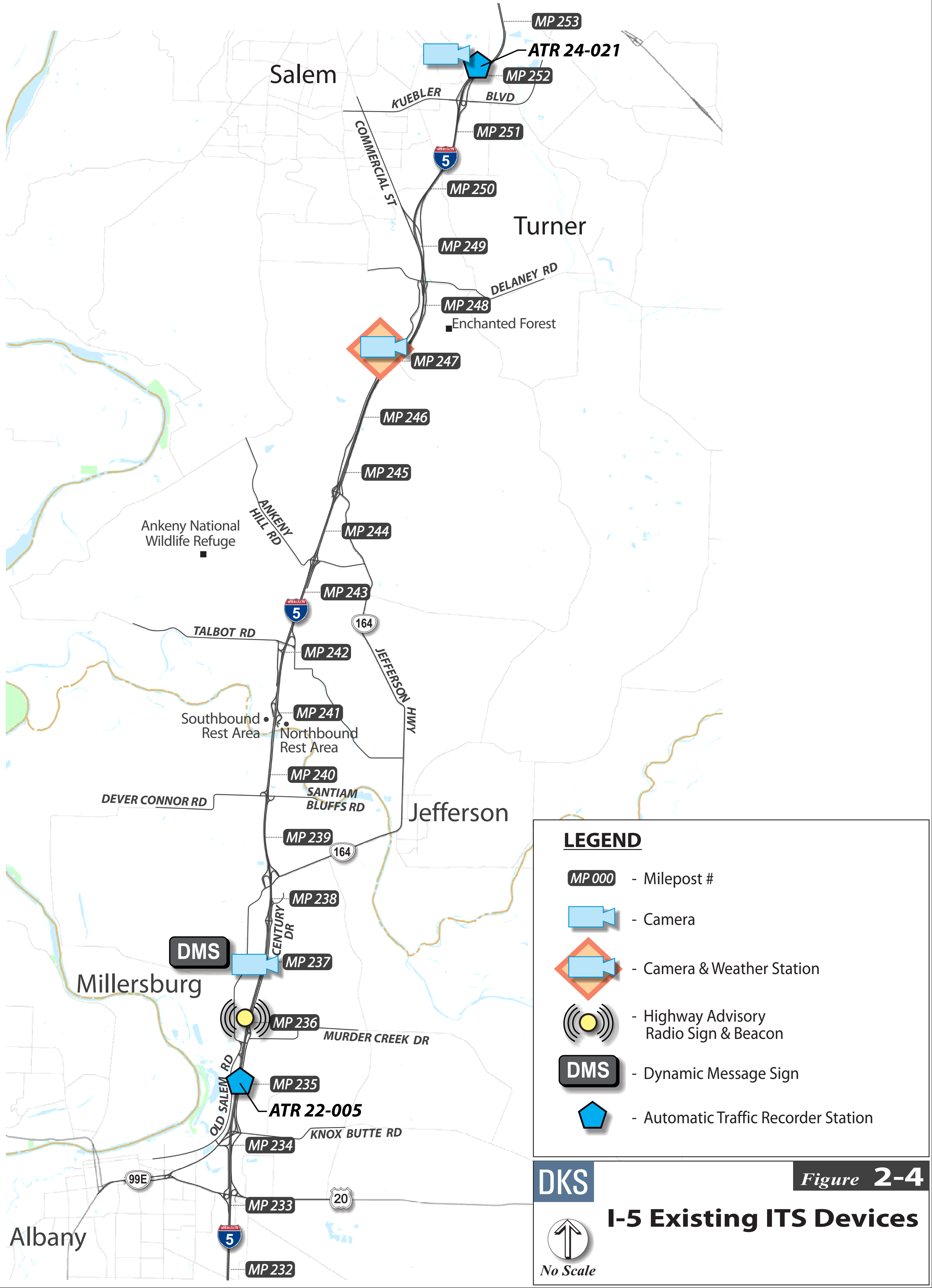

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Figure **2-4**

I-5 Existing ITS Devices

2.3 Traffic Volumes

Volume data was obtained from Automatic Traffic Recorders (ATRs) within the study corridor. This section summarizes current and past traffic volume trends, future projected volumes, and capacity growth analysis.

2.3.1 Current and Past Traffic Volumes Trends

There are two ATRs in the study area that collect traffic volume, speed, and classification data continuously. At the north end of the study area ATR 24-021 is located at mile post 252.2 (just north of the southbound Exit 252, where there is a three percent uphill grade in the southbound direction), collecting data since 2009. At the south end of the study area ATR 22-005 is located at mile post 234.8 (along a level straight stretch of roadway), collecting data since 2000.

At the north end of the study area by Salem, annual average daily traffic (AADT) is approximately 70,000 vehicles (combined northbound and southbound). At the south end of the study area by Albany, the AADT is slightly less at approximately 60,000 vehicles. Figure 2-5 shows the AADT volumes for both ATR stations. Both ATR stations show relatively steady traffic volumes since data collection began in 2000 and 2009, and similar peak and low volume months. Traffic volumes peak during the summer (August is up to 112% of the AADT), and the lowest volumes occur during January (approximately 85% of the AADT).

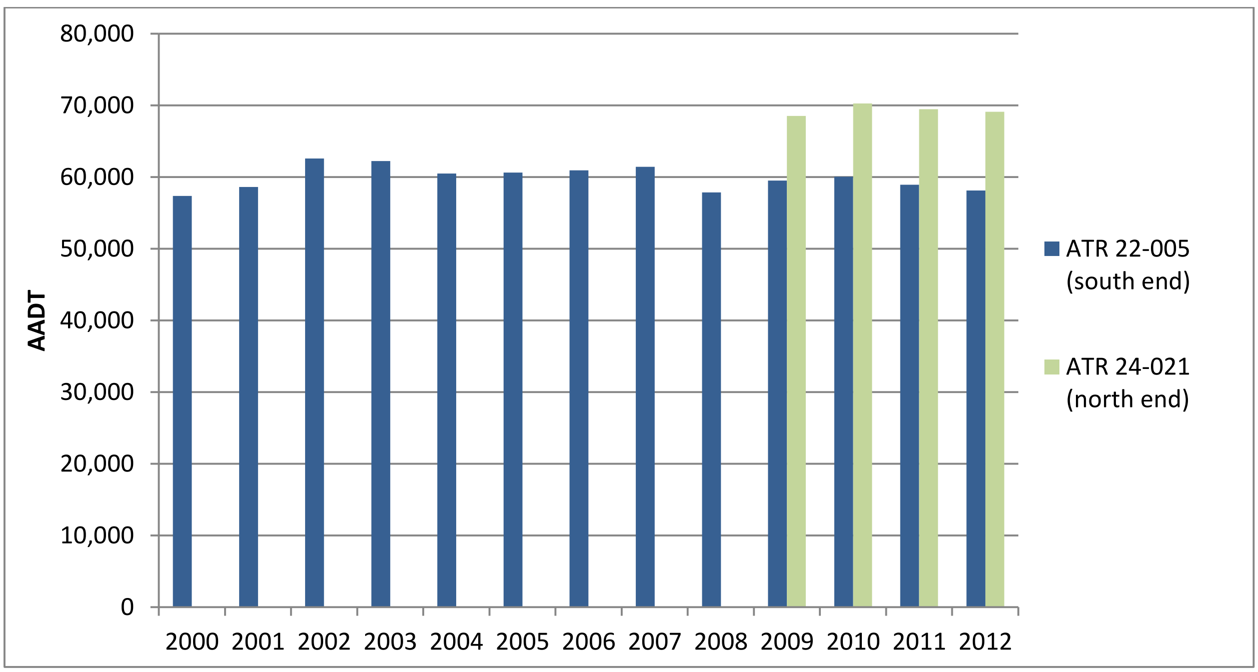


Figure 2-5: Annual Average Daily Traffic at the two ATR Stations

The ATR stations also provide annual vehicle classification averages. The Federal Highway Administration classifies heavy trucks as anything larger than a single unit truck (such as a delivery truck)[6]. In Figure 6, the passenger vehicle category includes motorcycles, cars, and pick-up trucks. The light truck/bus category includes single unit trucks and all buses.

Based on the 2012 ATR data, at the north end of the study area approximately 83 percent of the vehicles were passenger cars, motorcycles or light trucks, four percent were single unit trucks and buses, and the other 13 percent were heavy vehicles. At the south end of the study area the breakdown has a higher percentage of heavy vehicles (18 percent) and a slightly lower percentage of passenger cars, motorcycles and light trucks (78 percent), while the percent of single unit trucks and buses remains at four percent. These vehicle classifications are shown in Figure 2-6. The percentages were steady during each of the available collection periods for the ATR stations.

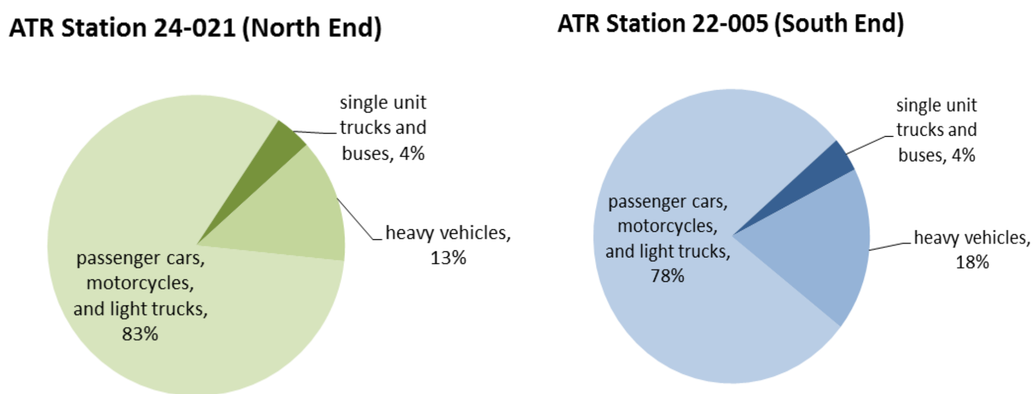


Figure 2-6: Typical Vehicle Classification for 2012

For comparison purposes we looked at vehicle classifications at three other ATR stations across Oregon. The two more rural locations show similar trends as this study area, but the urban location with the City of Portland limits had a much higher percentage of passenger cars/motorcycles/light trucks than the study area, and a lower percentage of heavy vehicles.

Table 2-1 shows the vehicle classifications at the additional three ATR stations.

[6] Federal Highway Administration. Figure 3-6. Link at: http://www.fhwa.dot.gov/environment/air_quality/conformity/research/improving_data/taqs03.cfm

Table 2-1: Vehicle Classification Data, 2012

Classification	ATR 17-001 I-5 North of Grants Pass (MP 64.20)	ATR 25-008 I-84 West of Hermiston (MP 168.55)	ATR 26-014 I-84 Portland Metro Area (MP 3.35)
Passenger Car, Motorcycle, & Light Trucks	77%	74%	95%
Single Unit Trucks and Buses	3%	2%	3%
Heavy Vehicles	20%	24%	2%

2.3.2 Future Projected Volumes

Future year 2032 highway volumes were obtained from ODOT's Transportation Systems Monitoring Unit Traffic Counting Program[7]. As stated on ODOT's website, the future volumes are estimates only and may be affected by local growth and comprehensive plans. These future volumes are intended to provide an idea of how the area may grow. Compared to 2011 traffic volumes, projected year 2032 volumes increase approximately 40 percent, with an annual growth rate of approximately 1.6 percent.

Figure 2-7 shows 2011 and 2032 AADT volumes at specified locations along the corridor. There are two distinctive spikes in volume. At the southern end there is a sharp increase between mile posts 233.73 and 234.8. This increase is due to entering volumes at Highway 20 and Highway 99E/Knox Butte Road. The p.m. peak hour ramp volumes at these interchanges are shown in Figure 2. Highway 20 and Highway 99E both access Albany as well as connecting to other destinations. Highway 20 connects with Corvallis to the west and eventually Newport on the coast. To the east Highway 20 connects with Lebanon and serves as a route to central Oregon as well. Highway 99E runs north/south parallel to I-5 to Eugene and beyond.

At the north end the traffic increases sharply between mile posts 251.03 and 252.20. This second spike in traffic volumes is due to the Kuebler Boulevard interchange (also where the freeway transitions from two to three lanes in each direction).

[7] ODOT's 2032 Future Highway Volume Table. Link at: http://www.oregon.gov/ODOT/TD/TP/Pages/Data.aspx

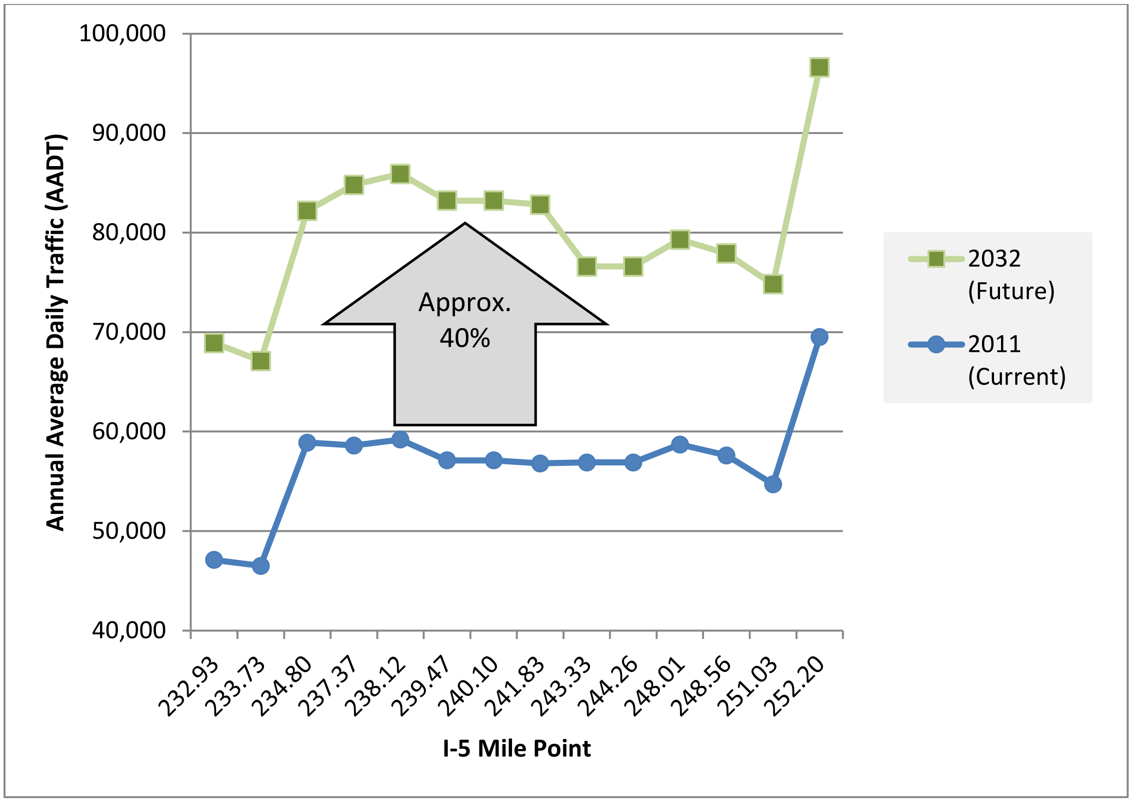


Figure 2-7: Future Volume Projections

2.3.3 Capacity Growth Analysis

Using the volume data from the two ATR stations and future volumes for 2032 from ODOT's future volume table, we examined the relationship between freeway traffic volumes and capacity.

Our methodology assumed linear growth from 2011 to 2032. We applied the annual growth rate calculated from the ODOT future volumes table, to the existing peak hour volumes at the two ATR stations in the study corridor. Each graph shows the northbound and southbound future volumes based on the linear growth rate, as well as the maximum capacity and the capacity according to a mobility standard of 0.70 (since most of the study area is outside the urban growth boundary).[8] The maximum capacity assumes a flow rate of 2,000 vehicles per hour per lane.

Figures 8 and 9 show the capacity growth results. Fridays tend to have a higher p.m. peak hour than the rest of the week, so each figure shows the estimated traffic volumes for a typical weekday and a Friday. The 2012 volumes for each of these were based on an average of all the Tuesdays through Thursdays, and Fridays during the peak month (August).

[8] Oregon Highway Plan Mobility Standard Guidelines. Aug 7, 2009. Appendix A, Table 6.

Based on these assumptions, the volume will not exceed maximum capacity at either of these locations by year 2035, but it will surpass the mobility standard at both the north and south end of the study corridor. At the north end, where I-5 is three lanes in each direction, southbound traffic volumes are greater than northbound volumes, and the Friday southbound volumes are expected to exceed the mobility standard in approximately year 2027 (as shown in Figure 2-8).

At the southern end of the study corridor (shown in Figure 2-9), the Friday traffic volumes are close to the mobility standard today. By approximately year 2018 the northbound weekday traffic volumes are expected to exceed the mobility standard at this location.

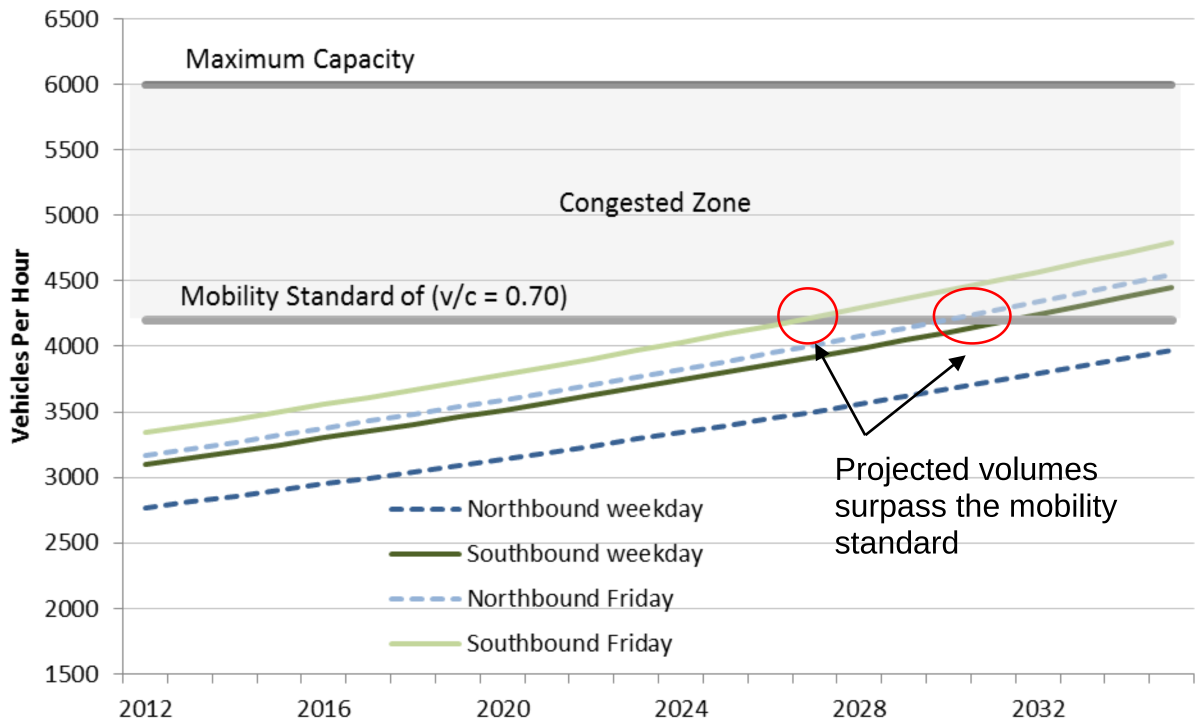


Figure 2-8: Volume Capacity Analysis at ATR Station 24-021 (near Kuebler Blvd)

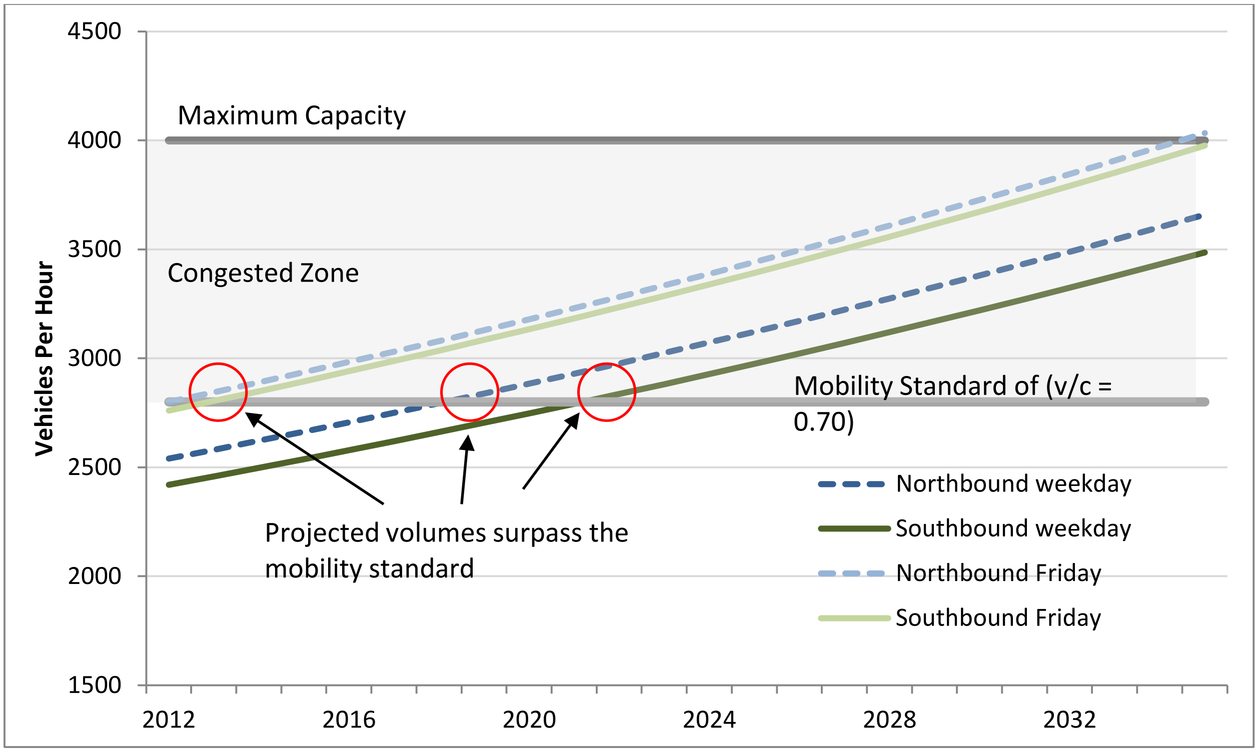


Figure 2-9: Volume Capacity Analysis at ATR Station 22-005 (near Knox Butte Rd)

2.4 Speed Differential

Throughout the study corridor there is a lower speed limit for trucks (55 miles per hour) than for passenger vehicles (65 mile per hour). Due to both the speed limit policy and the graded terrain along the corridor, speed differentials arise between trucks and passenger vehicles. There is the perception that speed differential causes notable congestion along the corridor. By analyzing data from the two ATR stations along the corridor we found a six to twelve percent speed differential between vehicle types, and in steeper areas the speed differential is likely a higher percentage. A six to twelve percent speed differential does confirm the perceived conflict between passenger cars and heavy vehicles, yet is consistent with the posted speed limits.

Each of the two ATR stations within the study area collects classification and speed data (by lane and hour) as well as volume data. We analyzed data at both ATR stations for the entire year of 2013 to determine whether there is a significant speed differential between passenger vehicles and heavy vehicles. The data collected by the ATR stations group vehicles in one of four classifications based on length: 0-20 feet, 20 to 35 feet, 35 to 61 feet, and over 61 feet. This length based classification is different than how the Federal Highway Administration classifies vehicles (by axles and units). The ATR data then places each vehicle in a speed bin grouped in five mile per hour increments, from 40 to 90 miles per hour.

Table 2-2 and Table 2-3 show the speeds by lane for each of the four vehicle classifications. Based on the analysis, we found a six to twelve percent difference of speeds in a lane at a given location when comparing the vehicles less than 20 feet to those over 61 feet in length. Those results are shown in the far right column of Tables 2-2 and 2-3. At each location the left most lane had the greatest speed differential between vehicle types.

The ATR station at the north end of the study area (24-021) is on a three percent grade, with southbound lanes heading uphill and northbound lanes heading downhill. Not surprisingly, northbound speeds across all vehicle classifications are slightly higher than southbound speeds. Comparing the percent difference in speed between passenger vehicles and vehicles over 61 feet long, the right lanes at this location have approximately a six percent differential and the middle and left lanes show a slightly higher percent difference of seven to eight percent.

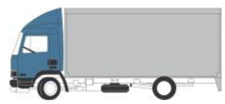
Table 2-2: Average Speeds (mph) by Lane and Vehicle Length (All hours of the day)[2]

	Length 1 0-20 ft 	**Length 2** 20-35 ft 	**Length 3** 35-61 ft 	**Length 4** Over 61 ft 
SOUTHBOUND – uphill (3% grade)				Speed & (% difference from Length 1 vehicles)
SB right lane	60	58	57	57 (5.7%)
SB middle lane	64	63	60	59 (8.0%)
SB left most passing lane	67	67	66	62 (8.1%)
NORTHBOUND – downhill (3% grade)				
NB right lane	64	62	60	60 (5.6%)
NB middle lane	67	66	63	62 (7.4%)
NB left most passing lane	70	70	69	65 (7.1%)
[2] Data collected at ATR Station 24-021 near Salem, mile point 252.2				

A similar analysis was completed for the second ATR station (22-005) at the south end of the study area. This ATR station is location along a flat stretch of I-5, and is a four lane cross section. The speed difference between vehicle classifications were slightly higher at this location, with the left most lane in each direction having the highest percent difference (11 to 12 percent), and the right lane showed an eight percent difference in speeds.

In areas with steeper grades, there is potential for the speed differential to be even greater due to heavy vehicles maintaining slower speeds. When heavy vehicles use the middle or left lanes in particular, it causes passenger vehicles to slow significantly both on the graded section as well as the flat section.

Table 2-3: Average Speeds (mph) by Lane and Vehicle Length (All hours of the day)[1]

	Length 1 0-20 ft 	**Length 2** 20-35 ft 	**Length 3** 35-61 ft 	**Length 4** Over 61 ft 
SOUTHBOUND – flat grade				Speed (% difference from Length 1 vehicles)
SB right lane	66	61	60	60 (8.6%)
SB left lane	70	67	67	62 (11.3%)
NORTHBOUND – flat grade				
NB right lane	65	61	59	59 (8.2%)
NB left lane	68	67	59	60 (11.9%)
[1] Data collected at ATR Station 22-005 near Albany, mile point 234.8				

2.5 Congestion and Delay

INRIX Analytic Tools were used to obtain congestion data along I-5. INRIX collects data anonymously from vehicles equipped with GPS as well as from smartphone devices that are GPS-enabled.

Understanding congestion patterns and key bottleneck locations is important so that solutions can target the appropriate locations or be implemented during an event. We observed congestion data for five different scenarios: a typical weekday during the peak month (August), a typical Friday during the peak month, a typical Sunday during the peak month, a Saturday with football games in both Corvallis and Eugene, and on a day with two severe crashes.

In general, the key findings include:

- Fridays tend to have the most recurring congestion in the study area
- A typical weekday has minimal recurring congestion
- Events (such as college football games) and incidents create significant non-recurring congestion

Figure 2-10 through Figure 2-14 show travel speeds, with red indicating speeds slower than 20 miles per hour and bright green indicating where speeds are greater than 60 miles per hour. The scale bar is shown in each of the figures.

Figure 2-10 shows typical traffic speeds during a weekday in August. INRIX shows minimal congestion on a typical weekday. There is some southbound slowing at the north end where I-5 goes from three lanes to two lanes. In the northbound direction near mile post 249 (the Enchanted Forest area) there is also some slowing.

Figure 2-11 shows a typical Friday during the month of August. In the northbound direction congestion begins around 2:30 p.m. near OR 99E and remains congested until after 6 p.m. In the southbound direction there is some minor congestion beginning around 5 p.m. near Exit 237.

Figure 2-12 shows a typical Sunday during the peak month. Similar to a weekday, INRIX data shows minimal congestion on a Sunday.

Figure 2-13 shows traffic congestion for a fall Saturday (October 26, 2013) with college football games in both Corvallis (Oregon State) and Eugene (University of Oregon). The football games generate a significant amount of traffic and people generally arrive several hours before a game. The game in Eugene started at 4 p.m. (versus UCLA) and the game in Corvallis started later, at 7:30 p.m. (versus Stanford). In the southbound direction there is a clear indication of congestion beginning around 11 a.m. north of Salem and lasting until about 3 p.m. The southbound congestion occurs just north of where there is a lane drop from three southbound lanes to two southbound lanes. As traffic approaches the southbound lane drop a bottleneck forms. Once traffic funnels into the two lane section, the bottleneck dissipates. In the northbound direction there is some congestion after 8 p.m. that is likely the result of people leaving the game in Eugene.

Figure 2-14 shows a day with multiple crashes. While this day shows the congestion associated with a severe crash, it is indicative of how a crash can cause secondary crashes and extensive delay. According to the crash report, the weather conditions were clear, so weather was not a factor.

The first crash occurred in the northbound direction just before 1 p.m. near mile post 244.24. It was a fatal run off the road crash. In the southbound direction at 1 p.m. there is a slight indication of congestion likely due to rubbernecking from the northbound crash. A second crash occurred in the northbound direction around 1 p.m., a rear end collision that was property damage only, at mile post 243 (slightly south of the original crash). The extent of congestion due to these crashes lasted about six hours, and spread out over ten miles. Then, in the southbound direction another rear end crash occurred around 3 p.m. that resulted in a severe injury. The extent of congestion stemming from that southbound crash can be observed in the figure, and a probable cause of the rear end crash might have been due to rubbernecking from the northbound crash.

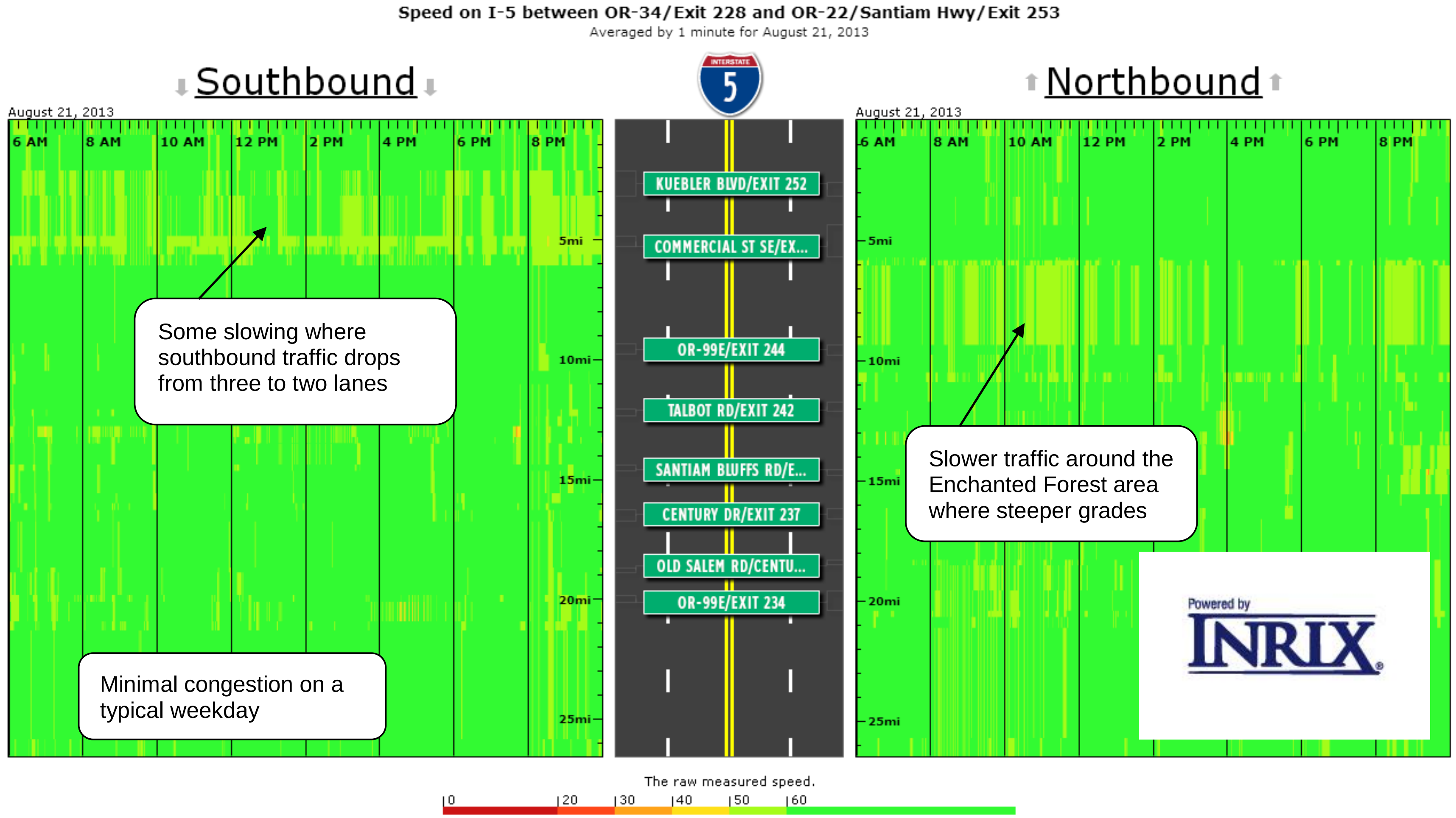


Figure 2-10: Congestion on a Typical Weekday, August 21, 2013

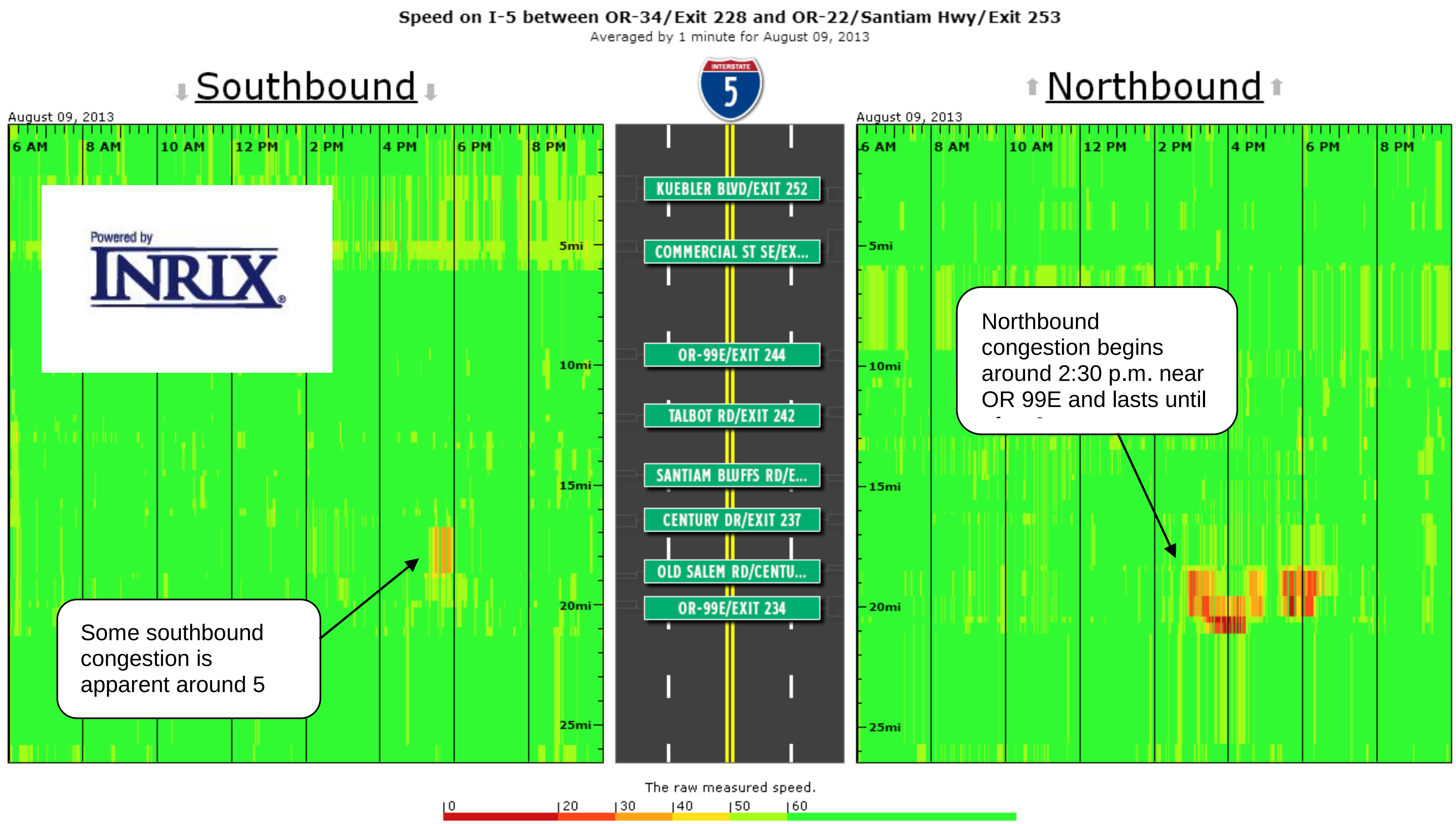


Figure 2-11: Congestion on a Typical Friday, August 9, 2013

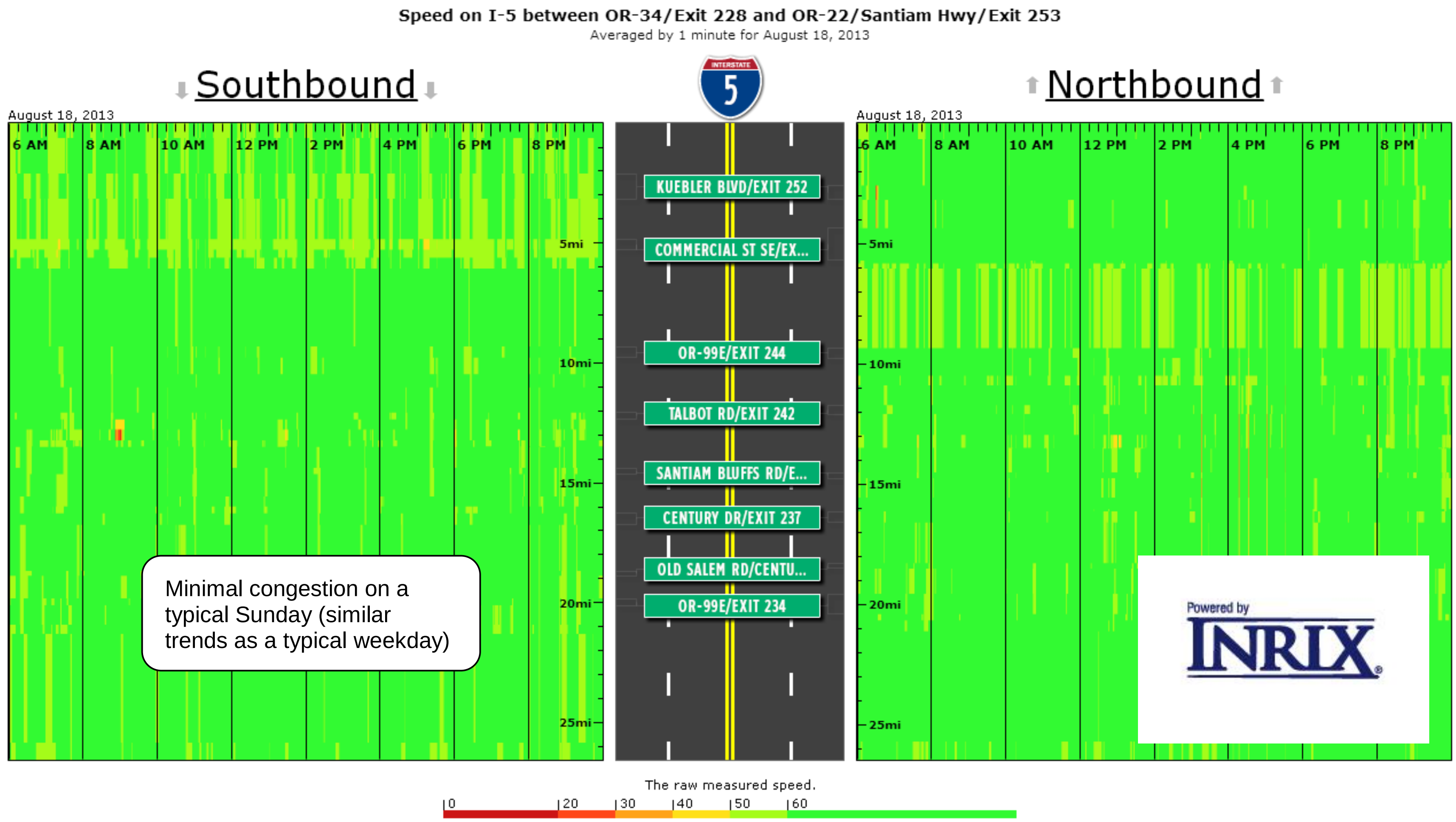


Figure 2-12: Congestion on a Typical Sunday, August 18, 2013

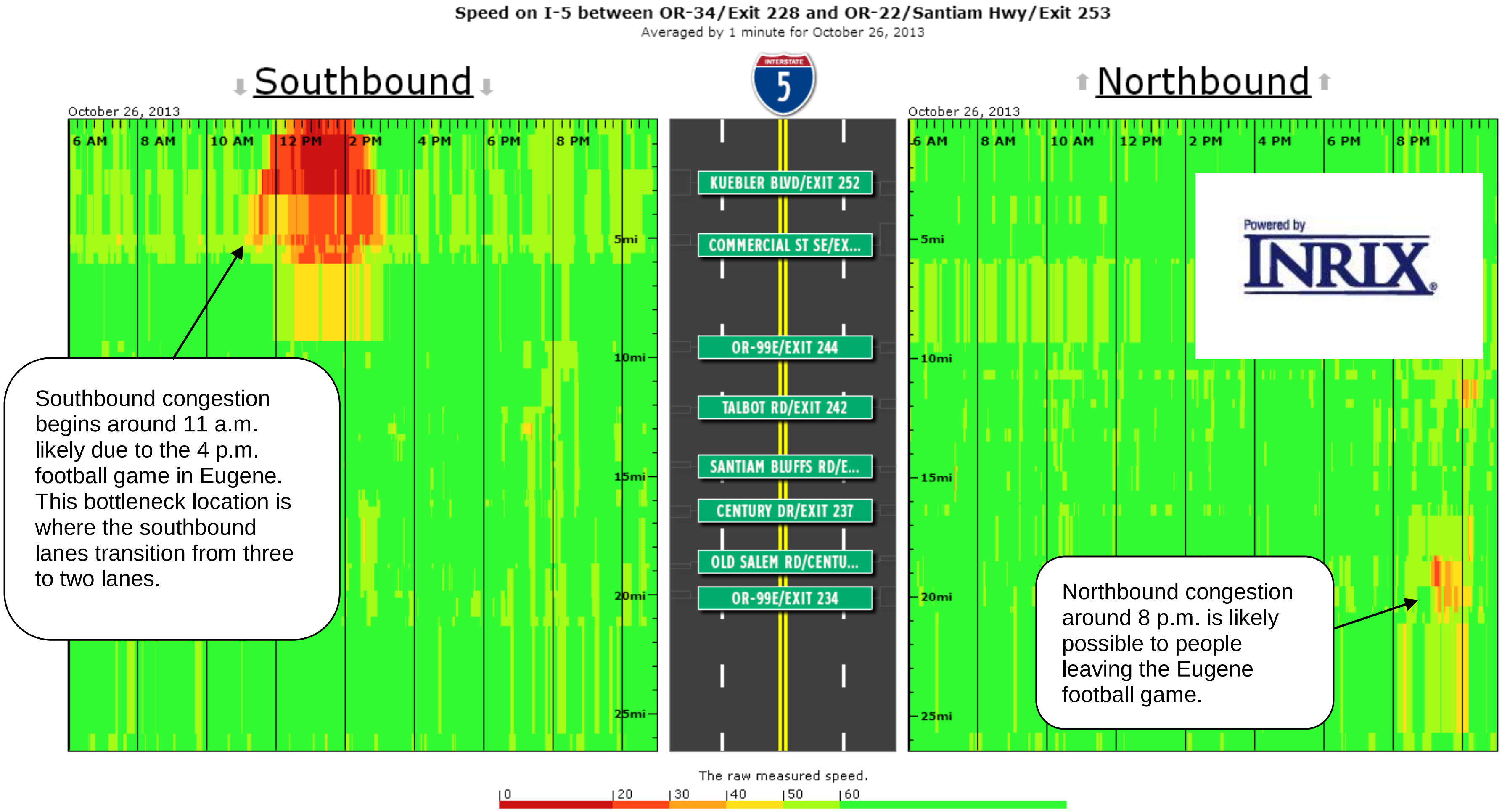


Figure 2-13: Congestion on a Saturday During a College Football Season with Games in Corvallis and Eugene

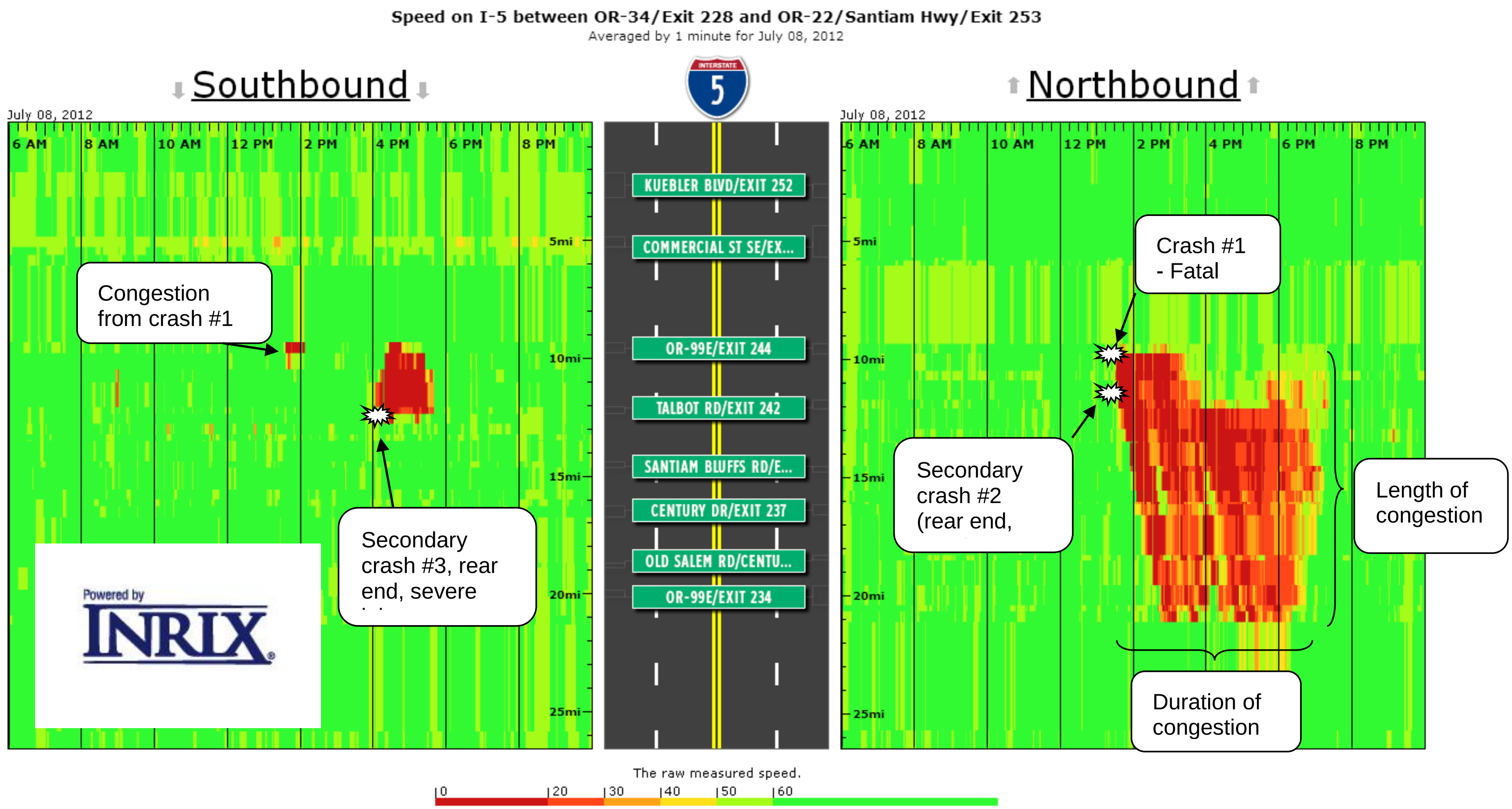


Figure 2-14: Congestion due to Crash, July 8, 2012

2.5.1 Bottleneck Locations

INRIX ranks bottleneck locations according to the length, duration and frequency of a bottleneck. The rankings change depending on the timeframe, however, there were a few locations that were repeatedly listed as the top bottleneck locations in the study area:

- Northbound at Commercial Street (Exit 244)
- Northbound at Ankeny Hill Road (Exit 243)
- Southbound at Ankeny Hill Road (Exit 243)
- Southbound at Talbot Road (Exit 242)
- Northbound at Old Salem Road/Century Drive (Exit 235)

2.5.2 Planning Time Index

Planning time index is a measure of how much time is necessary to ensure on-time arrival 95 percent of the time, and is an indicator of congested conditions. For example, if a trip normally takes 20 minutes, a planning time index of 1.6 means that to ensure on-time arrival 95 percent of the time you need to allow 32 minutes for the trip (20 minutes x 1.6). The closer the planning time index is to 1.0, the less congested the trip.

One year of INRIX data (2013) during the p.m. peak (4 to 6 p.m.) was reviewed to determine trends and variability in travel times through the study corridor. In the northbound direction the peak planning time index, 3.17, occurred on Fridays in August, and in the southbound direction the peak planning time index, 3.86, occurred on Fridays in December.

Table 2-4 shows the general trends in planning time index for the corridor. Looking at the 2013 annual averages, the highest planning time indexes occurred on Fridays and Sundays in both the northbound and southbound directions. Northbound planning time indexes were higher with 1.55 on Fridays and 1.46 on Sundays. The average southbound planning time indexes were 1.41 on Fridays and 1.14 on Sundays.

Looking at the planning time index as a monthly average revealed that while two summer months (August and July) had some of the highest planning time index numbers, so did two winter months (November and December). A peak in August is consistent with the ATR data that shows the peak traffic volumes occur during August and the summer months in general. However, the high planning time index in December is not intuitive since December typically has lower volumes. A review of weather data for December 2013 shows little to no snowfall in the study area, so the spike in planning time index is not attributable to snowy or icy conditions.

Table 2-4: Planning Time Index for 2013, P.M. Peak Hours (4-6 p.m.)

	Southbound	Northbound
Annual Averages		
Mondays-Thursdays	1.07	1.14
Fridays	1.41	1.55
Saturdays	1.10	1.07
Sundays	1.14	1.46
Peak Months (averages of all days)		
December	1.39	1.41
July	1.03	1.41
November	1.03	1.11
August	1.04	1.08
Peak Days		
	3.86 Fridays in December	3.17 – Fridays in August
	2.00 Tuesdays in April	3.04 – Sundays in December
		2.61 –Fridays in April and Sundays in March

2.5.3 Delay Causes

A regression analysis was performed to determine the portion of delay along the corridor due to rainfall and crashes. The analysis was based on 2012 data from the ATR stations in the study area, the ODOT crash database, National Oceanic and Atmospheric Administration (NOAA) climate data, and INRIX vehicle delay.

Based on the regression analysis, 6 percent of delay was due to rainfall, and 30 percent of delay was due to crashes. The remaining 64 percent of delay was due to other causes that include special events (college football games), maintenance or construction activities, incidents not categorized as crashes such as road debris, other weather conditions such as snow or fog, or other causes for congestion.

2.6 Crash and Incident Analysis

Five years of crash data from the ODOT Crash Analysis and Reporting Unit (2008 through 2012) was analyzed through the study area to determine crash trends and key safety concerns. Along the mainline of I-5 during this five year period there were 627 reported crashes. The crash severity is shown in Figure 2-15. A majority of the crashes (53 percent) were property damage only (PDO), and 45 percent of crashes resulted in minor injuries (Injury Type B/C). There were seven fatal crashes and four crashes that resulted in major injury (Injury Type A).

Approximately 13 percent of crashes involved heavy vehicles, which is consistent with the relative portion of heavy vehicles (13 to 18 percent as shown previously in Figure 2-6).

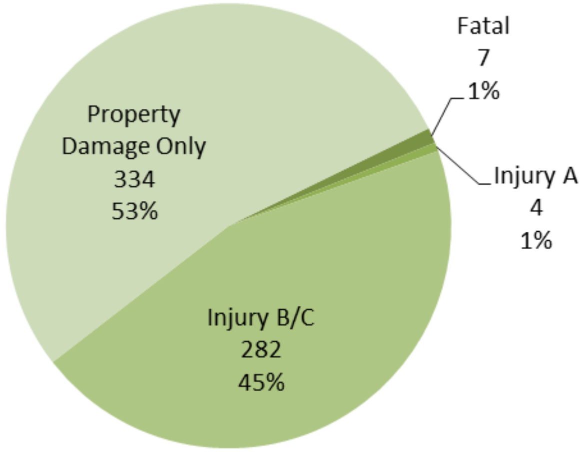


Figure 2-15: Crashes by Severity (2008-2012, 627 total crashes)

The three most common types of crashes were rear ends (47%), fixed object (30%), and side-swiping by overtaking (12%), shown in Figure 2-16.

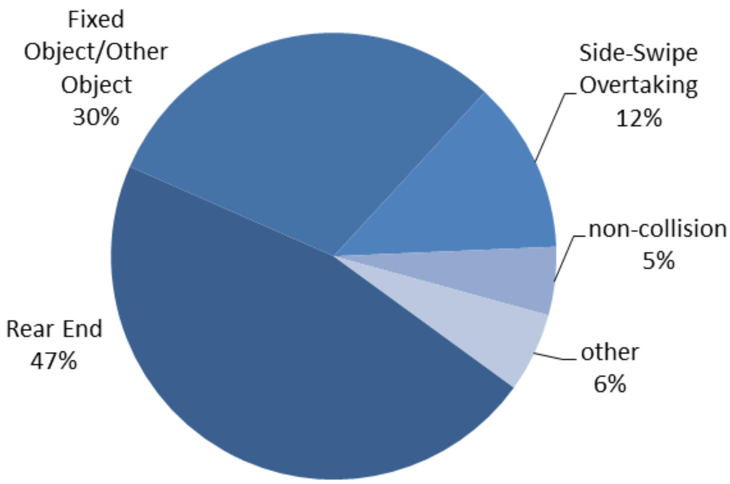


Figure 2-16: Crashes by Type (2008-2012, 627 total crashes)

Further analysis of the crash data revealed that a weather conditions did not seem to significantly impact crashes. A majority of crashes (68 percent) occurred during clear or cloudy conditions, which is consistent with the weather trend in the study area. According to weather data from the National Oceanic and Atmospheric Administration

(NOAA) precipitation occurred on approximately 34 percent of the days during the 2008-2012 five years of crash data analyzed.[9]

A map of all the crashes is shown in Figure 2-17. Additional maps show the three most common crash types: rear end crashes (Figure 2-18), fixed object crashes (Figure 2-19), and side-swipe by overtaking crashes (Figure 2-20). Figure 2-21 shows the location of weather related crashes.

There were seven fatal crashes during the 2008-2012 period. Details of these crashes are described in Table 2-5. Three of the crashes occurred at the north end of the study area, in the northbound direction, between mile posts 249 and 252 in an area with steeper grades and horizontal curves. The southbound crash at mile post 237.67 was a fixed object crash, which likely involved the supports of an overpass (between Viewcrest Drive and Sunnyview Drive). The pedestrian related crash occurred in an area of flat, straight roadway, with a grass median and a flat grassy area beyond the right shoulder.

Table 2-5: Fatal Crashes

Mile Post	Direction	Date	Crash Type	Weather Conditions	Roadway Character
252	NB	11/5/08	Head-on	Rain	Grade
250	NB	1/25/11	Overturned vehicle (non-collision)	Clear	Grade
249.15	NB	6/25/11	Overturned vehicle (non-collision)	Clear	Curve
244.24	NB	7/8/12	Overturned vehicle (non-collision)	Clear	Straight/flat
237.67	SB	6/11/09	Fixed object	Clear	Straight/flat
235.83	SB	3/22/10	Pedestrian	Cloudy	Straight/flat
235	SB	3/18/11	Overturned vehicle (non-collision)	Rain	Straight/flat

Other observations of these maps reveal the following:

- At the north end of the study area there is a peak in crashes near mile post 252 in the southbound direction. Most of these are rear end crashes and fixed object crashes. This area does have a barrier median and it is also were I-5 drops from three lanes to two lanes, which may explain the peak in crashes at this location.
- Around mile post 237 there is a peak in crashes. They appear to be mostly fixed object and rear end collisions. There is an overpass and some barrier median in this section, which may account for the spike in fixed object collisions.

[9] National Oceanic and Atmospheric Administration. Annual Climatological Summary 2008-2012. Salem McNary Field, OR.

- Around milepost 243 there is another spike in crashes. These are mostly rear end crashes and the terrain in this area is flat and straight in both directions. Over the five years studied, 45 crashes occurred between mile points 243 and 244 (the Ankeny Hill Interchange area). A disproportionate number of crashes occurred during 2011 (15 crashes) and 2012 (14 crashes) compared to the other years. In 2008 there were only two crashes, in 2009 there were 11 crashes, and in 2010 there were three crashes).
- Figure 2-21 shows crashes where weather was a factor. The majority of weather related crashes appear to be at the north end of the study corridor. Near mile posts 248 and 249 the segments are on vertical curves of about three percent grade, and also on horizontal curves. In general, this northern section of the study corridor consist of grades in the range of three to five percent, and horizontal curves as well that may be challenging to navigate in unfavorable weather conditions.
- Crashes that occurred in the vicinity of on-ramps and off-ramps were most prevalent at the following interchanges:
    - Exit 252 (Kuebler Boulevard) – southbound off-ramp (10 crashes)
    - Exit 249 (Commercial Street) – southbound on-ramp (8 crashes)
    - Exit 248 (Delany Road) – northbound off-ramp (5 crashes) and southbound on-ramp (5 crashes)
    - Rest Area Exit – southbound off-ramp (5 crashes) and southbound on-ramp (5 crashes)
    - Exit 238 (South Jefferson) – northbound off-ramp (5 crashes)

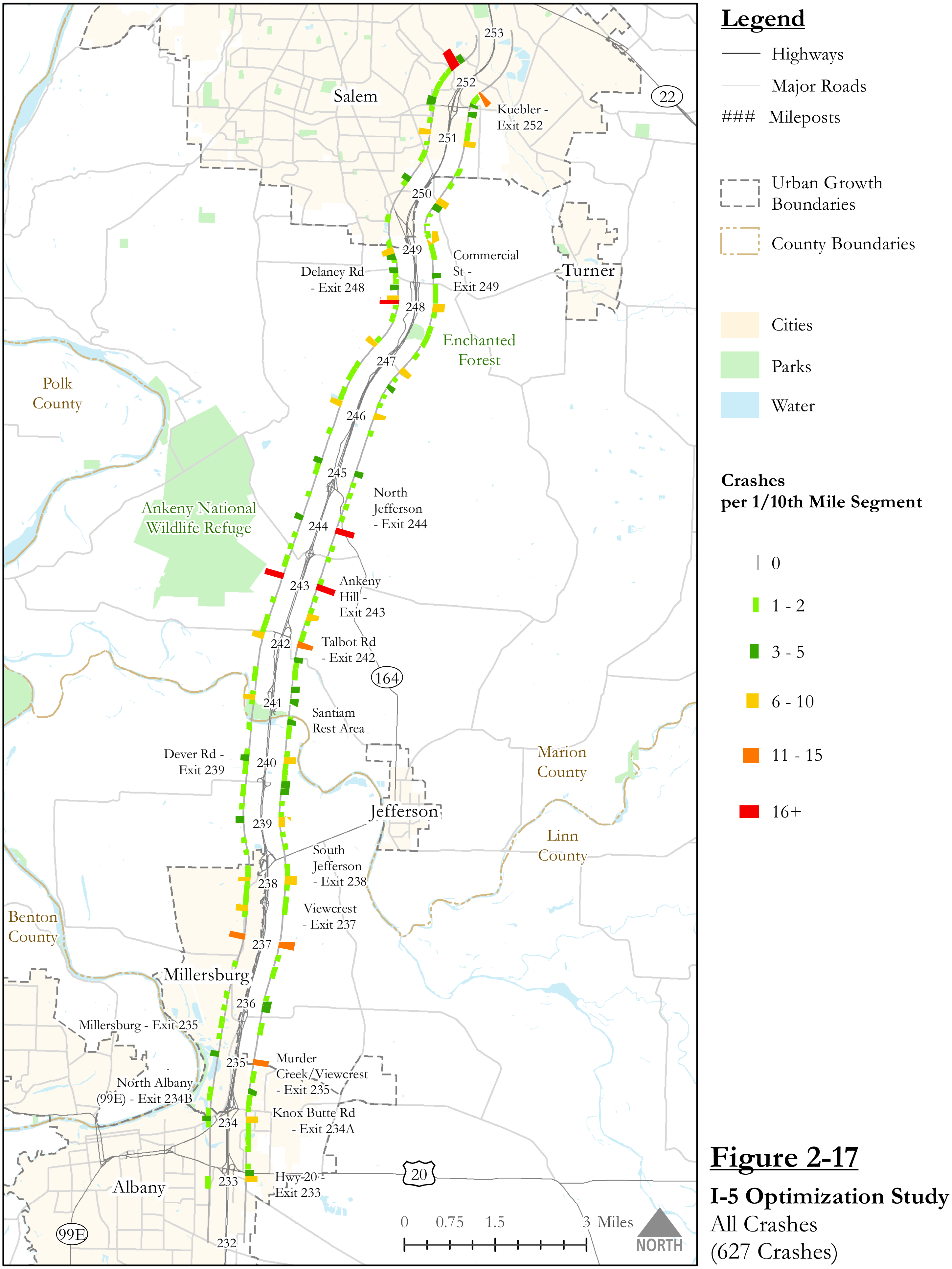


Figure 2-17

I-5 Optimization Study

All Crashes

(627 Crashes)

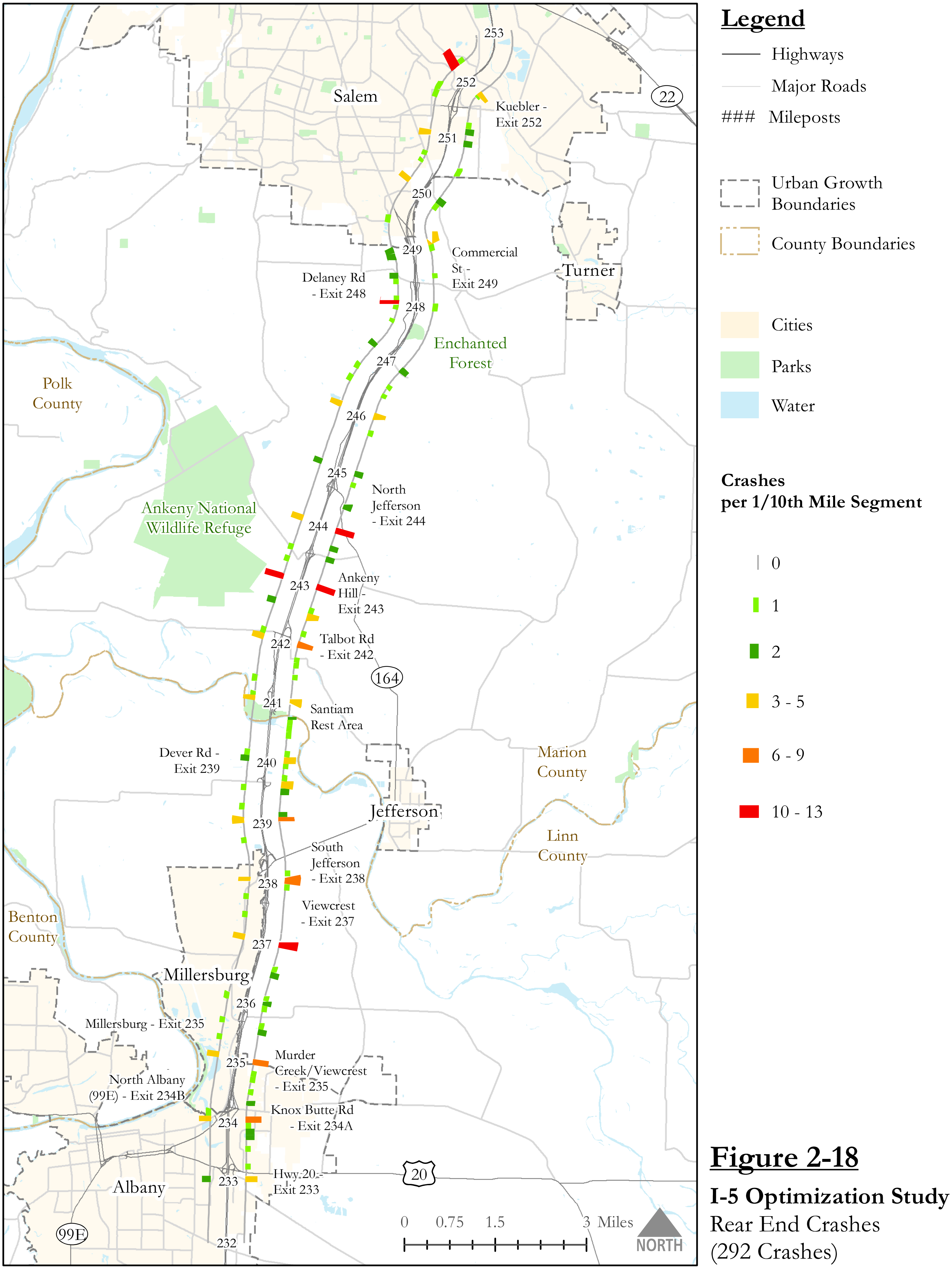


Figure 2-18

I-5 Optimization Study

Rear End Crashes

(292 Crashes)

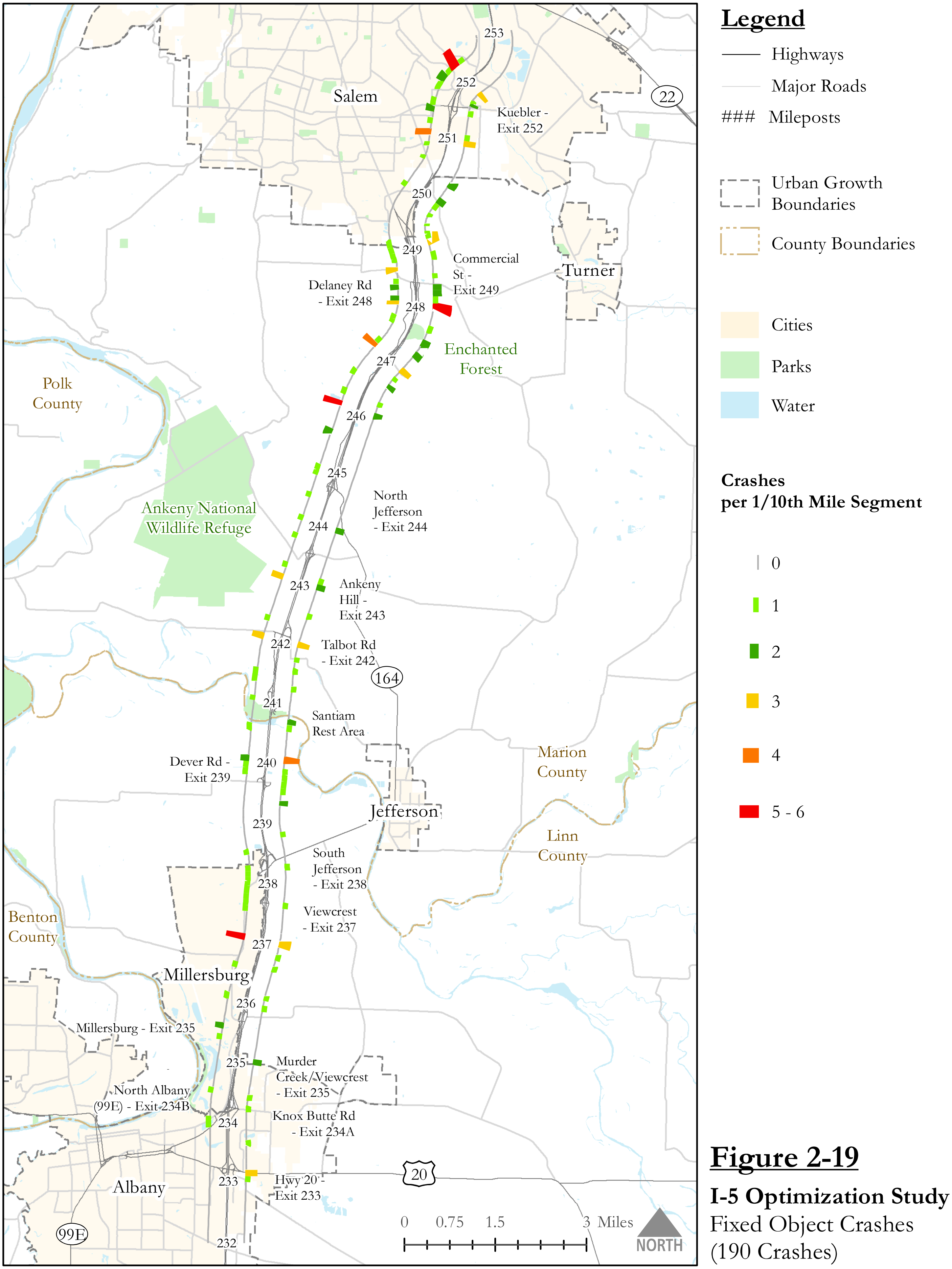
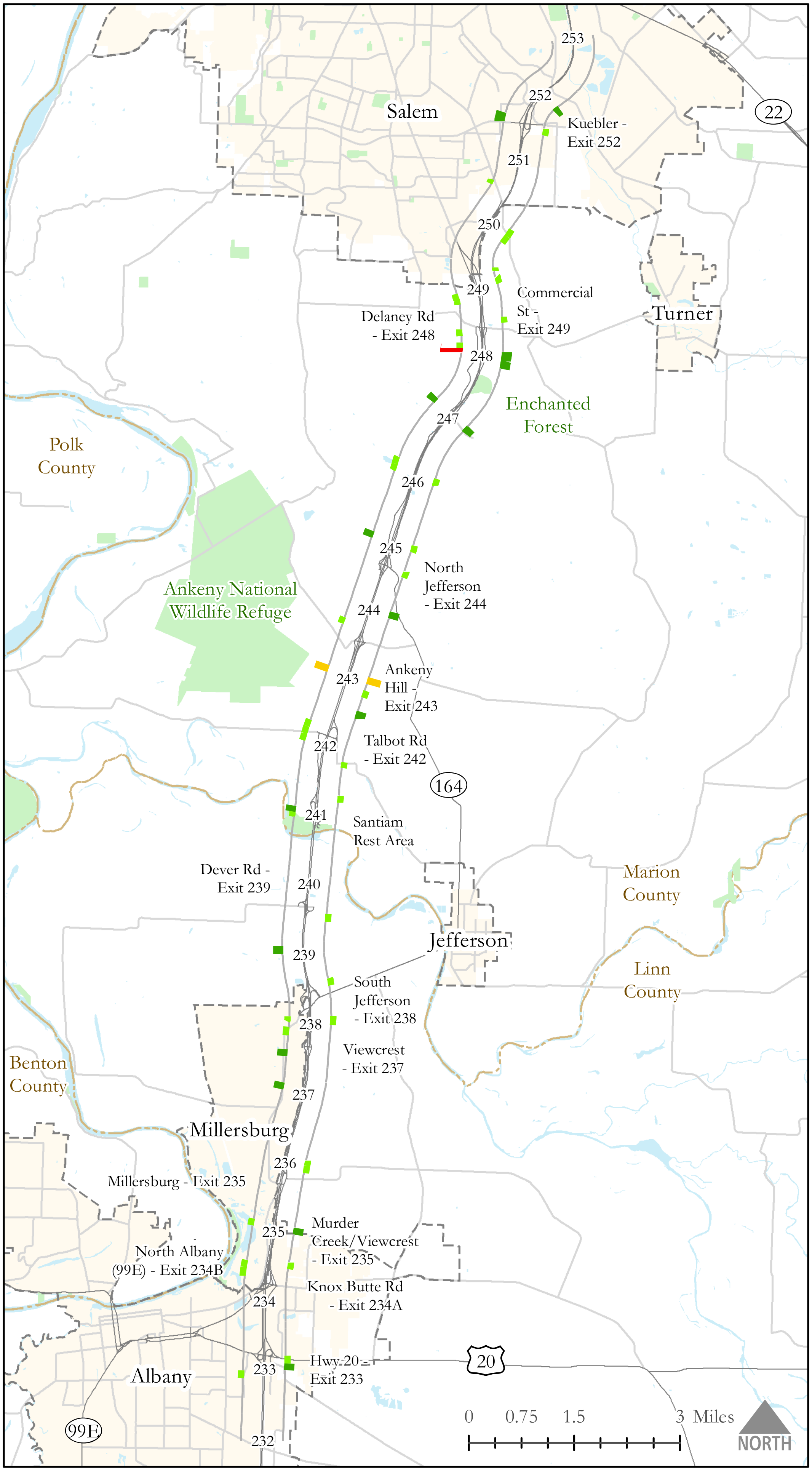


Figure 2-19

I-5 Optimization Study

Fixed Object Crashes

(190 Crashes)



Legend

- Highways
- Major Roads
- ### Mileposts
- Urban Growth Boundaries
- County Boundaries
- Cities
- Parks
- Water

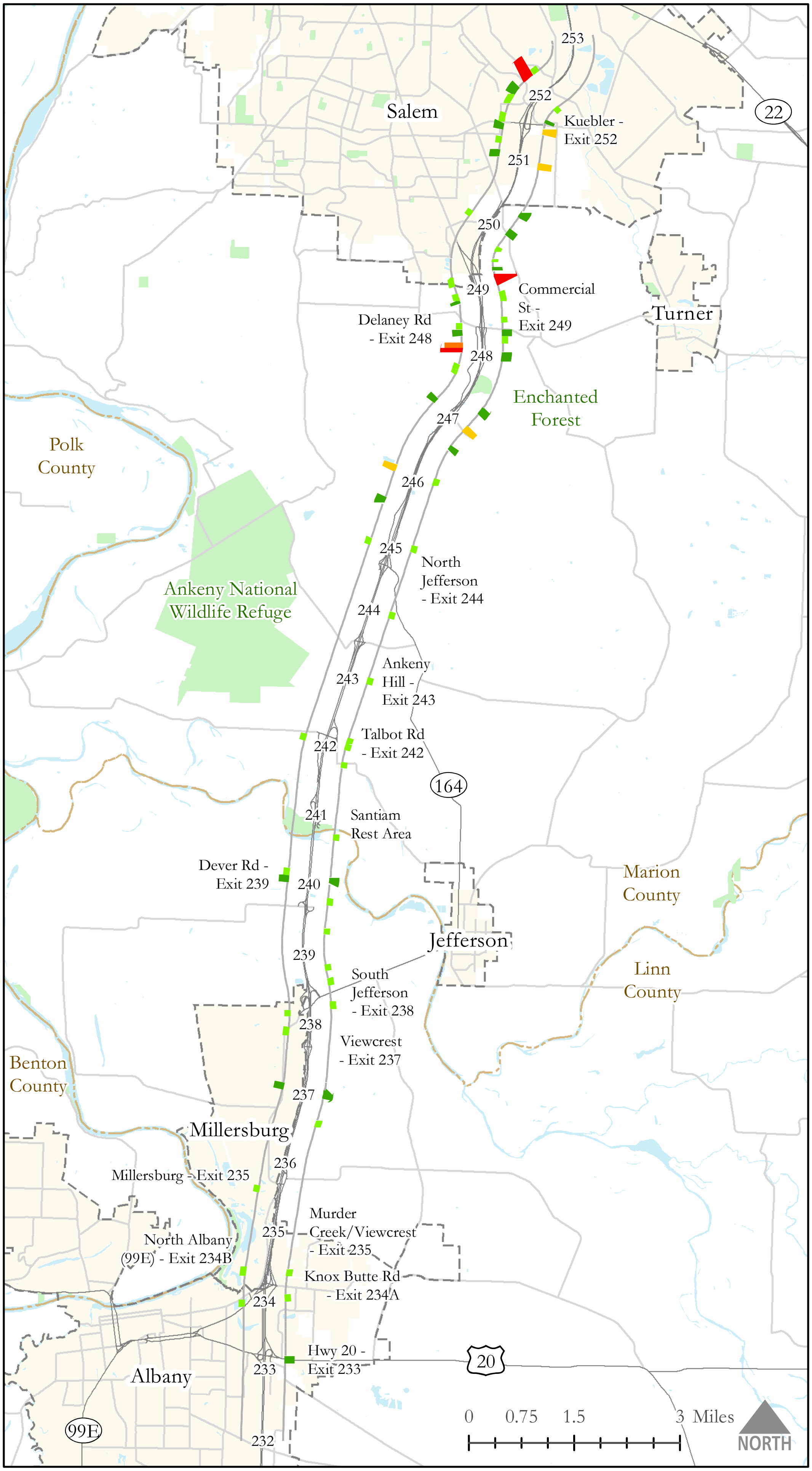
Crashes per 1/10th Mile Segment

- 0
- 1
- 2
- 3
- 4
- 5

Figure 2-20

I-5 Optimization Study

Side-Swipe Overtaking Crashes (78 Crashes)



Legend

Highways

Major Roads

Mileposts

Urban Growth Boundaries

County Boundaries

Cities

Parks

Water

Crashes per 1/10th Mile Segment

0

1

2

3

4

5 - 6

Figure 2-21

I-5 Optimization Study

Weather-Related Crashes (112 Crashes)

2.6.1 Safety Priority Index System

ODOT developed the Safety Priority Index System (SPIS) to identify segments of state highways that have safety problems. The SPIS ranking takes into consideration the frequency, severity, and rate of crashes on a roadway segment. Along the I-5 study corridor, there are no segments in the top five percentile of SPIS sites. Near Millersburg there is one location that is within the top ten percentile.

2.6.2 Segment Crash Rate Analysis

ODOT publishes an annual crash rate report and tables[10]. However, the segments used for these crash rates are based on city and urban/rural boundaries, which can create some very short segments with artificially exaggerated crash rates. We recalculated the segment crash rates using the five years of crash data (from 2008-2012) for two mile segment lengths and AADT from 2011. Segment crash rates are crashes per million vehicle miles of travel.

For segment crash rate information to be useful, the crash rate should only be compared to the rate of a similar facility. Through the study area, I-5 is classified as an urban interstate, a suburban interstate and a rural interstate. The statewide averages for each of those facilities are listed in the Table 2-6.

Table 2-6: ODOT Statewide Average Crash Rates by Facility Type

Jurisdiction and Classification	2011 Statewide Average Crash Rate
Urban Interstate	0.67
Suburban Interstate	0.31
Rural Interstate	0.30

Figure 2-22 shows the crash rates based on two mile segment lengths (from the 2008-2012 crash data) and AADT from 2011. Most of the segment crash rates are close to the statewide averages for similar facilities. The I-5 segment crash rate is higher than the statewide average for similar facilities in two locations: near mile posts 243 and 249 (circled in Figure 22). Referring back to Figure 17, which maps all crashes along the study corridor, there are spikes in crashes at those two locations.

The area around mile post 249 is near the Enchanted Forest area and has hilly and curvy terrain. A high number of weather related crashes occur in this area. The peak around mile post 243 (which is also apparent in Figure 17) is harder to explain. The

[10] ODOT 2011 State Highway Crash Rate Tables. Transportation Data Section Crash Analysis and Reporting Unit, August 2012.

area is on a long flat straight section of roadway. Most of the crashes in this area are rear ends, which is often caused by congested conditions.

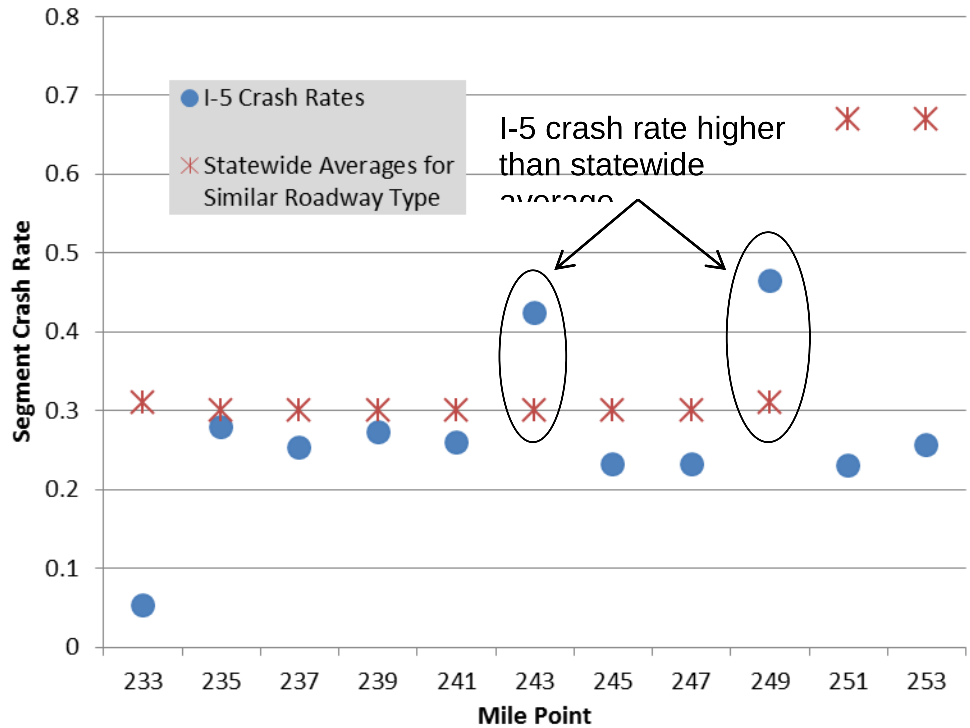


Figure 2-22: Segment Crash Rate Analysis

2.6.3 Incident Data Analysis

Incident data reveals the types of events that impact the freeway as well as whether or not the event caused a lane closure and the duration of the event. Lane closures can significantly impact capacity. A typical assumption is that closing a single lane of a two lane roadway reduces the capacity by 50 percent. Seems logical, but research suggests this assumption is not correct. Closing a single lane of a two lane highway reduces the available capacity by 65 percent. Even closing a shoulder reduces capacity by as much as 19 percent. Table 2-7 shows the percentage of capacity lost when lanes are closed. [11]

[11] Highway Capacity Manual 2000. *Transportation Research Board, National Research Council, Washington, D.C., 2000.*

Table 2-7: Freeway Capacity Changes

Number of Hwy Lanes	% Facility Capacity Lost by Blockage Type			
	Shoulder	1 Lane	2 Lanes	3 Lanes
2 Lanes	19%	65%	100%	N/A
3 Lanes	17%	51%	83%	100%
4 Lanes	15%	42%	75%	87%

Source: Transportation Research Board. Highway Capacity Manual, 2010.

We reviewed four years of incident data from ODOT (2010 through 2013) and found that 15 percent of incidents caused a lane closure. Along most of the study corridor, I-5 is two lanes in each direction, which means that closing one lane reduces capacity by 65% (as seen from Table 2-7). Aside from road construction and road maintenance, the incident types that most frequently closed a lane of traffic were: crashes, hazardous debris, disabled vehicles, and animals struck or on roadway.

Excluding road construction and maintenance activities, the greatest portion of lane closure incidents occurred near mileposts 252 (Kuebler Boulevard area), 248 (Delaney Road/Enchanted Forest area) and 238 (S Jefferson area) as shown in Figure 2-23. In areas with frequent lane closures, wider shoulders with the capability of temporarily running traffic may help reduce delays by temporarily increasing capacity.

By isolating the crash events that cause lane closures, we can better understand how long these events last and find ways to reduce the duration of these incidents. A non-fatal crash has an average roadway clearance duration of 56 minutes, with an additional 27 minutes until roadway conditions return to normal. A fatal crash has a longer average roadway clearance duration of 2 hours and 34 minutes, with an additional 38 minutes until the roadway conditional return to normal. These average clearance times for non-fatal and fatal crashes are shown in Figure 2-24.

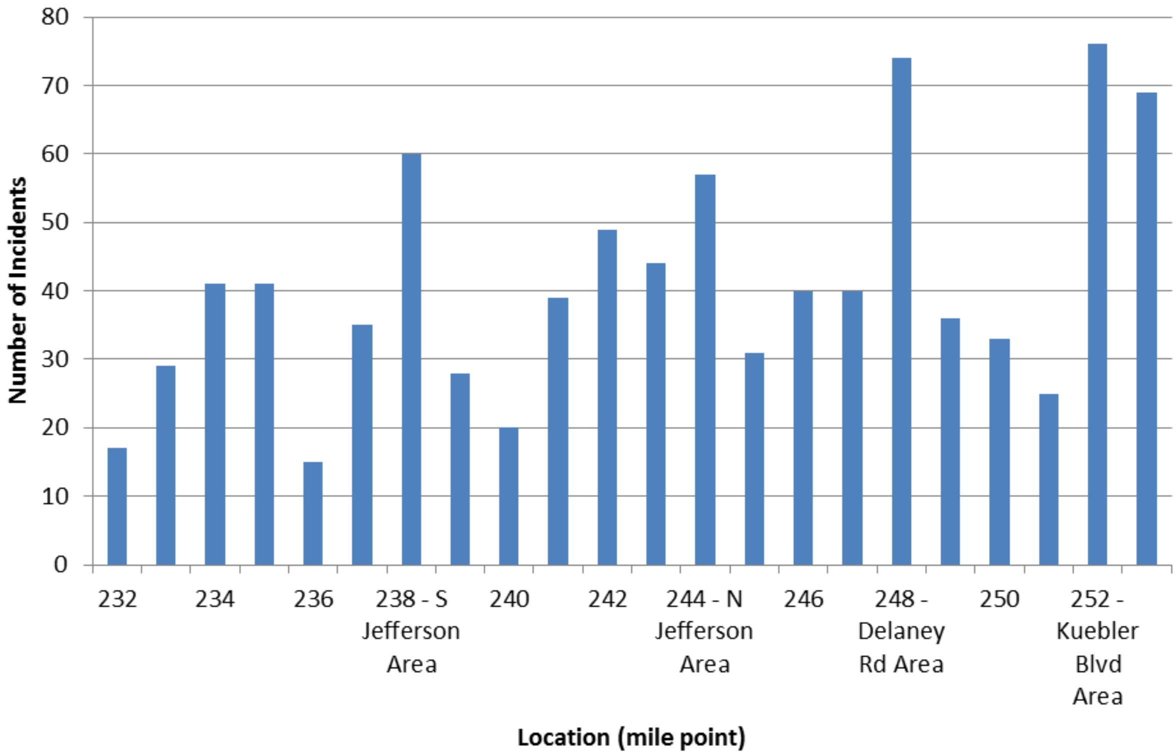


Figure 2-23: Incident Frequency, 2010-2013

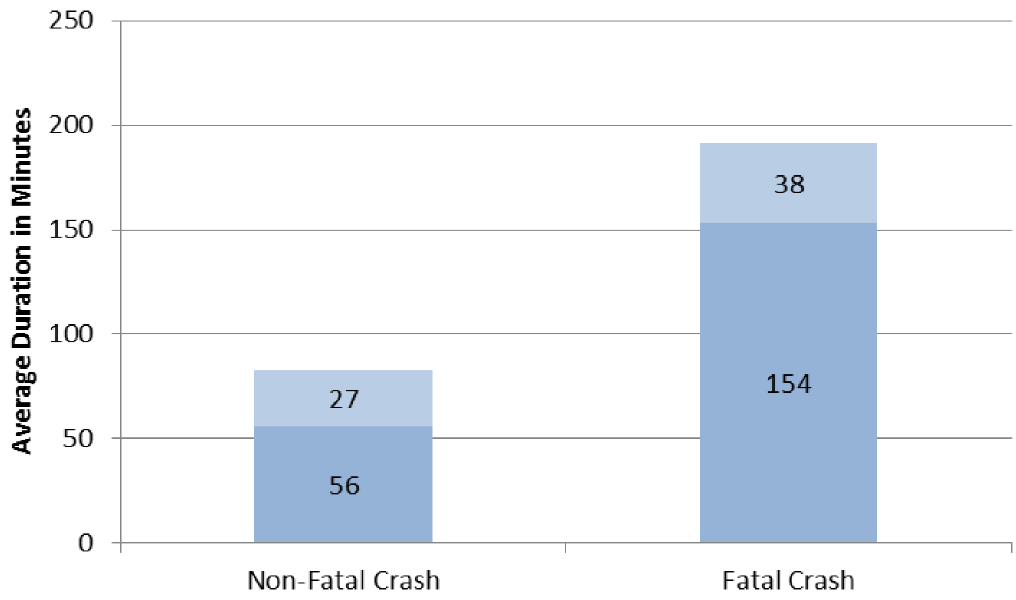


Figure 2-24: Average Duration of Crashes with Lane Closures

2.7 Observed Problems

In addition to data analysis, general observations by ODOT staff (who frequently travel on this segment of I-5) offer additional insight as to the existing challenges along this corridor.

Heavy Vehicle Speed Differential

One of the key concerns is the differential speed between passenger vehicles and heavy vehicles, particularly on graded sections of the interstate. The perception is that heavy vehicles slow down significantly faster than passenger vehicles, which can create a congestion ripple effect. When a heavy vehicle uses a lane other than the right most lane intended for slower traffic, it creates additional friction and safety issues by preventing passenger vehicles from passing on the left.

Knox Butte Southbound Off-Ramp

Another noted issue is that the southbound off-ramp to Knox Butte (Exit 234A) can back up onto the I-5 mainline during the evening commute hours. The off ramp ends with a stop controlled intersection to Airport Road and has approximately 600 feet of storage before the stop sign. The crash data shows three crashes occurred on this off-ramp between 2008 and 2012, and another four crashes occurred on the mainline within 400 feet of the exit gore area. The three crashes on the off ramp were all property damage only (low severity) and included a rear end crash, fixed object crash, and a turning movement crash. The severity of the four crashes on the mainline were a little worse (three involved minor injuries and one was a property damage only). Of the mainline crashes two were rear ends, one was a fixed object, and the other was an overturned vehicle crash.

Santiam Rest Area

Around the Santiam Rest Area, the freeway is built out to accommodate six lanes of traffic, however, it is only striped as a four lane facility currently. The extra shoulder width in this area provides enough room for trucks to park on the shoulder (particularly in the southbound direction), sometimes overnight as observed by ODOT staff. Staff has also observed “reckless” passing in this area, where vehicles pass in the shoulder lane. There are currently no signs that prohibit truck parking in this area.

Northbound Viewcrest On-Ramp

The northbound on-ramp from Viewcrest (Exit 235) seems to be too short to accelerate to the necessary freeway speed in the given length. The entrance ramp has a sharp curve with an acceleration lane approximately 900 feet in length. Based on ODOT standards[12], the acceleration lane for the existing entrance curve should be closer to 1400 feet.

[12] 2012 ODOT Highway Design Manual. Figure 9-11 Entrance Ramp Details.

Kuebler-Delaney-Enchanted Forest Area

At the north end of the study area, from the Kuebler interchange to the Enchanted Forest area, I-5 has several horizontal curves and graded sections. The interstate also varies back and forth between four and six lanes through this area, which increases the driving complexity through this section.

2.8 Other Relevant Information

Along this section of I-5 there have been several improvements since 2000, and there are also established detour routes and ITS plans that apply to this area.

Improvements to the Corridor Since 2000

Since 2000, several projects have been completed along this stretch of I-5. Most projects were minor repaving or preservation projects. The following list includes the more major projects:

- South Jefferson preservation project (Exit 238)
- Santiam Rest Area rebuilt
- Kuebler Boulevard Interchange improvements (Exit 252)
- Hoefer Drive interchange (Exit 240) removed
- North Albany pavement preservation project - extended auxiliary lane for on-ramp
- Exit 235 southbound on-ramp extended length just a bit to give trucks more room to accelerate
- North Jefferson – South Jefferson interchange improvements
- Battle creek overcrossing – raised overpass to improve clearance
- Exit 232 – lowered interstate under US20

I-5 Detour Plans

The recently updated ITS Plan for Central Willamette Valley includes incident detour plans for I-5 through the study area[13]. These plans provide alternate routes if a section of I-5 needs to be closed due to an incident. The following are planned detour routes:

- Between exits 238 and 244 both directions – Highway 99E
- Between exits 243 and 244 both directions – Highway 99E and Ankeny Hill Road
- Between exits 238 and 235 southbound – Old Salem Road
- Between exits 235 and 237 northbound – Century Drive
- Between exits 234 and 235 northbound – Century Drive

[13] Central Willamette Valley ITS Plan. Prepared for ODOT, Prepared by DKS Associates and IBI Group. December 2010. Appendix C.

ITS Plans

This project needs to be consistent with three ITS plans that apply to the Salem or Albany area:

- Central Willamette Valley ITS Plan – 2010
- Salem-Keizer ITS Plan
- Oregon Statewide ITS Architecture and Operational Concept Plan - 2006

3. CHAPTER 3 – GOALS AND OBJECTIVES

This chapter outlines the needs, goals, and objectives identified for the study corridor.

3.1 Corridor Problems

The project study area currently experiences unreliable travel times, congestion and delays caused by non-recurring events. The I-5 corridor is a freight route, and unreliable travel times are of particular concern to the freight industry. Review of the operational data identified 30 percent of the delay experienced by drivers is the result of crashes, and six percent is due to weather conditions. The remaining 64 percent results from special events, maintenance/construction activities, non-collision based incidents (i.e. road debris), and some recurring congestion.

3.2 Corridor Needs

Review of the existing conditions along I-5 identified the following set of project needs:

- **The project needs to find ways to address delay from non-recurring events.** Non-recurring congestion, such as crashes and special events, cause the greatest amount of delay along the study corridor.
- **The project needs to find ways to reduce the congestion caused by passenger vehicles and heavy trucks traveling at different speeds.** Speed differential between passenger vehicles and heavy trucks ranges from six to twelve percent, depending on the location.
- **The project needs to find ways to reduce weather related crashes, particularly at the north end of the study corridor.** At the north end of the study corridor there tends to be more weather related crashes than along the rest of the corridor. This northern section also has more graded sections and horizontal curves than to the south.
- **The project needs to find ways to reduce crash clearance times.** The average duration for a non-fatal crash with a lane closure is about 80 minutes, while the average duration for a fatal crash is just over three hours. Areas with a highly developed traffic incident management programs have an average incident duration of 64 minutes.[14] In California the average clearance

[14] Federal Highway Administration. Traffic Incident Management and Resource Management. 5.0 Potential Efficiency Improvements and Associated Cost Savings. Website accessed March 12, 2014: http://ops.fhwa.dot.gov/publications/fhwahop08060/50.htm

time for a major incident is 3 hours and 16 minutes, and in Washington the average clearance time for a major incident was 143 minutes.[15] Based on an Oregon legislative change in 2013, ODOT's target is to clear 100 percent of lane-blocking crashes within 90 minutes. In 2013 ODOT achieved clearing 80 percent of incidents within 90 minutes.

- **The project needs to find ways to improve reliability for freight.** This section of I-5 is classified as a freight route, with approximately 13 to 18 percent of traffic in the study area classified as heavy vehicles. Travel time reliability is critical for efficient freight movement during all times of the day (not just peak hours).

3.3 The Goals and Objectives

Review of the project needs have identified three primary goals: improve safety, improve commuter mobility, and improve freight mobility. A set of objectives is provided for each of these goals to identify specifically how they will be achieved.

- **Goal 1: Improve Safety**
    - **Objective:** Reduce rear end crashes by at least ten percent within five years of implementing strategies that target a reduction in rear in crashes.
    - **Objective:** Reduce fixed object and side-swipe crashes by at least five percent within five years of implementing strategies that target a reduction in these types of crashes.
    - **Objective:** Reduce weather related crashes.
    - **Objective:** Clear all lane blocking incidents within 90 minutes.
- **Goal 2: Improve Commuter Mobility**
    - **Objective:** Make travel times more reliable during peak hours. Achieve a planning time index of 1.2 or less during peak hours by 2018.
    - **Objective:** Reduce non-recurring delay for planned events. Achieve a planning time index along the corridor of 1.3 or less during planned events by 2018.
- **Goal 3: Improve Freight Mobility**
    - **Objective:** Make travel times more reliable during peak hours. Achieve a planning time index of 1.2 or less during peak hours by 2018.

[15] Oregon Department of Transportation, Annual Performance Progress Report for Fiscal Year (2012-2013). Upated January 27, 2014. Key Performance Measure #16. Web access: http://www.oregon.gov/ODOT/CS/PERFORMANCE/docs/2013ODOTAPPR.pdf

- **Objective:** Make travel times more reliable during non-peak hours. Achieve a planning time index of 1.1 or less during non-peak hours by 2018.
- **Objective:** Reduce freight related crashes by five percent by 2018.

4. CHAPTER 4 – PRELIMINARY SCREENING

This chapter describes the screening criteria used to narrow the initial list of 37 strategies to those with the greatest potential to improve safety and operations along the I-5 study area.

For organizational purposes, the strategies are grouped into six categories:

1. Active Traffic Management Strategies
2. Traveler Information Strategies
3. Incident Management and Towing Strategies
4. Rest Area Strategies
5. Demand Management Strategies
6. Capital Improvement Strategies

4.1 Screening Criteria

The following criteria (shown in Table 4-3) were used to assess which strategies have the greatest potential benefit to the I-5 study corridor:

- **Relative cost -** Each strategy was rated on a scale of 1 to 5, with 1 representing the lowest cost. These costs are a rough estimate of the initial capital and one year of operations/ maintenance.
    - 1 represents a cost less than < $500,000
    - 2 represents a cost between $500,000 and $1,000,000
    - 3 represents a cost between $1,000,000 and $5,000,000
    - 4 represents a cost between $5,000,000 and $10,000,000
    - 5 represents a cost greater than $10,000,000
- **Feasibility or limitations -** For some strategies institutional or technical feasibility issues and limitations are noted.
- **Frequency strategy is used -** Although some strategies offer high benefits, they might only be in use a small fraction of the time (on an annual basis). This screening criteria identifies how frequently on an annual basis the benefit from each strategy is likely to be recognized.
    - 1 represents a strategy in use less than 1% of the time
    - 2 represents a strategy in use between 1% and 5% of the time
    - 3 represents a strategy in use between 5% and 20% of the time
    - 4 represents a strategy in use between 20% and 50% of the time
    - 5 represents a strategy in use more than 50% of the time

- **Meeting project objectives -** Whether the strategy meets the project objectives, and how many objectives it meets. The project objectives were defined in the "Needs, Goals, and Objectives, Technical Memorandum #2" submitted to ODOT on March 18, 2014.
- **Additional benefits -** In some cases strategies offer additional benefits not captured by the other screening categories.
- **Preferred by ODOT personnel -** This category captures the discussions we had with several ODOT personnel to determine which strategies they felt would have the greatest benefit to the study corridor. In addition to the project management team at ODOT we also received input from district operations and maintenance managers. There was not necessarily consensus among ODOT staff as to the priority of each strategy, but this category captures the general feedback we received.

4.2 Strategies Recommended for Further Analysis

Based on all of the screening criteria, we recommend the nine strategies listed in Table 4-1 be carried forward as the best potential options for the I-5 study corridor. A more detailed explanation of each of these strategies is included in Table 4-3. The strategies carried forward were evaluated with a more detailed cost benefit analysis, included in Chapter Five.

Table 4-1: Strategies Recommended for Further Evaluation with this Project

Category	Strategies
Active Traffic Management	1. Variable speeds (on overhead gantry DMS signs) with a Weather Responsive System 2. Ramp metering – At the northbound exit 234 on-ramp and the southbound exit 252 on-ramp 3. Electronic truck lane use signs
Traveler Information	4. Roadside Information Signs – Travel Times 5. Roadside Information Signs – Incident Information 6. Traffic Surveillance
Incident Management and Towing	none
Rest Area	none
Demand Management	none
Capital Improvement	7. Targeted Shoulder Widening for Chain Up Areas 8. Targeted Shoulder Widening – Auxiliary Lane – 3rd northbound lane from N Jefferson to bottom of the hill where the 3rd northbound lane currently starts 9. Hard running shoulders – southbound between Kuebler and the Enchanted Forest

4.3 Additional Strategies Recommended for ODOT Internal Assessment

There were several additional strategies with strong potential to benefit this corridor, but due to the nature of these strategies, an extensive cost benefit evaluation is not necessary. Instead, these strategies are recommended for ODOT to pursue independently. Table 4-2 lists these strategies by category and whether or not further ODOT internal review is necessary to pursue the strategy. In some cases, such as installing the Oregon "Move It" law signs, the signs could be installed as funds become available, with little to no further evaluation necessary. In other cases, such as implementing a corridor operations team, some internal evaluation is necessary to determine organization and staffing logistics.

Table 4-2: Recommended Strategies for ODOT Internal Evaluation

Category	Strategies	
	No Further Evaluation Necessary	ODOT Internal Evaluation
Active Traffic Management	none	none
Traveler Information	none	none
Incident Management and Towing	○ Oregon "Move it" law - signing ○ Mile marker signs	○ Incident response vehicles ○ Corridor operations team ○ Median turn around(s) ○ Dry run towing ○ Hourly towing contract ○ Incentivized towing contract
Rest Area	○ No parking signs	
Demand Management		○ Support demand management strategies
Capital Improvement	○ Higher visibility pavement markings and signs ○ Inlaid pavement markings and reflectors	

Table 4-3: Preliminary Screening of Strategies for I-5 Optimization Study

Strategy	Description and Purpose	Project Dependencies (if applicable)	Relative Cost Scale: 1=low, < $.5M 5=high, > $10M	Feasibility or Limitations (if blank, no major feasibility issues or limitations)	Frequency the benefit of the strategy is realized Scale: 1= low < 1% of the time 5 = high frequency >50% of the time	Goal 1: Improve Safety				Goal 2: Improve Commuter Mobility		Goal 3: Improve Freight Mobility			Number of objectives met	Additional Comments	Preferred by ODOT personnel 5 = Greatest Potential 1 = Least Potential	Recommended for Further Evaluation
						Reduce rear end crashes	Reduce fixed object and side-swipe crashes	Reduce weather related crashes	Clear lane blocking incidents faster	Make travel times more reliable during peak hours	Reduce non-recurring delay for planned events	Make travel times more reliable during peak hours	Make travel times more reliable during non-peak hours	Reduce freight related crashes				
System Management Strategies																		
1. Active Traffic Management Strategies																		
Variable Speeds	Adjust the regulatory speed limit automatically based on real time congestion and weather conditions. The primary purpose of a variable speed system is to provide better information about current conditions and reduce crashes. The variable speeds would be displayed on dynamic message signs on overhead gantries with the potential for a dynamic message sign over each lane.	• This project assumes overhead DMS gantries would be installed along the corridor or section to which this strategy is applied • Communications required • Detection equipment required	4		4	✓	✓	✓		✓		✓	✓	✓	8	In addition to using variable speeds to adjust for downstream bottlenecks, this strategy could be linked with a weather responsive system	5	YES
Queue Warning	Install dynamic message signs that alert drivers to downstream slowing so that drivers are aware of an upcoming change in speed due to unexpected congestion.	• Assumes use of the equipment required for variable speeds (DMS gantries, communications, and detection)	3		3	✓				✓		✓	✓	✓	5	This strategy could be tied to the variable speed system.	4	YES (as part of Variable Speeds, but no further evaluation)
Weather Responsive Systems	Install sensors that detect conditions such as pavement grip factor and visibility. Then use the information to alert travelers of hazardous conditions either via electronic roadside signs or TripCheck. This strategy can also be used to manage a variable speed system.	• Assumes use of the equipment required for variable speeds (DMS gantries, communications, and detection)	2		4	✓		✓		✓		✓	✓	✓	6	This would be tied to a variable speed system	5	YES (as part of Variable Speeds)
Managed Lanes	Use overhead gantries with dynamic message signs over each lane to inform drivers whether a lane is "open" "closed" or if a merge ahead is necessary.	• Assumes use of the equipment required for variable speeds (DMS gantries, communications, and detection)	3	Limited benefit with two lanes	1	✓	✓							✓	3		1	
Ramp Metering	Manage the rate that vehicles can enter the freeway using a two phase (red/green) traffic signal device.		2		3		✓			✓	✓	✓	✓	✓	6	Greatest benefit at high volume on-ramps (urban areas). At the Exit 234 NB on-ramp ramp metering may improve operations on I-5.	3	YES
Dynamic Lane Merge Control	There are a few options for implementing this alternative: • Close the right lane in advance of a heavy on-ramp condition (requires three lanes) • Provide advance information asking through traffic to use left lane in advance of a heavy on-ramp condition	• Assumes use of the equipment required for variable speeds (DMS gantries, communications, and detection)	3	Limited benefit with two lanes	1	✓	✓			✓		✓		✓	5		1	
Electric Truck Lane Use Signs (use right lane)	Install electronic signs that instruct trucks to use the right most lane when specific conditions are present (such as heavy traffic volumes or inclement weather).	• Communications required • Could use stand alone roadside DMS or link to overhead DMS gantry signs if installed for other strategies	3		4					✓		✓			3	Greatest potential if used with a weather responsive system or traffic volume/speed detectors	5	YES
2. Traveler Information Strategies																		
Roadside Information Signs - Real-Time Travel Times	Display the real-time travel time between two locations on the corridor (or beyond the corridor) on dynamic message signs. This strategy also includes deploying the devices to measure travel times. The dynamic message signs should be placed in locations that allow drivers enough time to decide whether to take an alternate route.	• Assumes use of the equipment required for variable speeds (DMS gantries, communications, and detection)	3		5					✓	✓	✓	✓		4	Travel times could be displayed on DMS signs used for other strategies such as variable speed, or queue warning.	3	YES
Roadside Information Signs - Incident Information	Display real time incident information on roadside DMS for drivers to make enroute decisions.		3		3	✓	✓			✓		✓	✓		5		5	YES
Predictive Traveler Information	Provide predictive travel times using algorithms that combine existing data with future weather/event information. The predictive travel times could be accessed by travelers via a website, smartphone app, connected vehicle technology or possibly other options.	Dependent on extensive data	2		5					✓	✓	✓	✓		4	This strategy does not rely on field detection devices so in theory it has a lower cost than real-time traveler information.	3	
Traffic Surveillance	Monitor traffic operations in real-time using video cameras along the corridor that are controlled from a traffic management center (TMC). This strategy could be used in conjunction with providing real time information for both traveler information and incident management.	• Communications required	3		5				✓	✓		✓	✓		4		5	YES
Highway Advisory Radio (HAR)	Provide traveler information via radio to drivers.		1	The general consensus from ODOT staff is that HAR is difficult to update in a timely manner and that only a small percent of travelers use this service.	3					✓	✓	✓	✓		4		2	

Table 4-3: Preliminary Screening of Strategies for I-5 Optimization Study

Strategy	Description and Purpose	Project Dependencies (if applicable)	Relative Cost Scale: 1=low, < $.5M 5=high, > $10M	Feasibility or Limitations (if blank, no major feasibility issues or limitations)	Frequency the benefit of the strategy is realized Scale: 1= low < 1% of the time 5 = high frequency >50% of the time	Goal 1: Improve Safety				Goal 2: Improve Commuter Mobility		Goal 3: Improve Freight Mobility			Number of objectives met	Additional Comments	Preferred by ODOT personnel 5 = Greatest Potential 1 = Least Potential	Recommended for Further Evaluation
						Reduce rear end crashes	Reduce fixed object and side-swipe crashes	Reduce weather related crashes	Clear lane blocking incidents faster	Make travel times more reliable during peak hours	Reduce non-recurring delay for planned events	Make travel times more reliable during peak hours	Make travel times more reliable during non-peak hours	Reduce freight related crashes				
Connected Vehicles	Ensure that roadway related communications sent to ODOT's TripCheck Traveler Information Portal (TTIP) are also available for vehicles equipped with connected vehicle technology. This may include installing roadside dedicated short range communications (DSRC) radios. The system could deliver road conditions, current speeds, incident notification from the roadside to the vehicle.	• Private sector infrastructure required	1	Private sector infrastructure is not ready for this, and connected vehicles depends on having the field infrastructure first. Also, only a small percent of the vehicle fleet is currently equipped with connected vehicle technology. The full benefit of this strategy would not be realized for years.	3	✓	✓	✓		✓		✓	✓	✓	7		2	
3. Incident Management and Towing Strategies																Note: for ALL incident management strategies - faster incident clearance times reduce secondary crashes		
Automated Incident Detection	Install monitoring sensors or use private sector data to automatically detect changes in traffic flow and identify incidents.	• Communications and detection required	4	Requires a considerable investment in communications and detection	4	✓	✓		✓	✓		✓	✓	✓	7		3	
Automated Detour Routes	Automate detour routes on parallel roads during an incident that closes a section of I-5. This may involve turning on special signal timing plans, or activating roadside devices to instruct drivers of the detour.	• Communications required	2		1					✓		✓	✓		3	Although there is a low frequency in using detour routes, ODOT staff felt having detour routes automated will allow valuable resources to be better allocated during an incident (instead of using stall to set up detours).	4	
Incident Response Vehicles	Operate incident response to peak congested periods to assist disabled vehicles, respond to incidents and reduce clearance times.		2		3	✓	✓		✓						3		5	ODOT internal assessment
Corridor Operations Team	Implement a corridor operations team that meets regularly to coordinate operations within the corridor. Specific activities the corridor operations team could be responsible for could include: Planning management and operations (M&O) for special events, coordinate incident response, review performance, allocate resources for active corridor operations.		1		3				✓	✓	✓	✓	✓		5		5	ODOT internal assessment
Oregon's "Move It" Law - Signing	Install signs along the corridor that display the Oregon "Move It" law, instructing vehicles to move to the shoulder after a minor crash (as long as there are no injuries).		1		2	✓	✓		✓	✓		✓	✓	✓	7		5	ODOT internal assessment
Mile Marker Signs	Install 0.5 or 0.1 increment mile marker signs to help drivers identify their location when reporting a crash.		1		3				✓						1		4	ODOT internal assessment
Median Turn Around	Construct locations along the center median for emergency responders to turn around on the freeway.		2		1				✓						1	No existing median turn around locations along the study corridor	4	ODOT internal assessment
Dry Run Towing	Dispatch a towing service at the same time ODOT or emergency personnel respond to an incident. The towing service gets paid regardless of whether or not the towing service is ultimately used.		1		2	✓	✓		✓	✓		✓	✓	✓	7		3	ODOT internal assessment
Hourly Towing Contract	Initiate an hourly towing contract between ODOT and towing companies during bad weather conditions or other necessary events. This contract enables ODOT to dictate towing priorities and allocated towing resources as necessary.		1		1	✓	✓		✓	✓		✓	✓	✓	7		5	ODOT internal assessment
Incentivizing Clearing Heavy Vehicle Incidents	Create an incentives program to clear heavy vehicle crashes and open the freeway faster after an incident involving a heavy vehicle.		1		1	✓	✓		✓	✓		✓	✓	✓	7		2	ODOT internal assessment
4. Rest Area Strategies																		
No Parking Signs	Install static signs on the freeway the prohibit parking along the shoulders (specifically near the Santiam Rest Area). An exception would be noted for super-loads.		1		5		✓							✓	2		5	ODOT internal assessment
Electronic Truck Parking Information	Inform truck drivers about overnight parking south of Santiam Pass Rest Area at Knox Butte. Add a sign to indicate parking lot full and direct to Knox Butte (or other location).		2	Knox Butte is private property, resolution necessary	5		✓								1		3	
Rumble Strips	Install additional rumble strips in the wide shoulder near the Santiam Rest Area to discourage vehicles from using the shoulder as a travel lane. Consider striping as an alternative to the rumble strips		1		5										0	This strategy does not address the truck shoulder parking issue at the rest area, which is the primary concern.	1	
5. Demand Management Strategies																		
Support Demand Management Strategies	Promote travel that reduces overall demand on the system such as: bus transit, carpool, and non-peak hour commuting.		1		5					✓	✓	✓	✓		4		3	ODOT internal assessment

Table 4-3: Preliminary Screening of Strategies for I-5 Optimization Study

Strategy	Description and Purpose	Project Dependencies (if applicable)	Relative Cost Scale: 1=low, < $.5M 5=high, > $10M	Feasibility or Limitations (if blank, no major feasibility issues or limitations)	Frequency the benefit of the strategy is realized Scale: 1= low < 1% of the time 5 = high frequency >50% of the time	Goal 1: Improve Safety Reduce rear end crashes	Goal 1: Improve Safety Reduce fixed object and side-swipe crashes	Goal 1: Improve Safety Reduce weather related crashes	Goal 1: Improve Safety Clear lane blocking incidents faster	Goal 2: Improve Commuter Mobility Make travel times more reliable during peak hours	Goal 2: Improve Commuter Mobility Reduce non-recurring delay for planned events	Goal 3: Improve Freight Mobility Make travel times more reliable during peak hours	Goal 3: Improve Freight Mobility Make travel times more reliable during non-peak hours	Goal 3: Improve Freight Mobility Reduce freight related crashes	Number of objectives met	Additional Comments	Preferred by ODOT personnel 5 = Greatest Potential 1 = Least Potential	Recommended for Further Evaluation
6. Capital Improvement Strategies																		
Targeted Shoulder Widening - Chain Up and Chain Removal Areas	Create outside shoulders (right side) that are wide enough to be chain-up and chain-removal areas: • Northbound prior to Ankeny Hill (chain-up) • Northbound prior to Enchanted Forest Hill (chain-up) • Northbound near Delaney or Commercial (chain-removal)		4	Additional right of way may be necessary	3				✓			✓	✓		3	Ares of interest include: • SB left shoulder north of Viewcrest (exit 237) • Ankeny Hill (pull out/chain up area) • Enchanted Forest Hill (pull out/ chain up area)	5	YES
Targeted Shoulder Widening - Auxiliary Lane	Create a third northbound lane from the North Jefferson on ramp to the bottom of the hill (where the existing third lane begins). This third lane could be manually closed by ODOT during bad weather conditions and used as a chain up area.		5	Additional right of way may be necessary	5				✓	✓	✓	✓	✓		5		5	YES
Targeted Shoulder Widening	Widen shoulder areas (right or left) where inadequate shoulders currently exist. High priority areas: • Median barrier north of Viewcrest Interchange (SB)		4	Additional right of way may be necessary	3				✓	✓	✓	✓	✓		5	Ares of interest include: • SB left shoulder north of Viewcrest (exit 237)	5	
Hard Running Shoulders	Construct shoulder (right or left) to provide an extra travel lane during high demand or high congestion. The shoulder needs to meet roadway construction standards for a regular freeway traffic lane. An overhead gantry with dynamic message signs over each lane, as described in the "Managed Lanes" strategy, is required for this project.		5	Additional right of way may be necessary	4				✓	✓		✓	✓		4	Ares of interest include: • SB between Kuebler and Enchanted Forest	3	YES
Auxiliary Lanes	Construct an additional lane between interchanges. For example: the on-ramp lane from the first interchange would eventually become the off-ramp lane at the next interchange.		5	Additional right of way may be necessary	5					✓		✓	✓		4		1	
Climbing Lanes	Construct an additional lane on sections with an uphill grade.		5	Additional right of way may be necessary	5					✓		✓	✓	✓	5		1	
Higher Visibility Markings and Signage	Install lane markings and signage that increase visibility for drivers, especially during low visibility weather conditions or nighttime driving conditions. In particular, the merge at the north end (northbound merge at Kuebler)		2		5			✓						✓	2	This may also be a maintenance activity to clean signs and improve sign visibility.	5	ODOT internal assessment
Inlaid Pavement Markings and Reflectors	Use inlaid pavement markings and reflectors to improve durability and visibility of pavement markings		3		5		✓	✓							2	As the freeway gets repaved, the strategy is to move to inlaid markings	4	ODOT internal assessment
Close Ramps	Remove an on or off ramp at an interchange (but not the whole interchange).	On going South Jefferson to US 20 Environmental Assessment project	3	public process	3		✓			✓	✓	✓	✓		5		3	
Close Interchanges	Remove a full interchange.	On going South Jefferson to US 20 Environmental Assessment project	4	public process	3		✓			✓	✓	✓	✓		5		3	

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5. CHAPTER 5 - CORRIDOR IMPLEMENTATION PLAN

This chapter provides a planning level benefit and cost analysis of the nine strategies recommended for further analysis for the I-5 Optimization Study. It evaluates each strategy based on its ability to achieve stakeholder selected project goals and objectives and recommends a set of four strategies for implementation.

5.1 Summary of Recommended Strategies

Out of nine strategies that underwent a planning level cost benefit analysis, four strategies emerged as the ones with the greatest potential to improve safety and operations along I-5 in the study area:

Traffic Surveillance (four new cameras and two upgrades to existing cameras)

With a B/C ratio of 6.6, this project assumes the installation of four new cameras and upgrading two existing cameras along the study corridor. Key benefits from this strategy include reducing incident duration by up to 10%, which relates to over seven hours of delay savings on an annual basis. See Figure 5-1 for more details.

Ramp Metering (one new ramp meter)

With a B/C ratio of 5.6 at Exit 234, this strategy assumes the installation of a ramp meter for the northbound on-ramp at Exit 234. Key benefits from ramp metering include a 36% reduction in crashes near the on-ramp (which equates to a reduction of about one crash per year at this location), as well as a 10% improvement in freeway capacity and 10% reduction in fuel/emissions. See Figure 5-2 for more details.

Roadside Information Signs – Incident Information (three new DMS)

With a B/C ratio of 3.1, this project assumes the installation of three new dynamic message signs (DMS), two southbound and one northbound. There is already an existing northbound DMS near Millersburg. Key benefits include a reduction in injury crashes. Research shows a reduction in injury crashes of up to a 44%, however, for this analysis we assumed a conservative reduction in injury crashes of 5% which equates to a reduction of almost three crashes annually. This strategy also reduces driver delay by providing en route information that allows drivers to make en route decisions and take alternate routes during an event. When not in use for incident information, the DMS could display travel time information, which decreases driver delay even more. See Figure 5-3 for more details.

Variable Speed with Weather Responsive System (seven bi-directional gantries)

With a B/C ratio of 0.9, the return on investment is almost equal to the annual cost of the strategy. The cost estimate for this project is conservative, assuming fiber communications. If a different communication option is selected, the cost will decrease. This strategy assumes a variable speed system installed along approximately seven miles at the north end of the study area with overhead gantries and DMS. Key benefits include a 7% reduction in all crash types through the study area, plus an additional reduction of up to 18% weather related crashes (this analysis assumed a 10% reduction in weather related crashes). Based on these assumptions, implementing this strategy could reduce an average of five crashes per year. See Figure 5-4 for more details.

In addition to these four recommended strategies, the project team also recommends ODOT internally pursue the following thirteen strategies listed in Table 5-1. The strategies listed in Table 5-1 all benefit the corridor, but due to the nature of these strategies, an extensive benefit analysis was not necessary.

Table 5-1: Recommended Strategies for ODOT Internal Evaluation

Category	Strategies
Active Traffic Management	none
Traveler Information	none
Incident Management and Towing	• Install Oregon "Move It" law signing • Install half mile marker signs • Consider increasing incident response vehicles • Consider corridor operations team • Install median turn around(s) – to be evaluated with ODOT's Cable Median Barrier Project • Consider dry run towing • Consider hourly towing contract • Consider incentivized towing contract
Rest Area	• Install "No Parking" signs
Demand Management	• Support demand management strategies
Capital Improvement	• Install higher visibility pavement markings and signs • Install inlaid pavement markings and reflectors

5.2 Analysis Methodology

Each strategy was evaluated using three key categories: project goals, benefits, and cost. These evaluation categories are used to compare and contrast each option, prioritize and recommend a subset set for implementation.

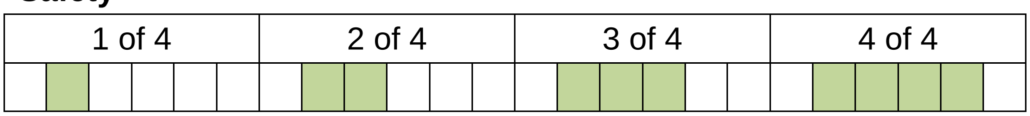
5.2.1 Project Goals

Each strategy is evaluated based on the number of project objectives it achieves. The goals and objectives are listed in Chapter Three, and summarized here.

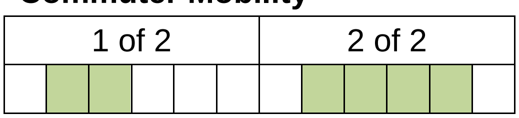
- Goal 1: Improve Safety
  - Reduce rear end crashes by at least ten percent
  - Reduce fixed object and side-swipe crashes by at least five percent
  - Reduce weather related crashes
  - Clear all lane blocking incidents within 90 minutes
- Goal 2: Improve Commuter Mobility
  - Improve travel time reliability during peak hours
  - Reduce non-recurring delay for planned events
- Goal 3: Improve Freight Mobility
  - Improve travel time reliability during peak hours
  - Improve travel time reliability during non-peak hours
  - Reduce freight related crashes

Each strategy is rated based on the number of relevant objectives. These results are displayed graphically for each strategy using the following system:

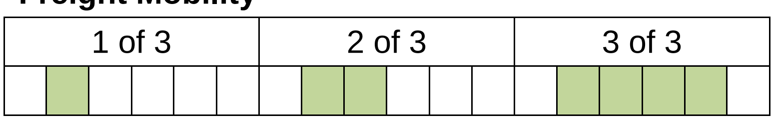
Safety



Commuter Mobility



Freight Mobility



5.2.2 Benefits Analysis

The quantitative benefits analysis, used to calculate the average annual benefit for each strategy, is based on information gathered from the Tool for Operations Benefit/Cost (TOPS-BC) and the Crash Modification Factors (CMF) Clearinghouse. Detailed calculations for each strategy are provided in Appendix A.

TOPS-BC

The TOPS-BC is a spreadsheet-based application created by the Federal Highway Administration (FHWA). Its purpose is to assist in conducting benefit cost analysis for transportation system management and operations (TSMO) strategies. This tool was used as a starting point for many of the strategies.

CMF Clearinghouse

The CMF Clearinghouse website is a database funded by the FHWA. The database includes crash modification factors and supporting documentation for a variety of countermeasures. The CMF can then be applied to the crash data in the study area to determine how many crashes a particular strategy reduces. Monetary benefits (crash savings) for each strategy are then calculated by monetizing each crash that is prevented. The FHWA establishes costs based on crash severity:

- Fatal crashes: $6,500,000 each
- Injury crashes: $67,000 each
- Property Damage Only crashes: $2,300 each

5.2.3 Costs Components

Strategy costs are divided into three components:

- Initial capital investment (equipment + design + build costs)
- Annual maintenance and operations (staffing hours, equipment maintenance, annual upgrades, replacement costs, etc.)
- Annual average cost (used to calculate the B/C ratio). This cost incorporates a portion of the initial capital cost based on the useful life of equipment, plus the annual maintenance and operations cost.

These are provided as separate line items for each strategy. Detailed calculations for each strategy are provided in Appendix A.

5.2.4 Communication Assumptions

Several of the recommended strategies require communications to operate. Communications are critical to transfer information from a central command center, such as the traffic operation center, to field devices. Factors such as reliability needs and data size or data type guide which communication options are available for each strategy. There are three basic levels of communications that we assumed for cost estimate purposes:

- **Leased cellular service**. This is the lowest cost option and has limited data transfer capability. This option also has the lowest level of reliability of the three communication options. A typical use for leased cellular service could be to communicate with a weather station. Cost includes an initial connection fee ($5,000 per location) plus a monthly service fee ($50 per month).

- **Leased DSL service.** This is the moderate cost option and has improved data transfer capability and reliability over the cellular option. Typical uses for leased DLS services include communication to roadside signs (DMS) and some installations of video surveillance. Cost includes an initial installation fee (approximately $50,000 per location) plus a monthly service fee ($125 per month).
- **Fiber installation.** This is the highest cost option and offers maximum data transfer capability and reliability. Typical uses of fiber installation include road safety devices, such as variable speeds and lane use signs. Installation and equipment typically costs $50 per foot.

The communication assumption for each strategy is noted in Figures 1 through 9.

5.3 Summary of Findings

In evaluating nine different strategies for consideration, four strategies stand out as the most beneficial based on the number of objectives they meet and their benefit/cost ratios. These include:

- Traffic Surveillance
- Ramp Metering
- Roadside Information Signs (DMS)
- Variable Speeds (with Weather Responsive)

A summary of these are provided in Table 1. Supporting information for each strategy is provided in Figure 5-1 through Figure 5-9, and detailed cost estimate and benefit information is included in Appendix A.

5.3.1 Traffic Surveillance

Along the I-5 study corridor, crashes account for 72 hours of delay annually. Traffic surveillance can reduce incident duration by 10%, saving drivers over 7 hours in delay per year. It allows operators to identify an

incident and issue an appropriate response remotely, which represents a time savings from sending operators out to the field to identify and determine the response. This advancement will contribute to achieving the following project objectives:

- Clear all lane blocking incidents within 90 minutes
- Improve travel time reliability during peak and non-peak hours

The strategy has a benefit/cost ratio of 6.3, which indicates a return on investment of over six times the average annual cost of the strategy.

5.3.2 Ramp Metering

Ramp metering can reduce crashes near on-ramps by 36%, which is approximately one crash a year at each the Exit 234 Northbound On Ramp location. Ramp metering also provides more even flow of traffic along the mainline, which reduces emissions and fuel consumption by approximately 10% and improves freeway capacity by 10%. These benefits align with the following project objectives:

- Reduce side-swipe crashes
- Improve travel time reliability during peak and non-peak hours
- Reduce non-recurring delay for planned events
- Reduce freight related crashes

This strategy has a benefit/cost ratio of 5.6 at Exit 234, which indicates a return of benefits almost 6 times that of the average annual cost of the strategy depending on the location.

Ramp metering was also considered for the southbound on ramp at Exit 252 (Kuebler Boulevard). However, the benefit at Exit 252 was less than at Exit 234 due to lower on ramp volumes, and would also cost more since two ramp meters are necessary (the interchange is in the process of being reconfigured with two southbound on ramps). At Exit 252 the B/C ratio was 2.4.

5.3.3 Roadside Information Signs – Incident Information

There are approximately 57 injury related crashes a year along this section of I-5. Studies show advance incident information signs reduce injury crashes by up to 44% where applied. Using even a very conservative estimate of a 5% reduction in injury crashes (which translates to approximately three crashes per year along the study corridor), is still shown to provide a desirable return on investments. This strategy also reduces delay, resulting from alternate routes when properly informed. This strategy contributes to the following project objectives:

Relevant objectives include:

- Reduce rear-end crashes
- Reduce fixed object and side-swipe crashes
- Improve travel time reliability during peak and non-peak hours
- Reduce non-recurring delay for planned events
- Reduce freight related crashes

The benefit/cost ratio for this strategy is 3.1, which represents a return of benefits almost four times that of the average annual cost of the strategy. Since this is based on a very conservative 5% reduction in injury crashes (where up to 44% may be reasonable), it is likely this value could also be much larger. In addition, when not in use displaying incident information, these dynamic message signs could display travel times which result in additional delay reduction as drivers make en route decisions based on real time information.

5.3.4 Variable Speeds (with Weather Responsive)

The variable speed project with weather responsive technology has a 7% - 8% reduction in crashes (variable speeds), plus up to an additional 18% reduction in weather related crashes, associated with it. When applied to the northern seven miles of the study area, where this project would be installed, the crash rate reductions translate to a decrease of approximately 4.5 crashes per year due to the variable speed and weather responsive components. This system would be particularly relevant during adverse weather conditions. Applicable project objectives include:

- Reduce rear-end crashes
- Reduce fixed object and side-swipe crashes
- Reduce weather related crashes
- Improve travel time reliability during peak and non-peak hours
- Reduce freight related crashes

This strategy has a benefit/cost ratio of 0.9, which indicates a return of benefits almost equal to that of the average annual cost of the strategy. However, if a less expensive communication option is selected the benefit/cost ratio will be even more favorable (this cost estimate assumes fiber which is the most conservative option cost-wise).

Table 5-2: Summary of the Nine Recommended Strategies – Listed by B/C Ratio

Strategy	Benefit/ Cost Ratio	Initial Capital Cost (Avg Annual Cost)	Goal 1: Safety	Goal 2: Commuter Mobility	Goal 3: Freight Mobility
Traffic Surveillance	**6.6**	$630,000 ($43,000)	■□□□	■■□□	■■□□
Ramp Metering Exit 234 NB on-ramp	**5.6**	$380,000 ($29,000)	■□□□	■■■■	■■■■
Roadside Information Signs - Incident Information	**3.1**	$1,440,000 ($77,000)	■■□□	■■□□	■■□□
Variable Speeds with Weather Responsive System	**0.9**	$8,650,000 ($450,000)	■■■□	■■□□	■■■■
Targeted Shoulder Widening - NB Auxiliary Lane	0.4	$5 to $10 Million ($300,000 to $450,000)	■□□□	■■■■	■■□□
Roadside Information Signs - Travel Times	0.2	see Roadside Information Signs – Incident Information	□□□□	■■■■	■■□□
Hard Running Shoulders SB between Kuebler and Enchanted Forest	0.1	$40 to $60 Million ($1.5 to $2.5 Million)	■□□□	■■□□	■■□□
Targeted Shoulder Widening – Chain-Up and Chain Removal Areas	N/A	$1,820,000 ($78,000)	■□□□	□□□□	■■□□
Electronic Truck Lane Use Sign	N/A	$350,000 ($24,000)	□□□□	■■□□	■□□□

Figure 5-1: Traffic Surveillance Strategy

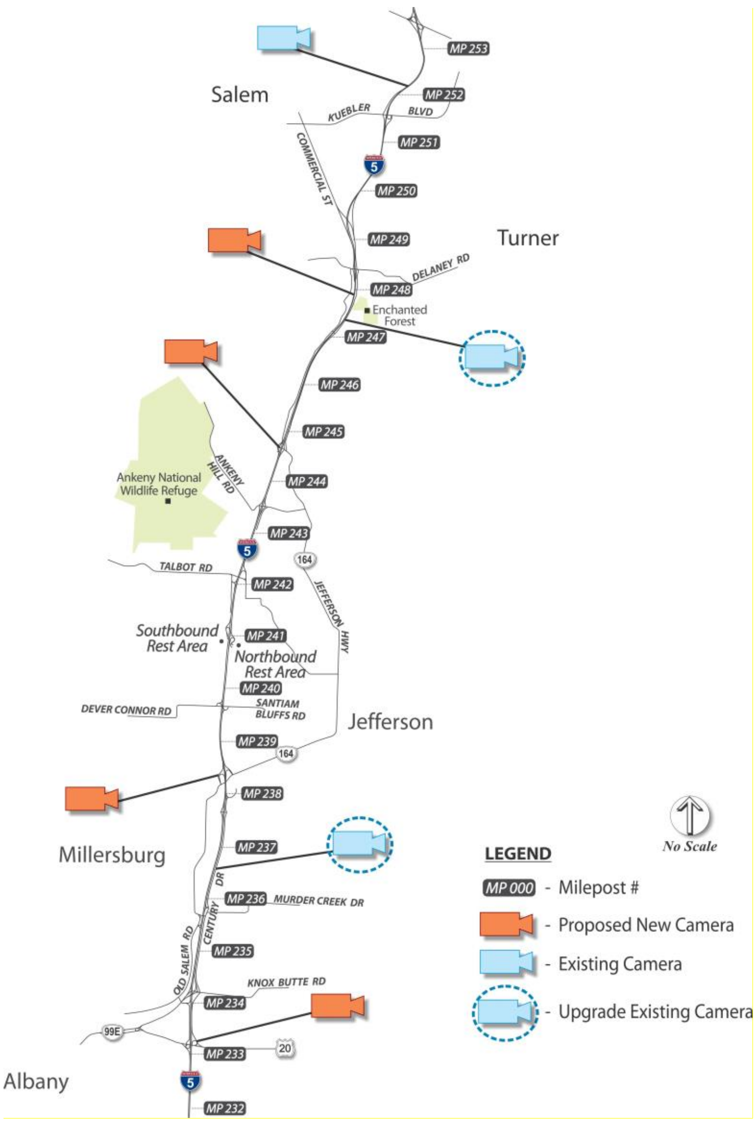
Strategy: Traffic Surveillance

Goal 1: Safety	Goal 2: Commuter Mobility	Goal 3: Freight Mobility	B/C Ratio
			6.6

Description:
Monitor traffic operations in real-time using video cameras along the corridor that are controlled from a traffic management center (TMC). These cameras would be used to monitor operations in real time and improve response time to incidents. Response time is improved by allowing operators to visually confirm crashes immediately and issue a response. This reduces the time to clear incidents and the likelihood of secondary crashes. Proposed locations include: 1) Delaney Rd Interchange (luminaire mount); 2) North Jefferson Interchange (camera pole required); and 3) OR 99E Interchange (luminaire mount).

Average Annual Benefit	**Average Annual Cost – 4 New Cameras and 2 Upgrades** $43,000	
$284,000	**Initial Capital Cost** $630,000	**Annual O&M Cost:** $10,000

Location:



Benefit:

- Reduce Incident duration between 2% and 10% (benefits assume 10%)
- Reduce incident response time
- Reduce incident clearance time
- Reduce delay

Related Strategy:
N/A

System Requirements:
ODOT already has the necessary software for traffic surveillance with cameras. Field equipment is required.

Related Resources:
N/A

Dependencies:

- Power source location
- Communications assumes leased DSL services plus the initial installation cost

Agency Resources and Partnerships necessary:

- ODOT dispatch and district maintenance staff hours to monitor and maintain cameras
- Link district offices to TMC to view camera activity.

Figure 5-2: Ramp Metering Strategy

Strategy: Ramp Metering (Traffic Actuated)

Goal 1: Safety	Goal 2: Commuter Mobility	Goal 3: Freight Mobility	B/C Ratio **5.6 (Exit 234)**

Description:

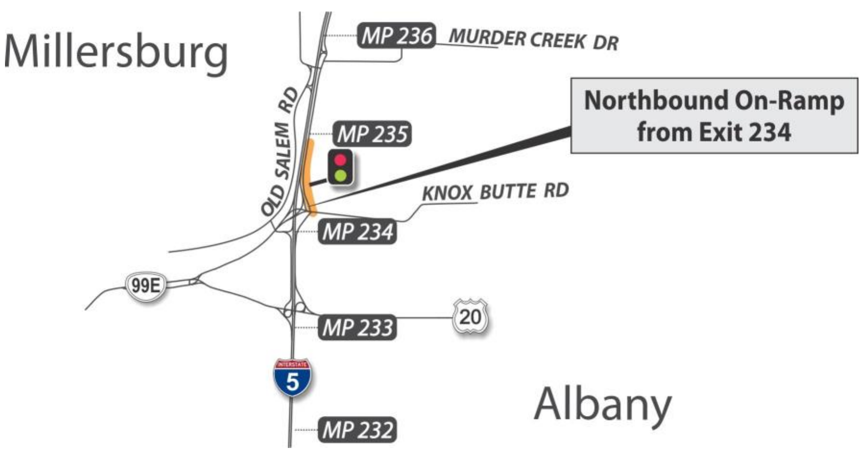
Manage the rate that vehicles can enter the freeway using a two phase (red/green) traffic signal device. The ramp meters would be activated when the mainline volume reaches a certain threshold.

ODOT does not have specific ramp meter warrants; however, based on Arizona DOT Operations[1], traffic conditions at the two ramps considered for this strategy meet several of the Arizona DOT ramp meter warrants including volume based warrants.

Average Annual Benefit (per ramp meter location)	**Average Annual Cost**	
	$29,000 (Exit 234)	
$162,000 (Exit 234)	**Initial Capital Cost** $380,000 (Exit 234)	**Annual O&M Cost:** $5,000 (Exit 234)

Location:

Northbound on-ramp from Exit 234 (99E/Knox Butte)



Benefit:

- Up to a 36% reduction in crashes near on-ramps
- Improve freeway capacity by 10%
- Reduction in fuel use by 10%

Related Strategy:

N/A

System Requirements:

ODOT already has the necessary software for ramp meters. Field equipment is required.

Related Resources:

N/A

Dependencies:

- Power source locations
- Communications assumes fiber installation

Agency Resources and Partnerships necessary:

- ODOT staff hours to maintain ramp meter system.
- Link district offices to TMC to view ramp meter activity

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[1] Arizona DOT Ramp Meter Design, Operations, and Maintenance Guidelines. April 2003

Figure 5-3: Roadside Information (Incident Information) Strategy

Strategy: Roadside Information (Incident Information)

Goal 1: Safety	Goal 2: Commuter Mobility	Goal 3: Freight Mobility	B/C Ratio
			3.1

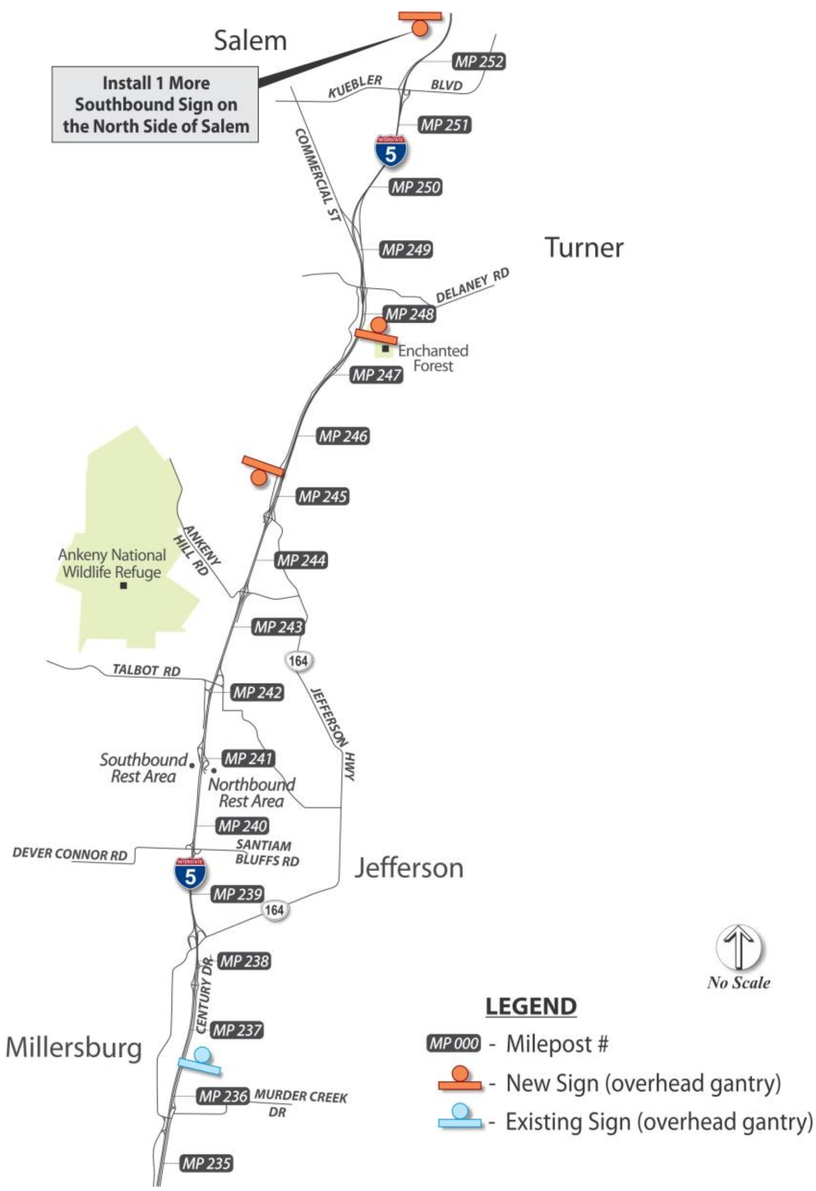
Description:

Display real time incident information on roadside DMS for drivers to make en route decisions.

These DMS signs could also be used to display travel time information when not in use for incident information

Average Annual Benefit	Average Annual Cost (for all three locations) $77,000	
	Initial Capital Cost	**Annual O&M Cost**
$237,000	**$1,440,000**	$15,000

Location:



Benefit:

- Up to 44% reduction in injury crashes (all types). This analysis used a conservative estimate of a 5% reduction in injury crashes
- Driver rerouting from additional information

Related Strategy:

Roadside Information (Travel Times) - Option to use the same DMS equipment for travel time information

System Requirements:

ODOT already has the necessary software for DMS signs. Field equipment is required.

Related Resources:

N/A

Dependencies:

- Power source locations
- Communication assumes leased DSL services to each of the three signs

Agency Resources and Partnerships necessary:

- ODOT staff hours to maintain DMS
- Link district offices to TMC to view DMS activity

Figure 5-4: Variable Speeds (with Weather Responsive) Strategy

Strategy: Variable Speeds with Weather Responsive System

Goal 1: Safety	Goal 2: Commuter Mobility	Goal 3: Freight Mobility	B/C Ratio
			0.9

Description:
Adjust the regulatory speed limit automatically based on real time congestion and weather conditions. The primary purpose of a variable speed system is to provide better information about current conditions and reduce crashes. The variable speeds would be displayed on dynamic message signs on overhead gantries with the potential for a dynamic message sign over each lane. The system would be tied to a weather responsive system and could also act as a queue warning system.

Average Annual Benefit	Average Annual Cost $450,000	
$420,000	**Initial Capital Cost** $8,650,000	**Annual O&M Cost:** $60,000

Location:

Benefit:
- Crash rate reduction approx. 7%-8% (variable speeds)
- Additional crash rate reduction (up to 18% - this analysis assumed a 10% reduction) and delay due to weather responsive system

Related Strategy:
Queue Warning

System Requirements:
ODOT already has the necessary software for variable speeds. Field equipment is required.

Related Resources:
Oregon Statewide Variable Speed Study
Variable Speed Studies for ODOT Region 3 and Region 4

Dependencies:
- Power source locations
- Communications assumes fiber installation (10 miles)

Agency Resources and Partnerships necessary:
- ODOT staff hours to maintain variable speed system and weather responsive system.
- Link district offices to TMC to view variable speed and weather data.

Figure 5-5: Targeted Shoulder Widening (NB Auxiliary Lane and Chain-Up Area) Strategy

Strategy: Targeted Shoulder Widening – NB Auxiliary Lane and Chain Up Area

(North Jefferson to Existing Three Lane Section)

Goal 1: Safety	Goal 2: Commuter Mobility	Goal 3: Freight Mobility	B/C Ratio
			0.4

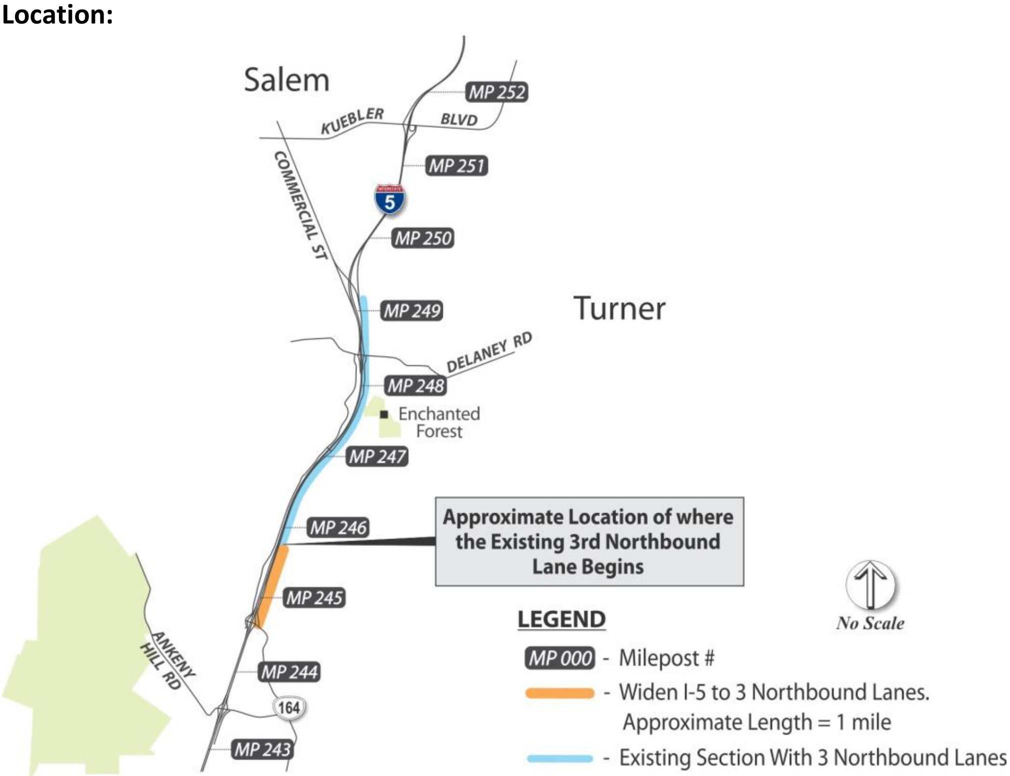
Description:

Provide a third northbound lane between the North Jefferson Interchange and the point where a third northbound lane currently exists (approximately 1 mile). This third lane, which runs on level terrain, could be used as a chain up area during winter conditions. ODOT will need to manually close off the lane during use as a chain up area.

Enchanted Way runs adjacent to I-5 along the east side of the freeway. Based on a preliminary evaluation, there appears to be enough room to widen I-5 to a third lane through this section, however, there may be some impact to Enchanted Way (matching the grade to I-5, or possibly shifting Enchanted Way to the east slightly). Mitigation would be necessary for Miller Creek, which runs between I-5 and Enchanted Way for about 800 feet through this project area.

Average Annual Benefit	Average Annual Cost $200,000 to $400,000	
	Initial Capital Cost	**Annual O&M Cost:**
$128,000	$5,000,000 to $10,000,000	$15,000

Location:



Benefit:

- Provides location for chaining up during adverse weather
- Provides additional capacity (reduces delay)

Related Strategy:

N/A

System Requirements:

N/A

Related Resources:

N/A

Dependencies:

Cost does NOT include any right of way acquisition or realignment of Enchanted Way

Agency Resources and Partnerships necessary:

N/A

Figure 5-6: Roadside Information (Travel Times) Strategy

Strategy: Roadside Information (Travel Times)

Goal 1: Safety	Goal 2: Commuter Mobility	Goal 3: Freight Mobility	B/C Ratio
			0.2

Description:

Display the real-time travel time between two locations on the corridor (or beyond the corridor) on dynamic message signs. This strategy also includes deploying the devices to measure travel times. The dynamic message signs should be placed in locations that allow drivers enough time to decide whether to take an alternate route.

This project will be in conjunction with the **Roadside Information (Incident Information)** strategy. While the dynamic message signs are not displaying incident related information, they will be used to display travel time information.

Average Annual Benefits	Average Annual Cost
$12,000 also see "Roadside Information - Incident Information" Strategy	**see Roadside Information (Incident Information) Strategy**

Location:

Benefit:

- Reduced delay by allowing drivers to choose an alternate route during non-crash events (such as football games).
- Travelers are better informed and can make en route decisions
- Less driver frustration

Related Strategy:

Roadside Information (Incident Information)

- Option to use the same DMS equipment for incident information

System Requirements:

ODOT already has the necessary software for DMS signs. Field equipment is required.

Related Resources:

N/A

Dependencies:

- Power source locations and communications
- Communication assumes leased DSL services to each of the three signs

Agency Resources and Partnerships necessary:

- ODOT staff hours to maintain DMS
- Link district offices to TMC to view DMS activity

Figure 5-7: Hard Shoulder Running Strategy

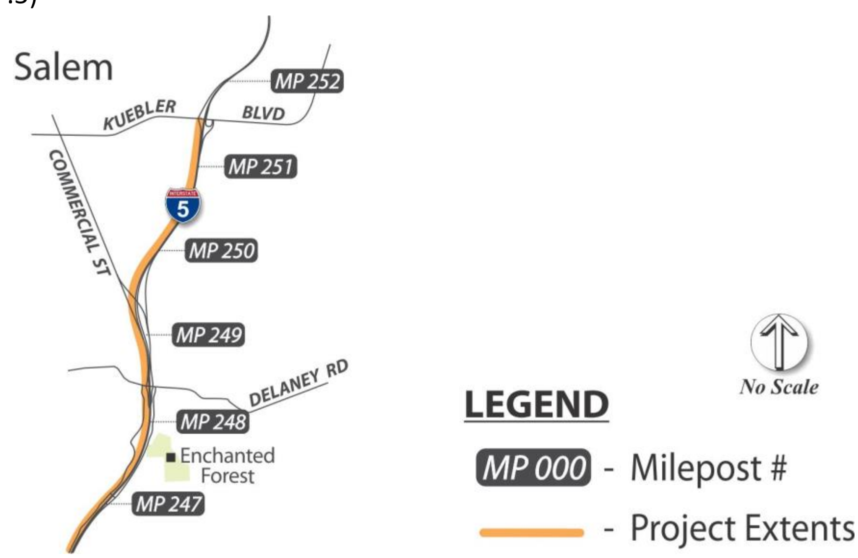
Strategy: Hard Running Shoulder
(SB Kuebler to Enchanted Forest)

Goal 1: Safety	Goal 2: Commuter Mobility	Goal 3: Freight Mobility	B/C Ratio
■□□□	■■□□	■■□□	**0.1**

Description:
Reconstruct shoulder to function as an extra travel lane during high demand or high congestion. The shoulder needs to meet roadway construction standards for a regular freeway traffic lane. Overhead gantries with a dynamic message/lane use sign over the shoulder lane are required approximately every ½ mile through the project area.

Average Annual Benefit	**Average Annual Cost (per location) $1.5 to $2.5 Million**	
	Initial Capital Cost	**Annual O&M Cost:**
$233,000	$40 to $60 Million	$75,000

Location:
Southbound Kuebler Interchange to Enchanted Forest (approx. MP 252.5 to 247.5)



Benefit:
- Additional capacity
- Minimizes delay during incidents (alternate path for vehicles)
- Reduces travel time

Related Strategy:
N/A

System Requirements:
Managed lanes architecture to support logic.

Related Resources:
N/A

Dependencies:
- Power source locations
- Communications assumes fiber installation

Agency Resources and Partnerships necessary:
- ODOT staff hours to maintain signs
- Link district offices to TMC to control managed lane signs

Figure 5-8: Targeted Shoulder Widening (2 NB Chain-Up Areas and 1 Chain Removal) Strategy

Strategy: Targeted Shoulder Widening – 2 NB Chain-Up Areas and 1 Chain Removal Area
(Near Ankeny Hill and Enchanted Forest)

Goal 1: Safety	Goal 2: Commuter Mobility	Goal 3: Freight Mobility	B/C Ratio
			N/A

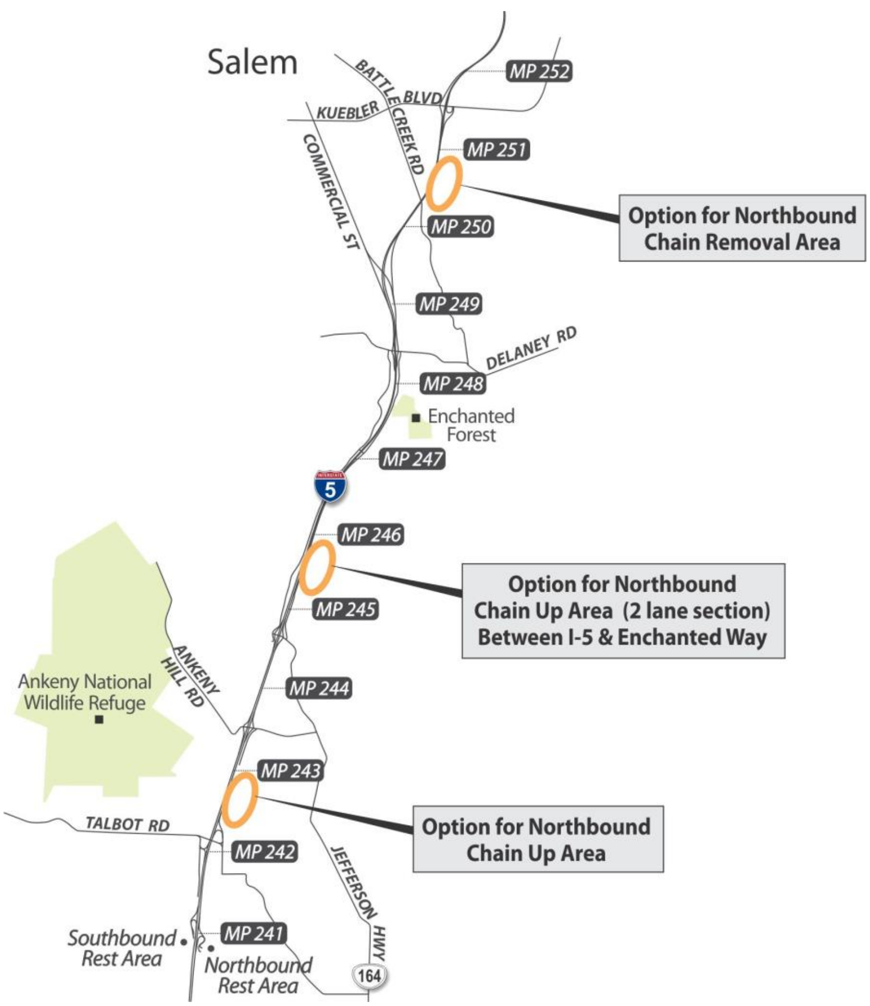
Description:

Construct two chain-up areas for northbound traffic as well as a chain removal area. The two chain-up areas would be prior to Ankeny Hill and the Enchanted Forest hill, and the chain removal area would be near Kuebler Boulevard.

The chain up area needs to be located before (south of) mile point 246 where the northbound direction becomes three travel lanes. At this point there is no available room between I-5 and Enchanted Way. Between mile points 245 and 246 there is limited space to widen I-5 to the east due to Enchanted Way as well as some terrain challenges (including drainage and grade).

Average Annual Benefit	Average Annual Cost (all three locations) $78,000	
	Initial Capital Cost	**Annual O&M Cost:**
$0	$1,820,000	$5,000

Location:



Benefit:
There is no research that indicates a reduction in crashes due to chain up areas.

Related Strategy:
N/A

System Requirements:
N/A

Related Resources:
N/A

Dependencies:
Available right of way

Agency Resources and Partnerships necessary:
N/A

Figure 5-9: Electronic Truck Lane Use Signs Strategy

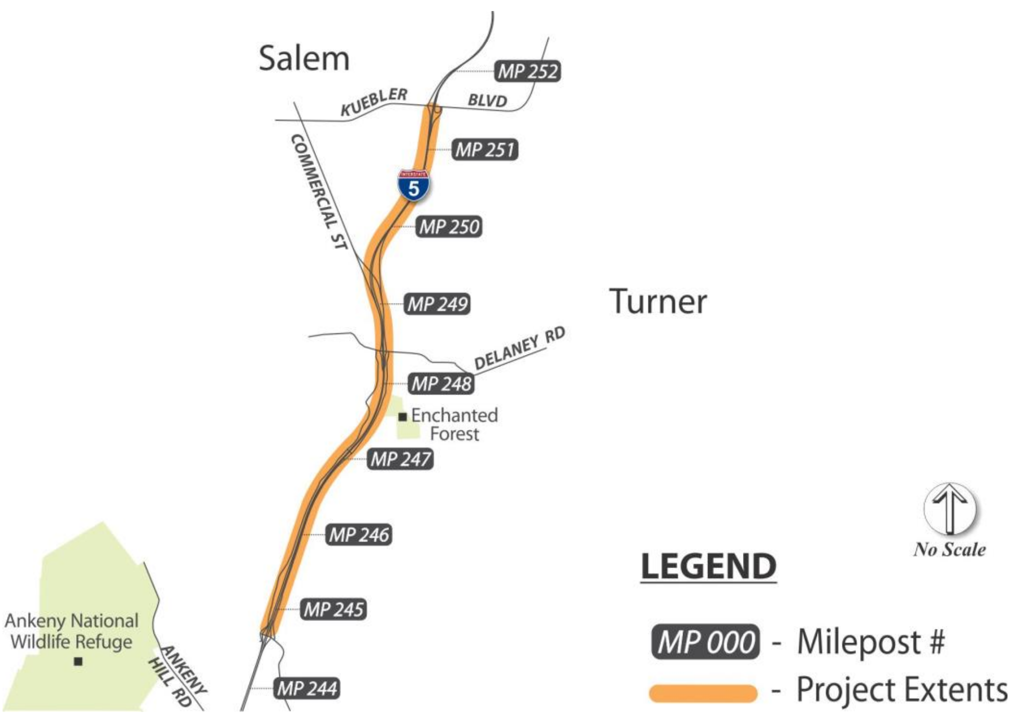
Strategy: Electronic Truck Lane Use Signs

Goal 1: Safety	Goal 2: Commuter Mobility	Goal 3: Freight Mobility	B/C Ratio
			N/A

Description:
Install electronic truck lane use signs that instruct trucks to travel in the right lane. These would be considered part-time advisory signs that are activated during specific conditions, including: heavy traffic volumes or inclement weather.

Average Annual Benefit	Average Annual Cost – 9 signs $24,000	
None – likely to cause an increase in crashes based on current traffic volumes	**Initial Capital Cost** $350,000	**Annual O&M Cost:** $5,000

Location:
Installing nine signs between the Kuebler and North Jefferson interchanges (approx. 6.75 miles)



Benefit:
- Improves travel time reliability
- Improves travel time
- Minimizes speed differential for travelers in the left lane

Related Strategy:
N/A

System Requirements:
ODOT already has the necessary software for part-time advisory signs. Field equipment is required.

Related Resources:
N/A

Dependencies:
- Power source location
- Communication assumes leased cellular services to each of the nine signs

Agency Resources and Partnerships necessary:
- ODOT staff hours to maintain signs
- Link district offices to TMC to view Electric Signs activity

6. CHAPTER 6 - OPERATIONAL CONCEPT

The I-5 operational concept recommends transportation system management and operations strategies to improve safety, commuter mobility, and freight mobility. These strategies, when used together, will create a more efficient and reliable travel experience. These include: traffic surveillance, ramp metering, incident information signs, and variable speeds with weather responsive system.

Traffic Surveillance (Estimated Initial Capital Cost: $630,000)

Traffic surveillance along the study corridor includes installing four new pan-tilt-zoom (PTZ) cameras and upgrading two existing cameras to PTZ cameras. The system will be used to monitor traffic incidents along the I-5 corridor. When incidents are reported, ODOT staff will be able to view, verify, and initiate response by using the cameras. Locations include:

Proposed Cameras:

1. South of Delaney Road interchange, positioned at hilltop
2. North Jefferson Interchange
3. South Jefferson Interchange
4. OR 99E Interchange

Upgrade to Existing Cameras:

1. Enchanted Forest
2. North of Murder Creek Drive

Proposed and upgraded cameras will be PTZ cameras that provide continuous video feed to the ODOT traffic management center (TMC) in Region 2. The cost estimate for this project assumed communications to the PTZ cameras will be via leased DSL services ($125/month/site). However, other communication options should also be considered. Leased DSL services may compromise PTZ capabilities due to limited bandwidth; further investigation is necessary. Camera installations are pending the availability of suitable cost effective communications.

Ramp Metering (Estimated Initial Capital Cost: $380,000)

A ramp meter will be installed at the Knox Butte/OR 99E interchange (Exit 234) to meter northbound traffic as it merges onto the freeway. The installation will be activated when mainline volumes reach a prescribed threshold, providing smoother flow for users.

Incident Information Signs (Estimated Initial Capital Cost: $1,440,000)

Dynamic message signs (DMS) will be placed strategically along the corridor to provide real-time information to drivers including incident information and travel times. Capturing travel time information requires installation of additional sensors (Bluetooth or radar) along the corridor not included in this cost estimate. The sensors could be installed with each strategy at a small incremental cost since power and communications will already be in place.

Proposed sign locations include:

1. North of Chemawa Interchange (for southbound traffic)
2. South of Delaney Interchange (for northbound traffic)
3. North of North Jefferson Interchange (for southbound traffic)

These new signs will be used in conjunction with the existing DMS located north of the Murder Creek Drive Interchange, which is positioned for northbound traffic. This strategy will allow drivers to respond to changes in traffic conditions and/or select alternative routes.

Variable Speed with Weather Responsive System

(Estimated Initial Capital Cost: $8,650,000)

The proposed variable speed installation will focus on a seven-mile segment from north of the Kuebler Boulevard interchange to north of the North Jefferson interchange. Seven overhead gantries will be installed and spaced strategically along the corridor to inform motorists when slower speeds are warranted due to current congestion or weather conditions. The cost estimate for this strategy assumes fiber installation along the project extents, since fiber offers the most reliable means of communication. Fiber is also the most expensive communication option, so if a different communication option is selected the project cost will likely decrease.

The system will monitor congestion, weather conditions, and the current grip factor on the roadway and post new speeds based on the current conditions. A queue warning system could also be implemented as part of this system, but is not part of this initial implementation.

During the next phase of project development, the project team will determine whether these signs will be regulatory or advisory. This decision may affect the communication needs of the project. If the displayed speeds are advisory, using leased services might be feasible.

Figure 6-1 shows how all four of these strategies will work together and the proposed locations along I-5.

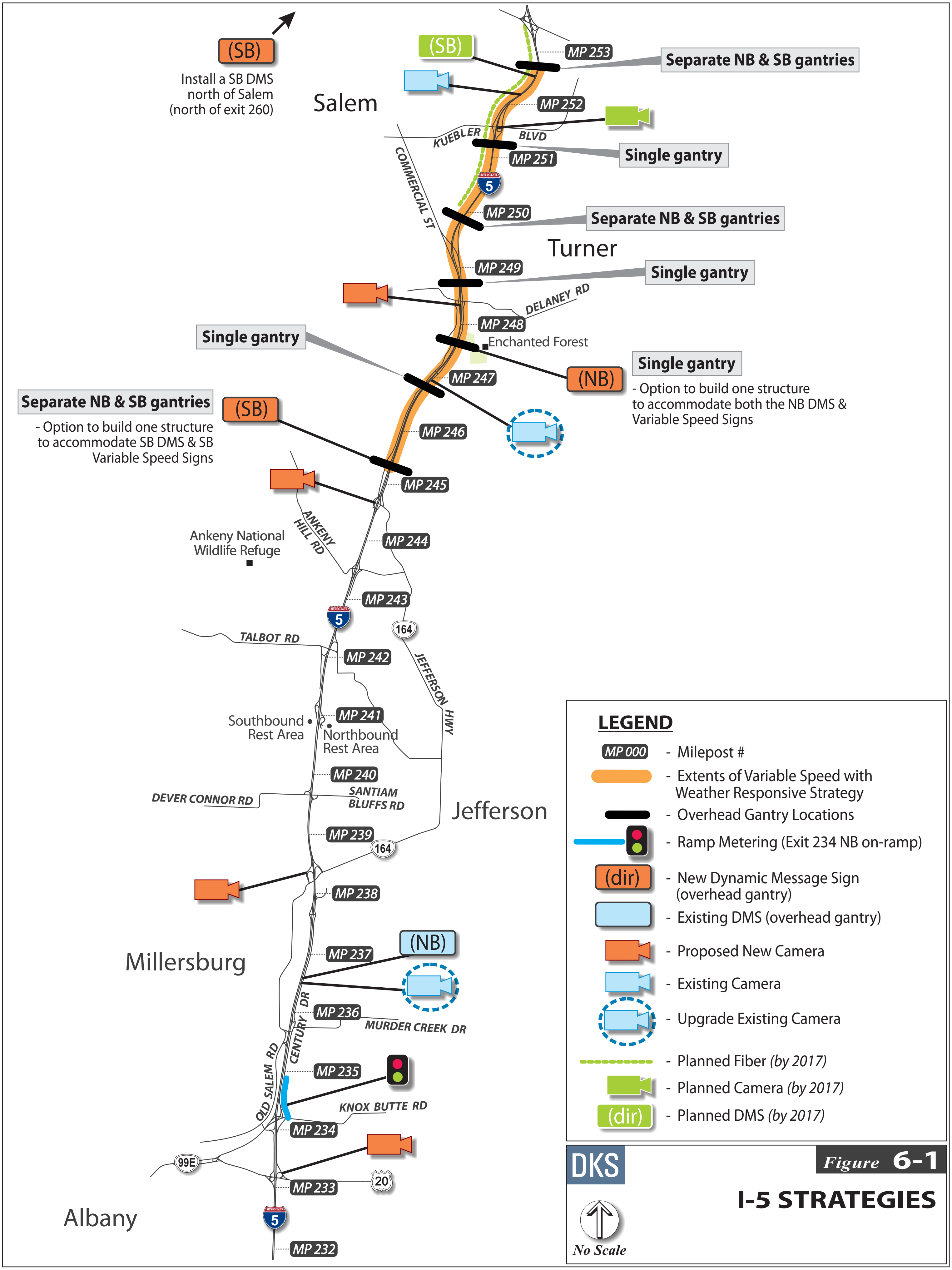


Figure 6-1
I-5 STRATEGIES

6.1 Functions

Implementation of the proposed system seeks to provide a set of key functions, which support the goals of improved safety and mobility within the corridor.

- Traffic Monitoring – The system will provide real-time traffic monitoring, which will be used to verify and respond to crashes. This will reduce crash clearance time, and thus reduce congestion and delay from non-recurring events. The surveillance feed will also be made available to the public, which will allow them to plan trips and routes more efficiently and reduce delay on the network.

- Opportunities to Reroute – Commuters and freight travel will have the opportunity to reroute when incidents occur or congestion is heavy. Rerouting is supported by the traffic surveillance, which if made public can allow drivers to self-select when to make trips. Rerouting is also supported by roadside information signs, which alert drivers to incidents on the roadway and provide travelers the opportunity to reroute, cutting down on travel time and congestion.

- Improved Traffic Flow – Improved traffic flow will result from the variable speed and ramp meter installations as part of the system upgrades. The variable speed components will adjust speeds in response to real-time congestion and weather conditions. This will reduce crashes and promote smoother travel. The ramp meter components will improve the northbound merge at Exit 234 to reduce congestion in this area and also improve traffic flow.

- Reduced Crashes – The components of the system will work in various ways to reduce crashes along the I-5 corridor. Ramp metering, variable speeds, and incident information all provide reductions in crashes, which improve safety and travel time.

- Reduced congestion – The components of the system will work to reduce congestion along the corridor by reducing crash clearance times, improving time of day travel selections, and reducing crashes near the Knox Butte northbound on-ramp.

6.2 System Needs

This section provides an overview of the basic system needs of each strategy including: capital improvements, maintenance, and software.

6.2.1 Capital Improvements

Capital improvements involve the construction and installation necessary to accommodate each of the strategies. Table 6-1 lists the field equipment and installation needs.

Table 6-1: Capital Improvements

Item	Comments
Cameras	• Install four new and upgrade two existing cameras to enable pan-tilt-zoom (PTZ) capabilities. • Upgrade two existing cameras with PTZ capabilities.
Gantries with Dynamic Message Signs (DMS)	• Three new installations with gantry supports (two southbound and one northbound) • Two of the proposed DMS locations could use the same gantries as the variable speed signs (near MP 245 and 248).
Gantries with Variable Speed Signs	• Seven overhead gantries with one variable speed sign per lane. • In some locations the gantries will span both northbound and southbound lanes, while in other locations a wide median allows for separate northbound and southbound gantry structures.
Ramp Meter	• One ramp meter installation for northbound on-ramp at Exit 234.
Communications	
Fiber	• Northern project limits for use on regulatory variable speeds. • Group with northern cameras and DMS installations
Leased Services	• Ramp meter location, southern cameras, and DMS • Northern cameras and DMS prior to installation of fiber
Power	• Power to all devices.

6.2.2 Maintenance and Operations

Maintenance and operation involve ongoing needs to support the functions of each strategy. Table 6-2 lists the operation and maintenance needs associated with each of the four strategies.

Table 6-2: Maintenance and Operation Needs

Strategy	Operation and Maintenance Needs
Traffic Surveillance	• ODOT dispatch and district maintenance staff hours to monitor cameras • ODOT ITS maintenance staff hours to maintain cameras • Implementation of ODOT's new Video Management Software in Region 2 to link district offices to TOC to view camera activity and to share video with external partners. • Leased communication services
Ramp Meter	• ODOT ITS maintenance and electrical staff hours to maintain ramp meter system. • ODOT Region 2 Traffic staff hours to operate ramp meter system • Link district offices to TOC to view ramp meter activity • Leased communication services
Roadside Information	• ODOT ITS maintenance staff hours to maintain DMS • Link district offices to TMC to view DMS activity • Leased communication services
Variable Speed with Weather Responsive System	• ODOT staff hours to maintain variable speed system and weather responsive system. • ODOT Region 2 Traffic staff hours to operate variable speed system • Link district offices to TOC to view variable speed and weather data.

6.2.3 Software Requirements and System Interfaces

Each component of the I-5 Optimization strategy requires specific software and system interfaces. ODOT has procured and/or developed the central system interfaces needed for the I-5 Optimization strategies as part of past projects. The systems are already designed as statewide systems, which mean these strategies can be installed without needing to procure new central systems, and can be installed at a significant cost savings. The following list describes the central systems that will be used to operate the I-5 Optimization strategies:

- Ramp Meter – System Wide Adaptive Ramp Metering (SWARM2) software
- Variable Speed – Oregon statewide variable speed software
- Traffic surveillance – Chameleon video monitoring and control software
- DMS – DMS control and message queue manager software

6.3 Project Stakeholders – Roles and Responsibilities

Table 6-3 lists the roles and responsibilities of each stakeholder associated with the proposed strategies.

6.4 Architecture

Figure 6-2 shows the high level system architecture for the four recommended strategies. This diagram illustrates that ODOT already has the central monitoring and control systems necessary for each strategy. The field equipment is the only necessary investment to implement each strategy.

Table 6-3: Roles and Responsibilities related to the I-5 Optimization Strategies

Stakeholder	Roles and Responsibilities	Status
ODOT TOC	Operate Region 2 Traffic Operations Center (TOC)	Existing
	Operate the ODOT cameras	Existing
	Dispatch incident responders and maintenance crews	Existing
	Manage information on Dynamic Message Signs (DMS)	Existing
	Dispatch response to variable speed with weather responsive system failures and implement manual override when requested	**Future**
ODOT ITS	Oversee ITS project implementation	Existing
	Design ITS projects	Existing
	Configure ITS equipment (cameras, DMS, ramp meter, variable speed, and detection)	Existing
	Maintain the ITS equipment (cameras, DMS, ramp meter, variable speed, and detection)	Existing
ODOT Region 2 Management Team	Oversee selection and implementation of the 12 non-capital strategies recommended for ODOT internal evaluation	Existing
ODOT Region 2 Traffic	Monitor ODOT cameras and coordinate with ODOT Region 2 Maintenance when events occur	Existing
	Operate Variable Speed System	**Future**
	Operate ramp meter	**Future**
	Operate dynamic message signs	Existing
ODOT Region 2 Maintenance	Respond to incidents	Existing
Information Service Providers	Subscribe to ODOT Trip Check	Existing
Travelers	Report incidents	Existing
	Request traveler information	Existing
Media	Broadcast traveler information (video, incidents, maintenance activities, etc.)	Existing

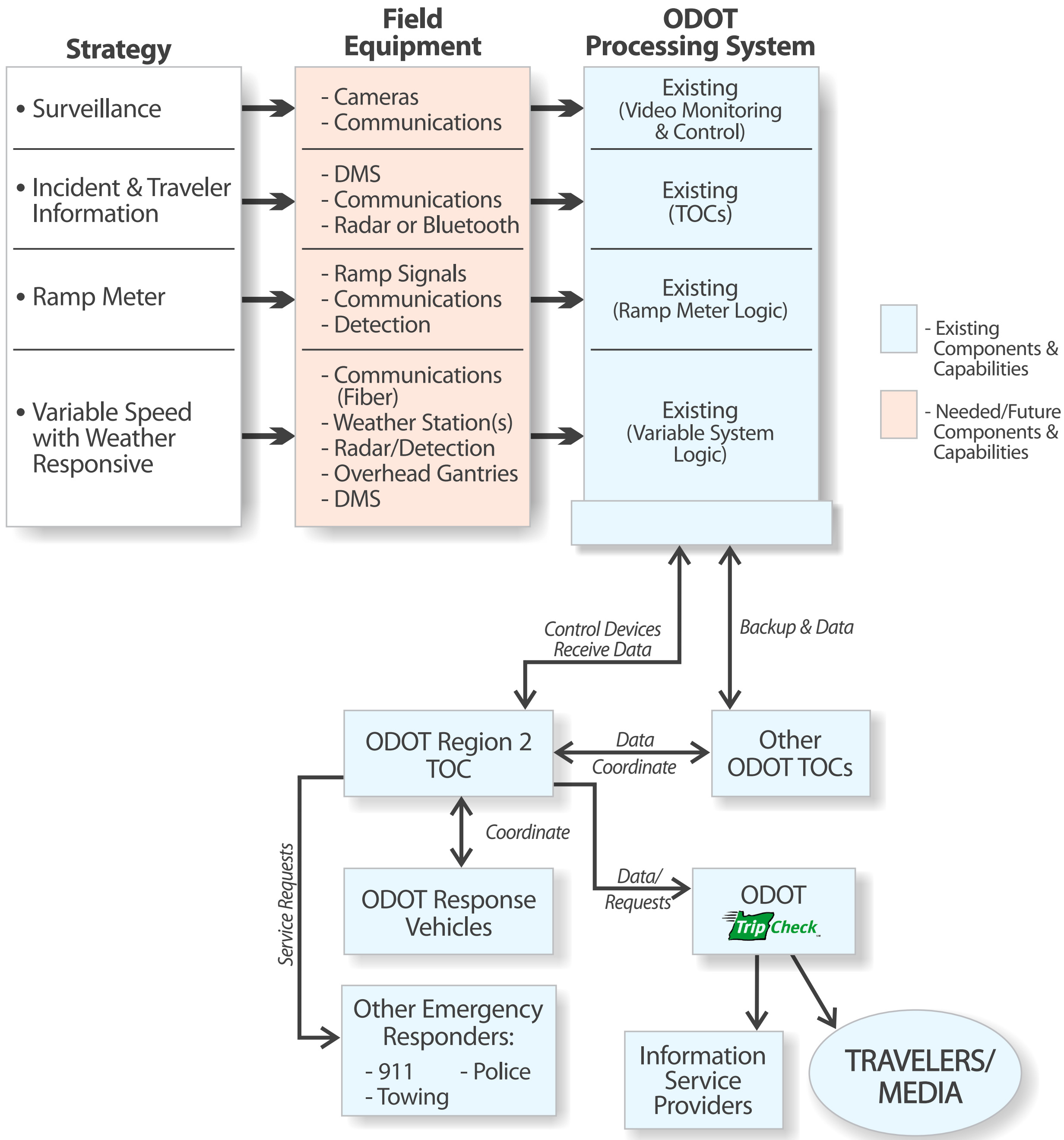


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Figure 6-2

ARCHITECTURE DIAGRAM
I-5 OPTIMIZATION STRATEGIES

6.5 Sequencing Considerations

Project sequencing recommendations are based on potential cost savings and efficiencies achieved by installing multiple strategies in a specific order.

6.5.1 Suggested Phasing

Simultaneous installation of the four components of the system is most beneficial as it results in a fiber communications backbone that can be used by all ITS elements, with the exception of the Exit 234 ramp meter. However, if funding is not available to develop all components at once, then the components will need to be installed in phases. If the components are installed sequentially, the cameras and DMS at the north end will need to use leased communication services until the fiber (required for the variable speed system) is installed.

If the components need to be phased, we recommend the following project order:

1. **Surveillance** – This component offers high benefits along an extensive section of the study area with a moderate cost, and will be relatively quick to implement. Surveillance supports faster recognition and clearance of crashes which account for 30 percent of the delay experienced by drivers along this I-5 study corridor. Prior to implementing the variable speed with weather responsive system, the cameras will need to use suitable cost effective communications.

   2. The cost estimate for this project assumed leased DSL services ($125/month/site), however, that may not provide enough bandwidth for full PTZ capabilities. Further investigation is required and other options including point-to-point Ethernet services, or wireless communications should be considered. Once fiber is installed along the north end of the study area, the PTZ cameras along that stretch of I-5 should be connected to fiber communications.

   3. Estimated Initial Capital Cost: $630,000

4. **Ramp Meter (NB Ext 234 on-ramp)** - This component also offers high benefits with a relatively low cost, and will be quick to implement. The area just north of Exit 234 experiences recurring congestion. Installing the ramp meter will improve flow along the mainline and reduce crashes in the vicinity of the on-ramp. The benefits of reducing crashes, even at a localized area, benefits all traffic on I-5 by reducing bottlenecks and delay caused by crashes. Since there is no existing fiber in the Albany area, this project should use leased services, which makes the project easier and quicker to implement than if fiber were required.

   5. Estimated Initial Capital Cost:: $380,000

6. **Incident Information Signs** – The three new DMS for displaying incident information (and travel time information when not in use for incidents) are recommended as the third sequencing of projects due to its complexity. This project requires simultaneous design development with the variable speed project to ensure that two of the sign gantries can accommodate both strategies. Prior to implementing the variable speed strategy, the DMS will be connected via leased communications. Once the variable speed project is installed the DMS along the shared corridor will be connected to fiber communications.

    7. Estimated Initial Capital Cost: $1,440,000

8. **Variable Speeds with Weather Responsive System** – The key to implementing the variable speed system is constructing the fiber communication infrastructure. Due to the extensive infrastructure needs for this strategy, it is the most complex of the four recommended strategies and has the highest initial capital cost of approximately $8.7 million. While the other strategies can all operate using leased communication services (or other more cost effective methods), a fiber connection was assumed for this project due to reliability needs. Once funding is available for complete fiber installation along the project corridor, the variable speed with weather responsive system can be installed. Ultimately, all ITS devices along the variable speed corridor should connect to the fiber.

    9. Estimated Initial Capital Cost: $8,650,000

6.5.2 Communications Overlap

At the north end of the study area, fiber should be installed along the extents of the variable speed project. The cameras and DMS within that stretch of I-5 (including the camera at the North Jefferson interchange) should connect into the fiber system once that is available. However, based on the sequencing recommendations, the variable speed system will likely be constructed after the other strategies. Prior to installing the fiber communications line, the cameras and DMS should use leased communication services or other cost effective communication that meets the capabilities of the respective equipment.

South of mile post 244, there is no proposed fiber installation. We recommend all equipment installed along the southern portion of the project area use leased communication services, including the ramp meter at exit 234.

6.5.3 Infrastructure Overlap

There are two locations were DMS and variable speed gantry locations overlap:

- Just south of MP 248 at Enchanted Forest
- Just south of MP 247

At these two locations the gantry structure should be built to accommodate both a DMS and variable speed signs over each lane.

Cameras should ideally be installed on independent poles that optimize viewing capabilities with a 50 foot mounting height.

7. CHAPTER 7: NEXT STEPS

This chapter discusses the next steps for implementing each of the strategies, and specifically references some unknowns at this stage that require further investigation as part of a high level design. The high level design for each strategy would identify equipment locations, availability of power and communications, and any potential conflicts.

7.1 Surveillance

For cost estimating purposes, high-speed leased services are assumed ($125/month/site) for the PTZ cameras discussed in this concept of operations. However, the availability of leased services has not been thoroughly investigated at this stage and limited leased service options may compromise some of the camera capabilities due to limited bandwidth. In some cases, limited camera capability (such as still images refreshed every few seconds and delayed panning capabilities) may still meet the project needs.

As this project proceeds, additional communication options for the PTZ cameras should be evaluated, such as point-to-point Ethernet services and wireless options. The installation of PTZ cameras will be pending availability of suitable cost effective communications.

7.2 Ramp Meter

In addition to installing the ramp meter for the northbound Exit 234 on-ramp, this project should consider adding a PTZ camera. The camera will provide a way to monitor the ramp meter operations as well as the surrounding area. Since the project will be installing power and communications, the camera could be installed and connected to the system relatively easily. Assuming the camera is installed on a pole of its own, the addition of a camera, pole, foundation, and electronics will cost approximately $50,000.

7.3 Incident Information Signs

In addition to displaying incident information, these signs should also be used to display travel time information when not in use for an incident. To display travel time information, sensors such as Bluetooth or radar need to be installed along I-5.

Before implementing any of the projects, we advise deciding whether to add sensors at some or all of the project locations. The four recommended strategies do not include sensors, but adding sensors would be a small incremental cost since each of the strategies will already have power and communications in place that the sensors could use.

7.4 Variable Speeds with Weather Responsive System

ODOT will need to determine whether the variable speeds signs will be regulatory or advisory. The variable speed project assumes fiber communications due to reliability needs. However, leased services may be an option, especially if the signs are used for advisory speeds instead of regulatory speeds. As this project progresses, other communication options, such as leased services, should be considered for the variable speed system.

Also, a variable speed study defined in OAR 734-020-018 *Establishment of Variable Speeds Zones* will need to be completed, and approval from the state traffic engineer is required.

7.5 ODOT Strategies for Internal Review

In addition to the four strategies detailed in this document, ODOT should evaluate the 12 strategies recommended for internal review and implement those deemed appropriate as funding is available.

APPENDIX A

I-5 Optimization Study

Benefit Cost Analysis

DKS

I-5 Optimization Study
Appendix A
June 10, 2014

SUMMARY

Strategy	B/C Ratio		Annual Benefit		Initial Capital Cost	Annual O&M Cost	Overall Annual Cost
Variable Speeds with Weather Responsive System	0.93		$420,000		$8,650,000	$60,000	$450,000
Ramp Metering - Exit 252	2.41		$118,000		$670,000	$10,000	$49,000
Ramp Metering - Exit 234	5.59		$162,000		$380,000	$5,000	$29,000
Electronic Truck Lane Use Signs	n/a		$0		$350,000	$5,000	$24,000
DMS Roadside Information - Incident Information	3.08		$237,000		$1,440,000	$15,000	$77,000
DMS Roadside Information - Travel Times	0.16		$12,000				
Traffic Surveillance	6.60		$284,000		$630,000	$10,000	$43,000
Northbound Auxiliary Lane	0.37		$128,000		$8,160,000	$15,000	$342,000
Chain Up and Chain Removal Areas (Northbound)	n/a		$0		$1,820,000	$5,000	$78,000
Hard Running Shoulder (Southbound)	0.12		$223,000		$45,760,000	$75,000	$1,906,000

DKS

Variable Speeds with Weather Responsive System

B/C 0.93

COST ESTIMATE

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST	USEFUL LIFE (Years)	ANNUALIZED COST
Fiber Communication Line	FT	52800	$50	$2,640,000	25	$105,600
Weather Station	EA	1	$40,000	$40,000	25	$1,600
Variable Message Sign	EA	28	$20,000	$560,000	25	$22,400
Gantry Tower (~every mile)	EA	7	$125,000	$875,000	25	$35,000
Speed Signal Controller	EA	7	$88,000	$616,000	25	$24,640
Radar Detectors (~every 1/2 mile)	EA	14	$15,000	$210,000	10	$52,500
				$0		
				$0		
SUBTOTAL				$4,941,000		
Design	%	20%		$988,200		$39,528
Construction Engineering	%	15%		$741,150		$29,646
Contingency	%	40%		$1,976,400		$79,056

TOTAL - Initial Capital Cost	**$8,646,750**
ROUNDED	**$8,650,000**
Annual Operations and Maintenance Cost	**$60,000**
Annualized Cost over 25 years*	**$449,970**
ROUNDED	**$450,000**

*Takes into account useful life of equipment as well as annual O&M costs

RESOURCES

FHWA - TOPS-BC Version 1.0

CMF ID 3340: Bham, G. H., Long, S., Baik, H., Ryan, T., Gentry, L., Lall, K., Arezoumandi, M., Liu, D., Li, T., and Schaeffer, B., “Evaluation of Variable Speed Limits on I-270/I-255 in St. Louis.” RI08-025, Missouri University of Science and Technology, Rolla, MO., (2010). Website Accessed April 10, 2014: http://www.cmfclearinghouse.org/study_detail.cfm?stid=233

CMF ID 4114– Zhirui, Y., Veneziano, D., Turnbull, I., “Safety Effects of Icy Curve Warning Systems.” Presented at the 91st Annual Meeting of the Transportation Research Board, Paper No. 12-0985, Washington, D.C., (2012) Website Accessed April 10, 2014:

BENEFITS ESTIMATE

Variable Speeds

7-8% crash rate reduction due to variable speeds

Crash Type	Average Annual Number	Cost	Reduction	Savings
FATAL	0.60	$ 6,500,000.00	7%	$ 273,000
Injury	21.40	$ 67,000.00	7%	$ 100,366
PDO	28.60	$ 2,300.00	7%	$ 4,605
BENEFIT FROM VARIABLE SPEEDS				$ 377,971

Crashes Reduced Annually: 3.54

Weather Responsive

10% reduction in weather related crashes

Crash Type	Average Annual Number	Cost	Reduction	Savings
FATAL	0.00	$ 6,500,000.00	10%	$ -
Injury	5.80	$ 67,000.00	10%	$ 38,860
PDO	9.60	$ 2,300.00	10%	$ 2,208
BENEFIT				$ 41,068
	15.40			1.54
TOTAL BENEFITS				$ 419,039
ROUNDED				**$420,000**

Crash rate reduction approx. 7%-8%· (variable speeds)

Additional crash rate reduction (up to 18%) and delay due to weather responsive system - assumed 10% for this analysis

Five Years of Crash data (2008-2012) between mile posts 246-252:
253 total crashes – 33% rear ends, 40% fixed object
Severity – 1% fatal (3), 42% injury (107), and 57% PDO (143)
Annual Crashes Reduced = 3.5

DKS

Ramp Metering - Exit 252

COST ESTIMATE (per ramp)

B/C 2.41

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST	USEFUL LIFE (Years)	ANNUALIZED COST
TMC Hardware for Freeway Control	EA	1	$22,500	$22,500	10	$5,625
Fiber Communication Line	FT	3500	$50	$175,000	25	$7,000
Controller	EA	2	$4,000	$8,000	25	$320
Ramp Meter (Signal, foundation)	EA	4	$35,000	$140,000	25	$5,600
Wavetronics (includes power connection)	EA	2	$15,000	$30,000	10	$7,500
Advance Signs - "Ramp Signal On"	EA	4	$1,000	$4,000	10	$1,000
SUBTOTAL				$379,500		
Design	%	20%		$75,900		$3,036
Construction Engineering	%	15%		$56,925		$2,277
Contingency	%	40%		$151,800		$6,072

TOTAL - Initial Capital Cost	**$664,125**
ROUNDED	**$670,000**
Annual Operations and Maintenance Cost	**$10,000**
Annualized Cost over 25 years*	**$48,430**
ROUNDED	**$49,000**

*Takes into account useful life of equipment as well as annual O&M costs

RESOURCES

FHWA - TOPS-BC Version 1.0

[1] CMF ID 5436: Liu, C.and Wang, Z., "Ramp Metering Influence on Freeway Operational Safety near On-ramp Exits." International Journal of Transportation Science and Technology, Vol.2, No.2, Multi Science Publishing, (2013) pp.87-94. Website Accessed April 16, 2014: http://www.cmfclearinghouse.org/study_detail.cfm?stid=342

BENEFIT ESTIMATE (per ramp)

EXIT 252

36% reduction in crashes near on ramps

Crash Type	Average Annual Number	Cost	Reduction	Savings
FATAL	0.00	$ 6,500,000.00	36%	$ -
Injury	1.20	$ 67,000.00	36%	$ 28,944
PDO	1.60	$ 2,300.00	36%	$ 1,325
BENEFIT FROM RAMP METER AT EXIT 252				$ 30,269

Crashes Reduced Annually: 1.01

10% Fuel Reduction (TOPS-BC)	$37,000
10% Improvement freeway capacity and travel time reduction (TOPS-BC)	$50,000
TOTAL BENEFIT FOR EXIT 252	$ 117,269
ROUNDED	**$118,000**

Up to a 36% reduction in crashes near on-ramps
Improve freeway capacity by 10%
Variable Speeds with Weather Responsive System

Ramp Metering - Exit 234

COST ESTIMATE (per ramp)

B/C 5.59

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST	USEFUL LIFE (Years)	ANNUALIZED COST
TMC Hardware for Freeway Control	EA	1	$22,500	$22,500	10	$5,625
Fiber Communication Line	FT	2000	$50	$100,000	25	$4,000
Controller	EA	1	$4,000	$4,000	25	
Ramp Meter (Signal, foundation, etc)	EA	2	$35,000	$70,000	25	$2,800
Wavetronics (includes power connection)	EA	1	$15,000	$15,000	10	$3,750
Advance Signs	EA	2	$1,000	$2,000	10	$500
SUBTOTAL				$213,500		
Design	%	20%		$42,700		$1,708
Construction Engineering	%	15%		$32,025		$1,281
Contingency	%	40%		$85,400		$3,416

TOTAL - Initial Capital Cost	**$373,625**
ROUNDED	**$380,000**
Annual Operations and Maintenance Cost	**$5,000**
Annualized Cost over 25 years*	**$28,080**
ROUNDED	**$29,000**

*Takes into account useful life of equipment as well as annual O&M costs

RESOURCES

FHWA - TOPS-BC Version 1.0

[1] CMF ID 5436: Liu, C.and Wang, Z., "Ramp Metering Influence on Freeway Operational Safety near On-ramp Exits." International Journal of Transportation Science and Technology, Vol.2, No.2, Multi Science Publishing, (2013) pp.87-94. Website Accessed April 16, 2014: http://www.cmfclearinghouse.org/study_detail.cfm?stid=342

BENEFIT ESTIMATE (per ramp)

EXIT 234

36% reduction in crashes near on ramps

Crash Type	Average Annual Number	Cost	Reduction	Savings
FATAL	0.00	$ 6,500,000.00	36%	$ -
Injury	1.20	$ 67,000.00	36%	$ 28,944
PDO	1.20	$ 2,300.00	36%	$ 994
BENEFIT FROM RAMP METER AT EXIT 234				$ 29,938

Crashes Reduced Annually: 0.86

10% Fuel Reduction (TOPS-BC)	$42,000
10% Improvement freeway capacity and travel time reduction (TOPS-BC)	$90,000
TOTAL BENEFIT FOR EXIT 252	$ 161,938
ROUNDED	**$162,000**

Up to a 36% reduction in crashes near on-ramps
Improve freeway capacity by 10%**Variable Speeds with Weather Responsive System**

DKS

Electronic Truck Lane Use Signs

COST ESTIMATE							B/C n/a	BENEFITS ESTIMATE

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST	USEFUL LIFE (Years)	ANNUALIZED COST
332 Controller Cabinet w/o controller	EA	9	$8,700	$78,300	25	$3,132
Service Cabinet/Meter Base (ODOT BMCL)	EA	9	$5,100	$45,900	25	$1,836
Vehicle Pedestal	EA	9	$1,750	$15,750	25	$630
Controller Cabinet Foundation	EA	9	$780	$7,020	25	$281
Service Cabinet Foundation	EA	9	$780	$7,020	25	$281
Vehicle Pedestal Foundation	EA	9	$1,300	$11,700	25	$468
PTR Sign: 36" X 36" (LED)	EA	9	$2,650	$23,850	25	$954
ODOT Type 3 Junction Box	EA	9	$265	$2,385	25	$95
Communications - Leased Cellular	EA	9	$600	$5,400	1	$5,400
				$0		
				$0		
				$0		
				$0		
SUBTOTAL				$197,325		
Design	%	20%		$39,465		$1,579
Construction Engineering	%	15%		$29,599		$1,184
Contingency	%	40%		$78,930		$3,157

TOTAL - Initial Capital Cost	**$345,319**
ROUNDED	**$350,000**
Annual Operations and Maintenance Cost	**$5,000**
Annualized Cost over 25 years*	**$23,997**
ROUNDED	**$24,000**

*Takes into account useful life of equipment as well as annual O&M costs

NONE

Increase of 28% in crashes (all types, all severities) from mitigation - this study found that when the daily traffic volume per lane was greater than 10,000 vehicles, this strategy results in an increase in crashes. When traffic volumes are less than 10,000 vehicles per day per lane, a decrease in crashes was reported. Through this study area there are approximately 15,000 vehicles per day per lane.

RESOURCES

CMF ID 1925: Fontaine, M.D., C.S. Bhamidipati, and L.E. Douglad, "Safety Impact of Truck Lane Restrictions on Multilane Freeways." TRB 88th Annual Meeting Compendium of Papers CD-ROM. Washington, D.C., (2009). Website Accessed May 1, 2014: http://www.cmfclearinghouse.org/study_detail.cfm?stid=103

DMS Roadside Information - Incident Information

B/C 3.078

COST ESTIMATE

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST	USEFUL LIFE (Years)	ANNUALIZED COST
Communications - Leased DSL installation	EA	3	$50,000	$150,000	25	$6,000
Communications - Leased DSL annual fee	EA	3	$1,500	$4,500	1	$4,500
Variable Message Sign	EA	3	$92,500	$277,500	25	$11,100
Variable Message Sign Support	EA	3	$125,000	$375,000	25	$15,000
Controller	EA	3	$5,000	$15,000	25	$600
				$0		
				$0		
SUBTOTAL				$822,000		
Design	%	20%		$164,400		$6,576
Construction Engineering	%	15%		$123,300		$4,932
Contingency	%	40%		$328,800		$13,152

TOTAL - Initial Capital Cost	**$1,438,500**
ROUNDED	**$1,440,000**
Annual Operations and Maintenance Cost	**$15,000**
Annualized Cost over 25 years*	**$76,860**
ROUNDED	**$77,000**

*Takes into account useful life of equipment as well as annual O&M costs

RESOURCES

FHWA - TOPS-BC Version 1.0

[1] CMF ID: 75, Elvik, R. and Vaa, T., "Handbook of Road Safety Measures." Oxford, United Kingdom, Elsevier, (2004). Website: http://www.cmfclearinghouse.org/detail.cfm?facid=75

BENEFITS ESTIMATE

CRASH REDUCTION SAVINGS

Crash Type	Average Annual Number	Cost	Reduction	Savings
Injury A	0.80	$ 67,000.00	5%	$ 2,680
Injury B/C	56.40	$ 67,000.00	5%	$ 188,940
				$ -
BENEFIT FROM CRASH REDUCTION				**$ 191,620**

Crashes Reduced Annually: 2.86

DELAY REDUCTION BENEFIT

	Percent fleet	Cost	travel time savings (hr)	Recurring travel time benefit per peak hour
trucks and on-the-clock autos	0.35	28	0.1	0.98
passenger vehicles	0.65	14	0.1	0.91

Peak Hour Vehicles (both directions, ~3000 per direction)	6000
Lane closure events per year that last longer than 1 hour	40
Percent of vehicles that reroute (and save 6 minutes)	10%

TOTAL DELAY REDUCTION SAVINGS	$45,360
TOTAL BENEFIT	**$236,980**
ROUNDED	**$237,000**

Crash reduction benefits:
44% reduction in injury crashes (all types). This relates to a reduction of 25 injury crashes per year in the study area. However, this estimate seems unreasonable and likely only applies to a reduction in secondary crashes (the study does not clarify). As a conservative estimate, if this strategy reduced injury crashes by 5%, that results in an annual benefit of $190,000

Delay reduction benefits
Within the study area there is an average of 40 incidents per year that close a lane for an hour or longer (not related to construction or maintenance activities)
Assumes 10% of drivers act on the information
Assumes average time saved by drivers acting on information is 6 minutes (signs must be in locations such that drivers may choose an alternate route)
Results in $45,000 annual savings

DKS

DMS Roadside Information - Travel Times

B/C 0.156

COST ESTIMATE

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST	USEFUL LIFE (Years)	ANNUALIZED COST
Communications - Leased DSL installation	EA	3	$50,000	$150,000	25	$6,000
Communications - Leased DSL annual fee	EA	3	$1,500	$4,500	1	$4,500
Variable Message Sign	EA	3	$92,500	$277,500	25	$11,100
Variable Message Sign Support	EA	3	$125,000	$375,000	25	$15,000
Controller	EA	3	$5,000	$15,000	25	$600
				$0		
				$0		
				$0		
SUBTOTAL				$822,000		
Design	%	20%		$164,400		$6,576
Construction Engineering	%	15%		$123,300		$4,932
Contingency	%	40%		$328,800		$13,152

TOTAL - Initial Capital Cost	**$1,438,500**
ROUNDED	**$1,440,000**
Annual Operations and Maintenance Cost	**$15,000**
Annualized Cost over 25 years*	**$76,860**
ROUNDED	**$77,000**

*Takes into account useful life of equipment as well as annual O&M costs

BENEFITS ESTIMATE

DELAY REDUCTION BENEFIT

	Percent fleet	Cost	travel time savings (hr.)	
trucks and on-the-clock autos	0.35	28	0.1	0.98
passenger vehicles	0.65	14	0.1	0.91

Peak Hour Vehicles (both directions, ~3000 per direction)	6000
Planned Events that Cause Significant (> 1hr delay) per year	10
Percent of vehicles that reroute (and save 6 minutes)	10%

TOTAL DELAY REDUCTION SAVINGS	$11,340
ROUNDED	**$12,000**

Crash reduction benefits:
none

Delay reduction benefits
Assumes vehicles may choose to reroute when an event occurs (such as football game congestion).
Over a year, approx. 10 events occur that last longer than 1 hour. On average we assume rerouted drivers save 6 minutes (0.1 hour).
10% of drivers act on information.

RESOURCES

FHWA - TOPS-BC Version 1.0

[1] CMF ID: 75, Elvik, R. and Vaa, T., "Handbook of Road Safety Measures." Oxford, United Kingdom, Elsevier, (2004). Website: http://www.cmfclearinghouse.org/detail.cfm?facid=75

DKS

Traffic Surveillance

COST ESTIMATE

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST	USEFUL LIFE (Years)	ANNUALIZED COST
332 Controller Cabinet w/o controller	EA	4	$8,700	$34,800	25	$1,392.00
Service Cabinet/Meter Base (ODOT BMCL)	EA	4	$5,100	$20,400	25	$816.00
Controller Cabinet Foundation	EA	4	$780	$3,120	25	$125
Service Cabinet Foundation	EA	4	$780	$3,120	25	$125
Camera Pole: 45' and foundation	EA	1	$21,200	$21,200	25	$848.00
Camera Lowering Device	EA	4	$7,400	$29,600	25	$1,184.00
PTZ Dome: Pelco 26x Analog Standard Definition	EA	4	$5,141	$20,564	10	$2,056
Single Channel Video Encoder (TXB-IP-P)	EA	4	$1,172	$4,688	10	$469
Camera Mounting Hardware (Pole Attachment)	EA	4	$275	$1,100	10	$110
ODOT Type 3 Junction Box	EA	4	$265	$1,060	25	$42.40
Upgrade existing camera	EA	2	$5,000	$10,000	10	$1,000.00
Communications - Leased DSL installation	EA	4	$50,000	$200,000	25	$8,000
Communications - Leased DSL annual fee	EA	4	$1,500	$6,000	1	$6,000
				$0		
SUBTOTAL				$355,652		
Design	%	20%		$71,130		$2,845
Construction Engineering	%	15%		$53,348		$2,134
Contingency	%	40%		$142,261		$5,690

TOTAL - Initial Capital Cost	**$622,391**
ROUNDED	**$630,000**
Annual Operations and Maintenance Cost	**$10,000**
Annualized Cost over 25 years*	**$42,837**
ROUNDED	**$43,000**

*Takes into account useful life of equipment as well as annual O&M costs

RESOURCES

FHWA - TOPS-BC Version 1.0
Efficiency Impact for Incident Management Systems: Incident Detection/Verification

B/C
6.605

BENEFITS ESTIMATE

Incident Information - 4 Years of Data

Type	Number	Duration (min)	Duration (hrs.)
Crash	1324	16455	274.25
Fatal Crash	7	921	15.35
Total	1331	17376	289.6
Average Annual	332.75	4344	72.4
10% reduction (faster incident detection and clearance)	0.1	434.4	7.24

DELAY REDUCTION BENEFIT

	Percent fleet	Cost	Annual Peak Hr. travel time savings (hr.)	Savings
trucks and on-the-clock autos	0.35	$28	2.5	$25
passenger vehicles	0.65	$14	2.5	$23
Total Recurring Travel Time Benefit per period				$47
Peak Hour Vehicles (both directions, ~3000 per direction)		6000		

TOTAL DELAY REDUCTION SAVINGS	$283,500
ROUNDED	**$284,000**

Reduce Incident duration between 2% and 10%

Based on incident data for the study corridor, the annual duration for all crash related incidents is 72.4 hours. A 10% reduction results in 7.2 hours of savings annually. **As a conservative estimate, 2.5 hours of reduced incident duration likely occurs during peak hours** which results in approximately $225,000 in annual savings related to decreased delay.

Reduce incident response time
Reduce incident clearance time
Reduce delay

Northbound Auxiliary Lane

COST ESTIMATE

B/C 0.374

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST	USEFUL LIFE (Years)	ANNUALIZED COST
New Pavement (includes base)	SF	126720	$21	$2,661,120	25	$106,444.80
Environmental Assessment	LS	1	$500,000	$500,000	25	$20,000.00
Temporary Traffic Control	LS	1	$500,000	$500,000	25	$20,000.00
Mitigation - Miller Creek	LS	1	$1,000,000	$1,000,000	25	$40,000.00
				$0		
				$0		
Assumes NO R/W Acquisition				$0		
Contingent - Enchanted Way Realignment				$0		
				$0		
				$0		
				$0		
				$0		
				$0		
SUBTOTAL				$4,661,120		
Design	%	20%		$932,224		$37,289
Construction Engineering	%	15%		$699,168		$27,967
Contingency	%	40%		$1,864,448		$74,578

TOTAL - Initial Capital Cost	**$8,156,960**
ROUNDED	**$8,160,000**

Range
$5 to $10 Million

Annual Operations and Maintenance Cost	**$15,000**

Annualized Cost over 25 years*	**$341,278**
ROUNDED	**$342,000**

*Takes into account useful life of equipment as well as annual O&M costs

BENEFITS ESTIMATE

DELAY REDUCTION BENEFIT

	Percent fleet	Cost	Average Person Hours of Travel Saved per Period*	Savings
trucks and on-the-clock autos	0.35	$28	10.7	$105
passenger vehicles	0.65	$14	10.7	$97
Total Recurring Travel Time Benefit per period				$202
Periods per year	250			

TOTAL DELAY REDUCTION SAVINGS	$50,558
ROUNDED	**$51,000**

*Accounts for VMT (see TOPS-BC tool)

Fuel/Emissions Reduction of 10%	$77,000

TOTAL BENEFIT	**$128,000**

Additional capacity and travel time savings, when using the third lane as a travel lane (not a chain-up area) result in approximately $35,000 of benefits per year.

There is no research that indicates chain-up areas reduce crashes.

RESOURCES

FHWA - TOPS-BC Version 1.0

DKS

Chain Up and Chain Removal Areas (Northbound)

COST ESTIMATE							B/C n/a	BENEFITS ESTIMATE

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST	USEFUL LIFE (Years)	ANNUALIZED COST
New Pavement (includes base)	SF	37500	$21	$787,500	25	$31,500
				$0		
Temporary Traffic Control	LS	1	$250,000	$250,000	25	$10,000
				$0		
				$0		
				$0		
Assumes NO R/W Acquisition				$0		
				$0		
				$0		
SUBTOTAL				$1,037,500		
Design	%	20%		$207,500		$8,300
Construction Engineering	%	15%		$155,625		$6,225
Contingency	%	40%		$415,000		$16,600

TOTAL - Initial Capital Cost	**$1,815,625**
ROUNDED	**$1,820,000**

Annual Operations and Maintenance Cost	**$5,000**

Annualized Cost over 25 years*	**$77,625**
ROUNDED	**$78,000**

*Takes into account useful life of equipment as well as annual O&M costs

There is no research that shows chain-up areas reduce crashes or traveler delay

RESOURCES

FHWA - TOPS-BC Version 1.0

DKS

Hard Running Shoulder (Southbound)

COST ESTIMATE

B/C
0.117

ITEM	UNIT	QUANTITY	UNIT COST	ITEM COST	USEFUL LIFE (Years)	ANNUALIZED COST
Excavation	CY	21761	$35	$761,650	25	$30,465.99
Aggregate Base	CY	21761	$35	$761,650	25	$30,465.99
Paving	TON	7040	$150	$1,056,000	25	$42,240.00
Striping	LF	42240	$2	$84,480	25	$3,379.20
Remove and relocate barrier	LF	2175	$70	$152,250	25	$6,090.00
Retaining wall	SF	14000	$66	$930,020	25	$37,200.80
Bridge - new or replace	SF	825	$25,000	$20,625,000	25	$825,000.00
Gantry	EA	8	$75,000	$600,000	25	$24,000.00
LED Sign	EA	8	$2,450	$19,600	25	$784.00
Communications - Fiber installation	FT	23120	$50	$1,156,000	25	$46,240
				$0		
				$0		
				$0		
SUBTOTAL				$26,146,650		
Design	%	20%		$5,229,330		$209,173
Construction Engineering	%	15%		$3,921,997		$156,880
Contingency	%	40%		$10,458,660		$418,346

TOTAL - Initial Capital Cost	**$45,756,637**
ROUNDED	**$45,760,000**
Annual Operations and Maintenance Cost	**$75,000**
Annualized Cost over 25 years*	**$1,905,265**
ROUNDED	**$1,906,000**

*Takes into account useful life of equipment as well as annual O&M costs

NOTES
1 CY - 2.025 TONS
~$40 per foot to install new barrier
Battlecreek, OR99E overpasses + Delaney underpass

BMP	EMP	length	Existing Shoulder Width (FT)	Additional needed for 12' lane + 6' shoulder
251.5	251.42	0.08	12	6
251.42	248.92	2.5	10	8
248.92	248.3	0.62	6	12
248.3	247.5	0.8	10	8

Benefits Estimate

DELAY REDUCTION BENEFIT

	Percent fleet	Cost	Average Person Hours of Travel Saved per Period*	Savings
trucks and on-the-clock autos	0.35	$28	15.4	$151
passenger vehicles	0.65	$14	15.4	$140
Total Recurring Travel Time Benefit per period				$291
Periods per year	250			

TOTAL DELAY REDUCTION SAVINGS	$72,765
ROUNDED	$73,000

*Accounts for VMT (see TOPS-BC tool)

Fuel/Emissions Reduction of 10%	$150,000
TOTAL BENEFIT	**$223,000**

In TOPS-BC hard running shoulders increases the number of available lanes by 0.5 (since it is operational part-time instead of 1.0 for full time)

Other Research from ITS International shows preliminary benefits of:
27% improvement in travel time reliability
10% emissions reductions
64% reduction in injury crashes

RESOURCES

FHWA - TOPS-BC Version 1.0

ITS International
Website Accessed May 1, 2014: http://www.itsinternational.com/categories/detection-monitoring-machine-vision/features/hard-shoulder-running-aids-uniform-traffic-flow-and-safer-driving/

APPENDIX B

I-5 Optimization Study

Comment Log

DKS

EXISTING CONDITIONS COMMENTS

Number	Name	Company	Date	Sheet Section/Page Number	Comments	Action Taken	Action By
1	Dan Fricke	ODOT	2/10/2014	Exist Cond Outline	Capacity-growth analysis. Not sure what this means – what kind of data will be collected that isn't being collected for the other items in Task 2.	in email from 2/11/14 "For the capacity growth analysis, that term might be misleading. Really what we're trying to do with that is look at the existing and future year 2032 volumes by mile point on I-5 and show where (and if) the volumes exceed capacity. We'd be basing this analysis on available data including existing and future ADT volumes, number of lanes in each section, classification of roadway (urban, suburban, or rural), and an assumed hourly per lane vehicle flow rate (likely 2200). Let me know if you think this piece of information would be valuable. "	JLB
2	Dan Fricke	ODOT	2/10/2014	Exist Cond Outline	4 – Incident data. Sounds like this goes with the collection of safety data in Task 3? Not sure what kinds of land closures you are looking for and intending to map or what information this would provide beyond the safety data.	in email from 2/11/14 "The incident data is actually a separate data set than the crash data. We thought looking at where lane closures occur could provide some information or justify a project like a wider shoulder or hard running shoulder in spot locations. "	JLB
3	Dorothy Upton	ODOT	2/18/2014	Kick-off Meeting Minutes/Exist Cond	I think the only thing missing in the minutes is that under Other Key Issues - Other hot spot areas - at the rest stop - I think the issue is not necessarily parked cars getting hit, as the "congestion", the reduced sight distance and how those impact driver behavior such as improper merges, reckly passing, ect.	Updated meeting minutes and included in existing cond memo	JLB
4	Valerie Grigg Devis	ODOT	2/21/2014	Kick-off Meeting Minutes/Exist Cond	Other key issues: I mentioned the importance of this corridor as a Freight Route. The freight industry is a "primary customer": They have need for reliability, as opposed to speed. Please make a note of that. Thanks!	added to exist cond memo, and referenced freight concern in the needs and goals memo.	JLB
5	Dorothy Upton	ODOT	2/18/2014	Exist Cond DRAFT	Page 1 - the bullet list needs to refer to Kuebler Boulevard not Road	corrected throughout	JLB
6	Dorothy Upton	ODOT	2/18/2014	Exist Cond DRAFT	* Page 2 (and throughout) - There needs to be a clear definition of where the north end is - report refers to Keubler as the north end but has data that is also north of the on ramps - this is important when doing the comparisons since the cross secion does not add a 3rd through lane until at Keubler, the rest is really 2 thrugh plus the climbing (which is also NOT an auxillary lane).	clarified the north end is just north of the Kuebler interchange	JLB
7	Dorothy Upton	ODOT	2/18/2014	Exist Cond DRAFT	* Page 2 - Why are 2000 volumes from the State of the Interstate report used when there is more current data available (especially for mainline reporting).	Discussed with Dorothy and Valerie. These are the most recent balanced volumes for the area.	JLB
8	Dorothy Upton	ODOT	2/18/2014	Exist Cond DRAFT	* Page 5 - Bullets 3 &5 are missing "and" between the segment ends	incorporated	JLB
9	Dorothy Upton	ODOT	2/18/2014	Exist Cond DRAFT	* Figure 2 - It would be helpful to show locations of the 2 ATR's used in report	Added to Figs 1 and 3 (already on 4)	JLB
10	Dorothy Upton	ODOT	2/18/2014	Exist Cond DRAFT	* Page 9 - ATR 22-005 has been collecting data since 1999	incorporated	JLB
11	Dorothy Upton	ODOT	2/18/2014	Exist Cond DRAFT	* Page 10, Paragraph 2 - A 5% jump in heavy vehicle percentages can be significant and not necessarily "similar".	incorporated	JLB

EXISTING CONDITIONS COMMENTS

Number	Name	Company	Date	Sheet Section/Page Number	Comments	Action Taken	Action By
12	Dorothy Upton	ODOT	2/18/2014	Exist Cond DRAFT	* Page 12 & 13 - graphs are a bit misleading since the north end is the last mile or so of the corridor and not through the hills; also the assumption of 2,000 cars per lane in steep terrain is not appropriate	No direct HCM method available to calculate reduced flow.	JLB
13	Dorothy Upton	ODOT	2/18/2014	Exist Cond DRAFT	* Pages 13-15 - the discussion of the speed differential needs to point stronger to the fact that the table values are NOT on the grades, which will introduce even more difference	Ironically, the data shows a higher differential at the ATR on level terrain. The Northern ATR is on a 3% grade.	JLB
14	Dorothy Upton	ODOT	2/18/2014	Exist Cond DRAFT	* Page 20 - could highlight the northbound congestion around 8 pm as possible effect from game as well	incorporated	JLB
15	Dorothy Upton	ODOT	2/18/2014	Exist Cond DRAFT	* Page 22, Bullet List - Label OR 99E at MP 244 as Commercial Street (as Knox Butte is also an OR 99E connection)	incorporated	JLB
16	Dorothy Upton	ODOT	2/18/2014	Exist Cond DRAFT	* Page 22 - What and where were the 7 fatal crashes?	Adding a map and table for fatal crashes	JLB
17	Dorothy Upton	ODOT	2/18/2014	Exist Cond DRAFT	* Page 31 - related to the spike in crashes at MP 243 - was there a construction project at Ankeny Hill during the 2008-2012 time period?	Did not find any construction activity	
18	Jim Peters	DKS	2/24/2014	Exist Cond DRAFT	Include a "resource Section"	Out of scope	JLB
19	Valerie Grigg Devis	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	Emphasize freight reliability	Added language about I-5 being a freight route, more emphasis in the goals memo	JLB
20	Valerie Grigg Devis	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	When describing the study area, refer to it as “mid-Albany”, rather than northern part or southern part of Albany. Make this consistent in the document.	incorporated	JLB
21	Valerie Grigg Devis	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	Need to revise the study area map – not clear which portion is the study area. Need to add a bubble around it to make it stand out.	incorporated	JLB
22	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	o Interchange Updates • We discuss the Viewcrest interchange – it is planned to be closed. This involves removing the bridge and all the ramps. We need to note this somewhere. Maybe an appendix?	Added note to Figure 1 Study area graphic, and general text" An on-going project, the I-5 South Jefferson to US 20 Environmental Assessment , is evaluating ways to improve accessibility, mobility and safety along that six stretch of I-5 (between mile post 233 and mile post 239). That project will address interchange modifications in an attempt to achieve interchange spacing standards. "	JLB
23	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	§ Murder Creek will have the ramps closed. So the underpass will remain, but the ramps will be gone. Connection to Century Road will remain.		JLB
24	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	§ Viewcrest and Murder close when Millersburg goes in. None of this will happen until Millersburg goes in. Very important.		JLB
25	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	§ Millersburg – www.I5sj20.com (see here for info on Millersburg planned build out). This needs to be referenced. Discuss in interchanged spacing area.		JLB

EXISTING CONDITIONS COMMENTS

Number	Name	Company	Date	Sheet Section/Page Number	Comments	Action Taken	Action By
26	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	§ Condemnation lawsuit with viewcrest. Be careful how we word this. Need to be vague. Maybe say "there will be modifications in an attempt to achieve interchange spacing standards." Reference folks to the I-5 South Jefferson to US 20 Environmental Assessment.		JLB
27	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	o Page 10 – vehicle break down. Would like to compare the HV% and break down in our study area to other parts of I-5. Is this high?	Added three ATR comparison sites	
28	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	o Figure 7 – needs a better description. Why are we seeing this – what is the message of the figure? Need more info about spike at highway 20 – not just because highway 20 is there but more so because of how people are using it. What does the more wiggly line in 2032 mean for the project?	Added details	JLB
29	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	o Figure 9 – doesn't like vertical lines. Maybe do a circle with a call out instead.	incorporated	JLB
30	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	o In congestion section – Valerie wants some highlights. Maybe make a key take aways bullet list?	incorporated	JLB
31	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	o Why does the Game day congestion only extend south till Salem – but not into Albany and/or Eugene? Is there a cross section change?	Explained the SB lane drop. Bottleneck as traffic approaches the lane drop, then the bottleneck dissipates.	JLB
32	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	o VMS is proposed for I-5 in Corvallis area to manage game day traffic and graduation day. Currently the OSP works very closely with ODOT. OSP guides traffic and they modify signal timing within Corvallis. This is outside the study area though. OSU, OSP, City of Corvallis, Corvallis Police, ODOT. This isn't like incident response, but very similar. Do we want to include this group in our stakeholder discussions? Joe and Kendall Weaks would be the contacts for this to get more info. They will be very important for Phase 2 when we focus on US 20.	Noted	JLB
33	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	o Jefferson Emergency Response would be a good stakeholder to include in corridor management focus group strategy.	None - instructed by ODOT to keep this as an internal ODOT evaluation.	JLB
34	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	o Consider reviewing one more date in INRIX for congestion – maybe graduation date or the Linn County Fair, Albany Art & Air Festival? Maybe check a couple of these.	Out of scope	JLB
35	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	Exist Cond DRAFT	o Heavy Vehicle Speed Differentials and Focus Area Problem Spots seem consistent with what we've been hearing –so this looks good.	No action necessary	JLB

GOALS AND OBJECTIVES COMMENTS

Number	Name	Company	Date	Sheet Section/Page Number	Comments	Action Taken	Action By
1	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	TOOLBOX	· For incident detour routes – look at adding automated signs for common detour routes. Not all the drivers will know where these routes are. Amy thinks this would be VERY helpful.	Evaluated as part of the strategy	JLB
2	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	TOOLBOX	· Ask Joe whether Dry Running Towing has ever been tried in R2.	addressed as an internal ODOT maintenance/operations project	JLB
3	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	TOOLBOX	· Ask Joe if we need additional incident response vehicles during peak congestion periods. Would this strategy do anything new? Ask Joe and Don.	addressed as an internal ODOT maintenance/operations project	JLB
4	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	TOOLBOX	· Look into OR laws – Is there something that says the trucks HAVE to use the Right lane?	Did not find a law regarding this subject	JLB
5	Amy			TOOLBOX	Incident management - detour routes, would be very helpful. Also good for events	Noted	JLB
6	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	TOOLBOX	For Truck Lane Use Signs - consider calling out RV's too, Any "tow" vehicle to use right lane	Addressed in the benefit cost analysis - this strategy is actually detrimantial to this corridor based on current traffic volumes	JLB
7	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	TOOLBOX	Ramp Metering - more of an urban strategy near Salem or Albany	reviewed for an exit in Albany and Salem	JLB
8	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	TOOLBOX	Parking Management study planned for future (in regard to demand management strategies)	Noted	JLB
9	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	TOOLBOX	Higher Visibility markings and signage - Merge at north end. Light up merge sign in poor conditions	addressed as an internal ODOT maintenance/operations project	JLB
10	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	TOOLBOX	Closing ramps and interchange strategies helps support the environmental assessment for the South Jefferson/Millersburg study	Noted	JLB
11	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	TOOLBOX	Add Strategy: Increase Rest Stop Infor - Inform travelers if Santiam parking is full. "Lot Full, Use Exit XX"…Find out if Knox Butte is private	Added to preliminary screening list	JLB
12	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	EVALUATION CRITERIA	Add "technically" under feasibility. Remove cost here since already included as own category	incorporated	JLB
13	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	EVALUATION CRITERIA	Criteria list seems a little long.	Focused criteria for final review	JLB
14	Attendees: Valerie, Amy, Joe, Tegan, and Jim	ODOT	3/7/2014 Meeting	EVALUATION CRITERIA	· Remove special events from Percent of Time category. Those are caught in non-recurring delay.	incorporated	JLB

CON OPS COMMENTS

Number	Name	Company	Date	Sheet Section/Page Number	Comments	Action Taken	Action By
1	Valerie Grigg Devis	ODOT	6/19/2014	Acknolowledgements	No hypen in name	incorporated	JLB
2	Valerie Grigg Devis	ODOT	6/19/2014	2.1 Overview	The project purpose is to focus on "lower cost capital improvement solutions: so cost should be included. KEEP IN MIND THAT COST WILL VERY LIKELY DRIVE WHAT & WHEN STRATEGIES CAN (OR CANNOT) BE IMPLEMENTED….SO LET'S KEEP COSTS FRONT. THANKS!	incorporated	JLB
3	Valerie Grigg Devis	ODOT	6/19/2014	Table 3	Change ODOT Region 2 Planning to ODOT Region 2 Management Team	incorporated	JLB
4	Valerie Grigg Devis	ODOT	6/19/2014	5.1 Suggested Phasing	Add cost est	incorporated	JLB
5	Valerie Grigg Devis	ODOT	6/19/2014	6 Next Steps	Do not list specific strategies for ODOT internal review	incorporated	JLB
6	Dorothy Upton	ODOT	6/30/2014	2.1 - Variable Speeds	Will these be suggested or regulatory speeds? If regulatory, then a speed zone investigation will need to occur and then be processed according to the OAR (734-020-0018). No other regulatory variable speed zones have been established on the interstate, yet, so this may be one of the pilot projects referred to in the OAR.	Addressed in 2.1 and next steps. Advisory vs regulatory will be determined as part of the next step	JLB
7	Dorothy Upton	ODOT	6/30/2014	2.3 Opportunities to Reroute	This will have limited benefit since there are few alternate routes.	noted	JLB
8	Dorothy Upton	ODOT	6/30/2014	Table 1	Edit Ramp Meter - add "northbound"	incorporated	JLB
9	Dorothy Upton	ODOT	6/30/2014	Table 3	ODOT Region 2 Traffic - Region Traffic also has a roll in the messages on a dynamic message signs.	incorporated	JLB
10	Dorothy Upton	ODOT	6/30/2014	6 - Next steps	ODOT should actively pursue and implement the 12 strategies - This is worded too strongly. Consider using "ODOT should consider the following 12 items previously identified:"	Edited based on Valerie's comments	JLB
11	Galen McGill	ODOT	7/1/2014	General	Here are my comments on the document. We didn't discuss travel time data as part of this project. With all of the proposed sites with power and communications, addition of Bluetooth sensors would be a very inexpensive addition, and I think would be a valuable traveler information improvement for the corridor.	Added discussion of installing sensors with the other projects as a cost effective method	JLB
12	Galen McGill	ODOT	7/1/2014	2.1 Traffic Surveillance	The current Kuebler interchange project includes extending fiber and adding an additional camera south of the current camera location at Kuebler. All of these remaining cameras are in locations that will require leased services of some type unless the fiber discussed below can be installed. I'm not sure how practical PTZ cameras will be on leased services. There should at least be some statement saying this is pending availability of cost effective communications. We really need the ability to purchase point-to-point Ethernet services. We are working on this through the DAS and the State Data Center, but I don't know when we'll be able to do this or what the cost will be.	incorporated in Next Steps section	JLB
13	Galen McGill	ODOT	7/1/2014	Table 2	several edits	incorporated	JLB
14	Galen McGill	ODOT	7/1/2014	Table 3	several edits	incorporated	JLB

CON OPS COMMENTS

Number	Name	Company	Date	Sheet Section/Page Number	Comments	Action Taken	Action By
15	Galen McGill	ODOT	7/1/2014	5.1 Suggested Phasing - ramp meter	Consider adding a camera at this location for remotely monitoring operation.	incorporated in Next Steps section	JLB
16	Galen McGill	ODOT	7/1/2014	5.1 Suggested Phasing - Variable Speeds	I agree with the preference for fiber, but I don't think it is an absolute requirement. The system on I-84 and parts of the Mt. Hood system will be on leased services.That being said, there is enough going on in the corridor that fiber would be very beneficial.	incorporated in Next Steps section	JLB

FINAL REPORT COMMENTS

Number	Name	Company	Date	Sheet Section/Page Number	Comments	Action Taken	Action By
1	ODOT Meeting Attendees	ODOT	7/30/2014	acknowledgements	update with everyone at today's meeting	done	JLB
2	ODOT Meeting Attendees	ODOT	7/30/2014	chapter 1	Add information on the project team. Say it was an "internal ODOT Team". Who were the folks at ODOT.	incorporated in exec summary…see if it needs to be added elsewhere.	JLB
3	ODOT Meeting Attendees	ODOT	7/30/2014	1.4	Add benefit cost ration for each strategy. This was key in the decision making process	incorporated	JLB
4	ODOT Meeting Attendees	ODOT	7/30/2014	1.4 - VS strategy	Comment about how cost is high level and conservative and the dollar amount could go down.	incorporated	JLB
5	ODOT Meeting Attendees	ODOT	7/30/2014	1.4	Add documentation to main document that the Kuebler Interchange project will be adding a PTZ at interchange. Extending fiber from Kuebler to Battle Creek overcrossing. Also installing a VMS at 252.5 for SB traffic as part of the Kuebler project. There will be a SB lane extension as well from Kuebler to Battle creek overcrossing.	added to graphic	JLB
6	ODOT Meeting Attendees	ODOT	7/30/2014	1.4	Add a sentence that this $ could be less depending on if the comm goes down because of advisory rather than regulatory.	incorporated	JLB
7	ODOT Meeting Attendees	ODOT	7/30/2014		Include priority. High, medium, low. The group examined and these are the priority rating. These are the ones that are ongoing.	incorporated	JLB
8	Sonny Chickering	ODOT	7/30/2014	Chapters 5, 6, and 7	Discuss how the variable speed cost is very conservative and will decrease with comm options other than fiber.	incorporated in chapters 5 and 6 (and exec summary)	JLB
9	Galen McGill	ODOT	7/30/2014		Determine whether to include CAD integration as an ODOT project	DId not add strategy based on Galen's email from 8/6/14 - "*With the consultant work as far along as it is, I would say that we leave it out. I think we can work on the CAD integration whether or not it is in the consultant report. It would be in the future a bit before we work on it as our current focus is on finishing the project with the 911 centers along US 97 in Central Oregon.*"	JLB