FINAL REPORT

I-84 Pendleton–La Grande

VSL and Corridor Management Project

March 2018

DKS

ACKNOWLEDGMENTS

ODOT Project Manager

Laura Slater

ODOT District Managers

Marilyn Holt
Ace Clark
Paul Woodworth

ODOT ITS Unit

Galen McGill
Blaine Van Dyke
Doug Spencer

Other Key ODOT Staff

Ken Patterson
Craig Sipp
Patti Caswell
Sean Maloney
Teresa Penninger
Paul Howland
Dennis Hackney
Robin Berheim
Randy Randolph
Tom Strandberg
Jeff Berry
Tom Davis

Additional Stakeholders

Ash Grove Cement Company
Baker County
Baker County Emergency Management NOAA
Baker Rural Fire
Bowman Trucking
CCNO
CTVIR
City of Joseph (Mayor)
City of Ontario
Fenn’s Towing
Idaho Transportation Department
La Grande Fire
La Grande Rural Fire
Malheur County
Mid Co Bus Oregon State Police
Office of Representative Cliff Bentz
Ontario Chamber of Commerce
Senator Merkley’s Office
Senator Wyden’s Office
Umatilla County
Umatilla County Fire
Union County

Consultant Staff

DKS

Jennifer Bachman, Jim Peters, Elliot Hubbard, Deena Platman, Ben Chaney, Ana Roeszler, Jean Senechal Biggs, Eric Shulte

DEA

Kevin Bracey, Molly Davis, Christina Weber

JLA

Stacy Thomas

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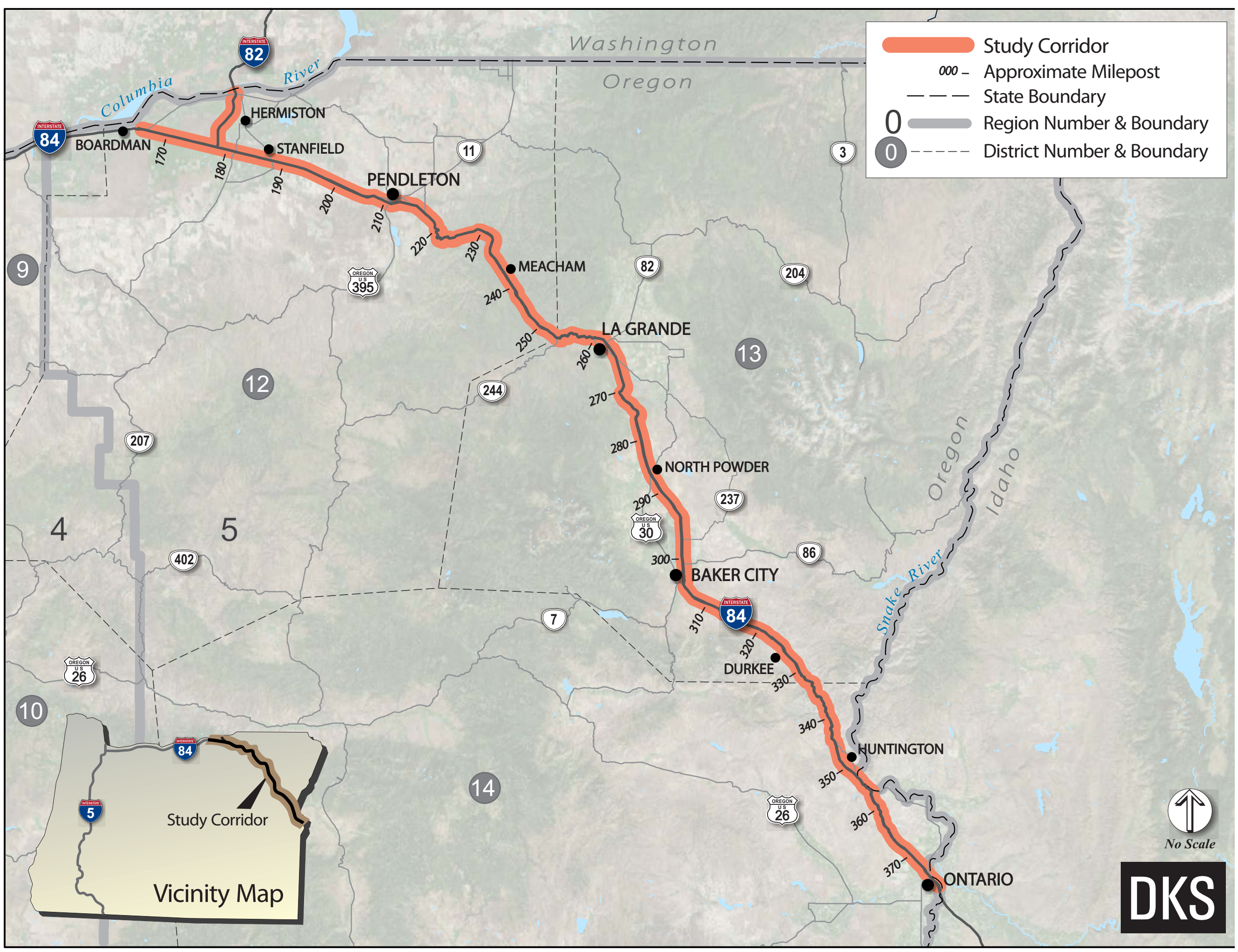
Executive Summary

This project evaluated over 200 miles of I-84 and I-82 in eastern Oregon, between Boardman and Ontario, seeking to find transportation system management and operations (TSMO) solutions to improve safety and operations along the two interstate routes. TSMO strategies focus on improving performance of existing infrastructure rather than building additional capacity, and tend to be lower cost than capital infrastructure projects. For example, instead of building additional lanes, a TSMO strategy improves the safety and operations of the existing lane miles by incorporating communications, technology, and cross jurisdictional coordination.

The study area encompasses all of I-84 and I-82 in ODOT Region 5 as shown in Figure 1. The study area is mostly rural, with two-lanes of interstate in each direction and often over ten miles between interchanges. The terrain varies considerably between the east and west end of the corridor, moving from desert through mountain passes to sections with sharp curves and steep drop-offs. Weather through eastern Oregon creates additional challenges, with some sections experiencing snow or ice on the road up to 60 days of the year.

Figure 1. Study Area



During the project, ODOT worked with a broad range of stakeholders across the region to gain insight on a variety of user needs and priorities along the corridor. The project team evaluated nearly 40 strategies with potential to improve safety and operations along the corridor. Through a collaborative screening process and a benefit cost analysis, five top strategies to improve safety and operations along the corridor emerged. The table below provides a description of each strategy, as well as the implementation priority. All of the high priority strategies and locations are shown in Figure 2.

TOP FIVE RECOMMENDED NEW STRATEGIES | **PHASING**

1. Weather Responsive Variable Speed Systems

Install variable message signs over travel lanes that display the speed limit adjusted for current weather and roadway conditions. The speed limit signs would adjust automatically based on current conditions.

Proposed High Priority Location

- Cabbage Hill and Meacham (MP 217-252)
- Additional locations noted as medium and low priority

Phasing: Near Term (1-3 yrs)

(1 location)

2. Enhanced Delineation

Install enhanced delineation along areas with curves, compromised visibility, or high crash areas. Option to also install a single solid white lane line along curve segments with high rates of side swipe crashes to discourage drivers from changing lanes.

Proposed High Priority Locations

- Several crash hot spot locations (see map on page 13)

Phasing: Near Term (1-3 yrs) hot spot locations

Mid-Term (3-5 yrs) additional locations

3. Curve Treatments

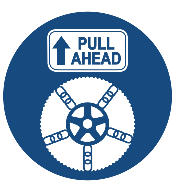
Install static signs with flashing beacons at curves with high crash frequency.

Proposed High Priority Locations

- Several crash hot spot locations (see map on page 14)

Phasing: Near Term (1-3 yrs) hot spot locations

Mid-Term (3-5 yrs) additional locations



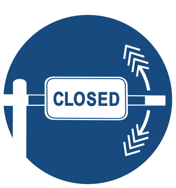
4. Chain-Up Area: Real-time Parking Availability

Install a system at chain-up areas that informs vehicles, especially trucks, where there is available space to park and install chains.

Proposed High Priority Locations

- Westbound chain-up area at MP 280

Phasing: Mid–Long-Term (3-5 yrs)



5. Remotely Operated Gates

Install gates at select locations, either on ramps or on the interstate, that can be controlled remotely to facilitate the road closure process.

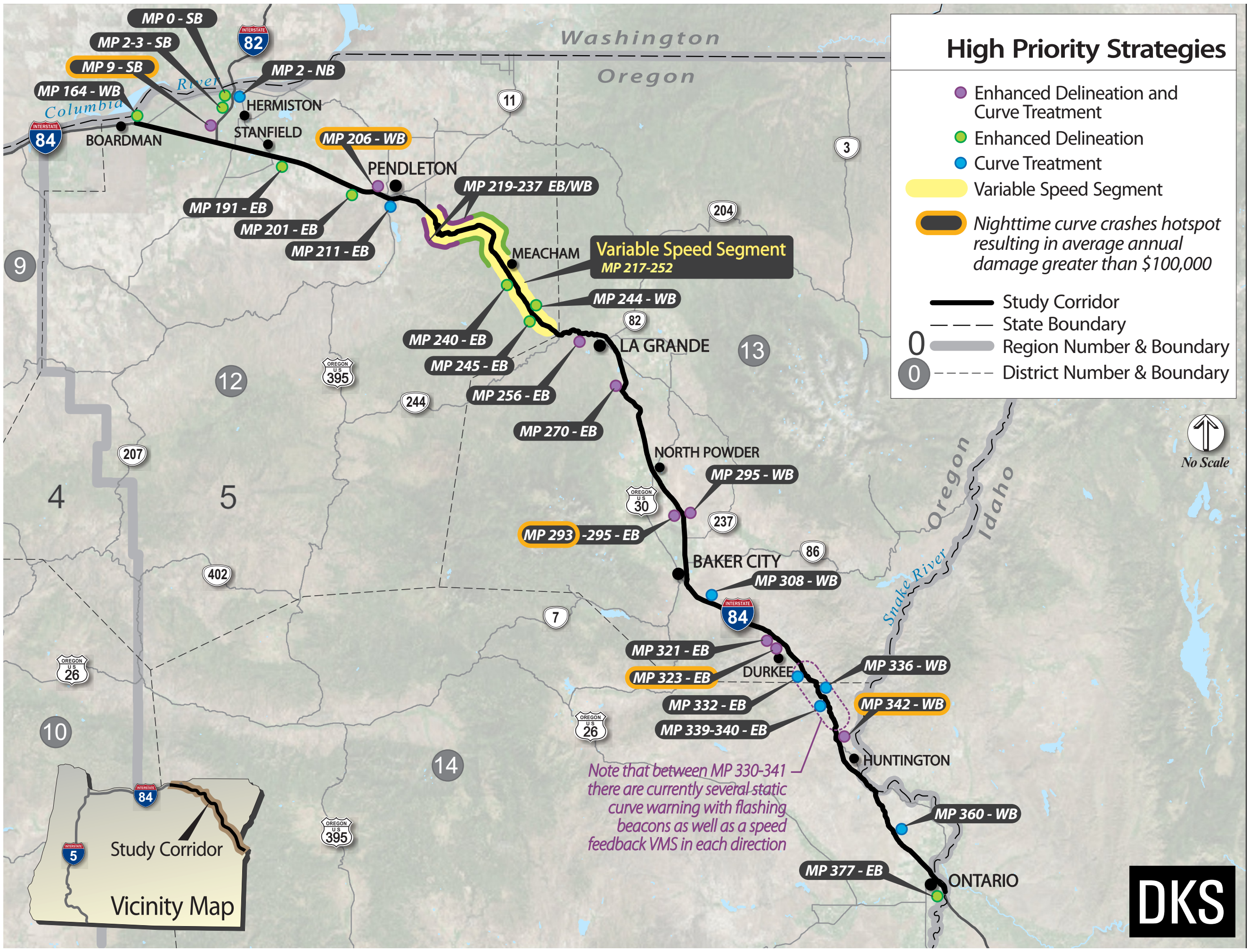
Proposed High Priority Locations

- On-ramps throughout the corridor
- Mainline at typical points of closure

Phasing: Mid-Term (3-5 yrs) on-ramp locations

Long-Term (5+ yrs) freeway locations

Figure 2. High Priority Strategies



Additonally, the project evaluated strategies ODOT already manages and recommended three for further advancement.

EXISTING STRATEGIES TO ENHANCE

Traveler Information During Closures

Improve traveler information provided to travelers and businesses during a road closure.

Local Traffic Sorting System

Improve the traffic sorting system for local traffic to proceed past a secondary closure if the traveler’s destination is before the primary point of closure.

Truck Parking Management Plan

Identify the components and stakeholders necessary to develop a Truck Parking Management Plan during roadway closures.

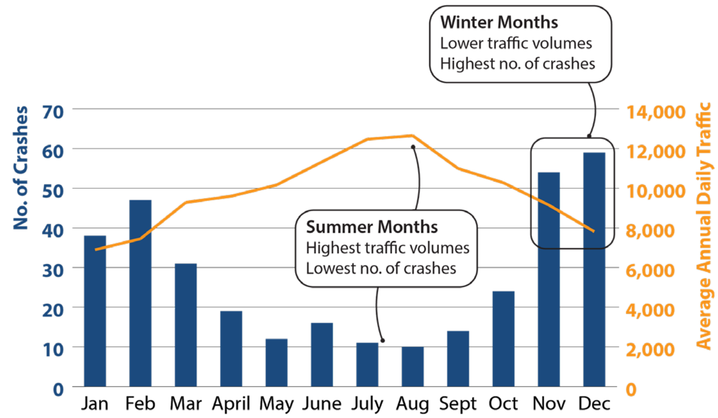
Existing Conditions

The first phase of the project evaluated the current conditions along the corridor, analyzing crash data, understanding weather data, documenting existing intelligent transportation system (ITS) devices (such as cameras and variable message signs), and understanding traffic volume trends.

	I-84	I-82
Traffic Volumes	Typical average daily traffic ranges from roughly **8,000 to 14,000, with heavy vehicles accounting for up to 50 percent of traffic in some areas.** There is heavy seasonal fluctuation along the corridor, with an increase in traffic volume by about 50 percent during summer months compared to winter months.	Average daily traffic on I-82 is roughly **18,000 vehicles, with heavy vehicles accounting for up to 25 percent.** Traffic volumes increase nearly 50 percent during summer months. I-82 is a well-used route for heavy vehicles, accounting for 25% of the average daily traffic volumes of 18,000 vehicles.
Crash Trends	**Crash trends are inversely related to seasonal trends, with crash numbers quadrupling during winter months.** The Cabbage Hill area is a hot spot for crashes (approximately mile posts 218-224). Other high crash areas include the stretch between Deadman Pass and La Grande (approximately mile posts 224 - 260), and between La Grande and North Powder (approximately mile posts 270-290). Heavy vehicles are involved in about 30 percent of the crashes along the corridor.	**Crashes on I-82 occur three times more frequently in the southbound travel direction than the northbound direction.** Southbound crashes account for 72% of all crashes while northbound crashes account for 28% of all crashes. Much of the imbalance occurs during the winter months, with southbound crashes increasing significantly compared to northbound crashes.
Key Crash Causes	• weather conditions (60%) • speed (70%)	• speed (52%) • fatigue (43%)
Key Crash Types	• roadway or lane departure crashes (65%)	• fixed object crashes (36%)
Conditions	The Cabbage Hill, Meacham, and Ladd Canyon areas all reported an average of over 20 days of snow on the road and over 25 days with ice on the roadway. Through Meacham there is typically snow or ice on the roadway for 50 days of the year. Other common weather conditions include low visibility from fog or blowing dust and patches of ice.	Snow and ice account for a disproportionate number of crashes relatively to the frequency of the weather conditions. Snow and icy conditions occurred less than 2% of the year but 43% of all crashes were attributed to these weather conditions. Between 2010-2014, there were 31 southbound crashes attributed to snowy or icy roadways; in the northbound direction, there were 9 crashes.
Hot Spots	The Cabbage Hill area is a hot spot for crashes (approximately mile posts 218-224). Other high crash areas include the stretch between Deadman Pass and La Grande (approximately mile posts 224 - 260), and between La Grande and North Powder (approximately mile posts 270-290).	Southbound near the Columbia River crossing.

Figure 3 shows the monthly crash trends and average annual daily traffic (AADT) for the section of I-84 between mile posts 217 and 252. This segment encompasses Cabbage Hill and Meacham, both of which experience severe winter weather conditions. As shown in the graph, crashes peak during winter months, when average daily traffic is at its lowest, indicating that winter weather has a strong correlation to increased crashes.

Figure 3. Monthly Crash Trends, Mile Posts 217-252 (2012-2014)



Several Intelligent Ransportation System (ITS) devices currently operate along the corridor, as indicated in the

Existing ITS devices along I-84 and I-82	
Variable Message Signs	Electronic signs that ODOT can use to post information to travelers about incidents, weather conditions, detours, or other current travel conditions.
Closed Circuit TV Cameras	Cameras produce still images or video and are linked to ODOT's TripCheck website.
Snow Zone Signs	Newer snow zone signs use high resolution graphic capable VMS to display chain-up information. These signs offer flexibility and can be used for other messages during non-snow events. Older drum style snow zone signs are being phased out. The drum style signs can be operated remotely by revolving a drum with different pre-set messages.
Actuated Curve Feedback Signs	There are three actuated curve feedback warning signs located south of Baker City through the Burnt Creek Canyon area (mile posts 336 and 340). The signs provide travelers with their travel speed and warning messages to slow down for approaching curves.
Road Weather Information System Stations	Weather and road condition information from these sites include temperature, wind speed, wind direction, humidity, and road surface temperature. This information is posted on TripCheck.
Highway Advisory Radio	Each HAR site can broadcast travel condition information from the ODOT's TripCheck system over a three- to five-mile radius.
Weather Responsive Variable Speed Limit (VSL) System	In the Baker Valley area, between mile posts 277 and 306, a weather responsive variable speed system began operating in 2017. The installation includes nine new VSL signs, six new VMSs, additional weather sensors (RWIS stations) and cameras along the corridor.

Variable message sign

New VMS style snow zone sign

Actuated curve feedback speed warning sign

Weather responsive variable speed limit signs

Needs, Goals, and Objectives

The project team held three workshops across the project area in Pendleton, La Grande, and Ontario, pulling in stakeholders to provide input on the corridor needs. Workshop participants included representatives from ODOT (planning, operations, and maintenance sections), Oregon State Police, Confederated Tribes of the Umatilla Indian Reservation (CTUIR), National Oceanic and Atmospheric Administration (NOAA), emergency response agencies, transit agencies, school districts, state legislative offices, trucking companies, and towing companies. Through a collaborative process, the project team and stakeholders developed four key goals and related objectives for this project.

GOAL 1
Improve safety for all I-84 corridor users

OBJECTIVES

- Reduce Fatal and Injury A crashes by 20% per vehicle miles traveled by 2025.
- Reduce weather related crashes by 25% per vehicle miles traveled by 2025.
- Reduce heavy vehicle related crashes by 10% per vehicle miles traveled by 2025.
- Reduce speed related crashes by 20% per vehicle miles traveled by 2025.

GOAL 2
Improve communications along the I-84 corridor

OBJECTIVES

- Communicate real-time travel conditions to travelers of all modes (vehicles, bicyclists, freight, transit) within 5 minutes of condition being recognized by 2025.
- Improve internal ODOT communication procedures.
- Improve communications with ITS devices.
- Improve communication with external stakeholders (other transportation service providers).

GOAL 3
Improve road closure process and reduce impacts for all users

OBJECTIVES

- Improve means to allow local traffic to reach destinations.
- Prevent truck parking from spilling back to freeway facilities.
- Provide real-time notifications and updates to travelers about road closures, updating information at a minimum of every five minutes by 2025.
- Improve coordination with partner agencies before, during, and after a road closure event.

GOAL 4
Improve resource efficiency

OBJECTIVES

- Enable ODOT districts to track real-time location of all maintenance vehicles by 2025.
- Enable ODOT to track all ITS devices in real-time and send instant notifications when equipment fails by 2025.
- Improve coordination between agencies and districts that maintain, operate, or respond to incidents along the facility.
- Improve coordination between agencies that respond to incidents on the roadway.

Key Needs Identified

Through the course of three workshops held with a broad range of stakeholders across Region 5 in Pendleton, La Grande, and Ontario, the project team learned about key needs across the corridor. The highest priority needs are shown below and organized by operation area.

Operation Area	Key Needs Identified
Traffic operations and management	• Reduce speed-related, weather-related crashes, and run off the road crashes. • Improve monitoring for system performance. • Improve real-time information (road conditions, closures, restrictions, incidents, etc.) available to the public as well as ODOT operators, both during regular operating conditions and a road closure event.
Road closure management & weather event management	• Close on-ramps faster during a closure of I-84. • Proactively manage inclement weather events.
Freight management	• Provide truck drivers with better information about parking availability, especially during closures of I-84.
Maintenance and construction management	• Improve maintenance activity operations, providing real-time vehicle location information to operators, and quicker notification when equipment fails. • Coordinate construction activity across the region and actively manage work zone signs.

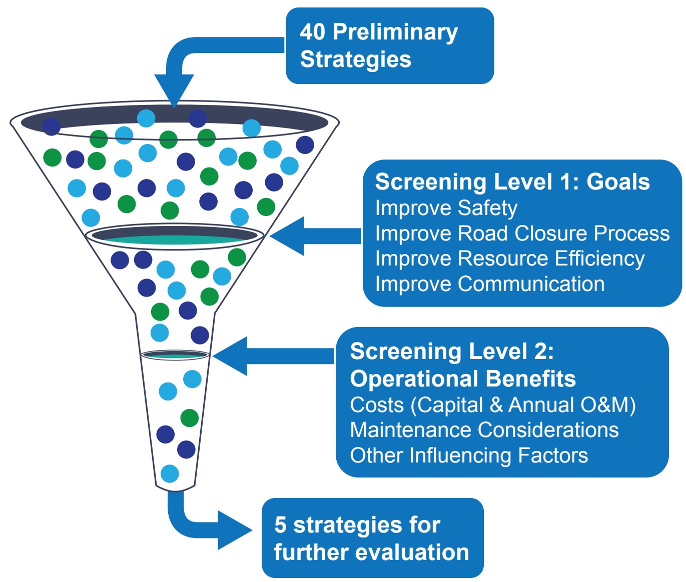
View westbound to La Grande

Typical snowy/icy conditions descending Cabbage Hill (westbound)

Screening Strategies

The project team filtered the full toolbox of TSMO strategies through two levels of screening to identify which strategies offer the best potential to improve safety and operations along the corridor. The first level screening narrowed strategies based on how well they achieved the four goals for managing the I-84 corridor:

- Improve safety for all I-84 corridor users
- Improve communications along the I-84 corridor
- Improve road closure process and reduce impacts for all users
- Improve resource efficiency



The second level screening ranked the remaining strategies based on:

- Potential for operational benefits (such as reducing crashes)
- Feasibility to implement based on physical factors, institutional factors, and operational and maintenance factors
- Implementation cost
- Annual operations and maintenance costs

Through the screening process five top strategies were identified for advancement.

TOP FIVE RECOMMENDED NEW STRATEGIES

Weather Responsive Variable Speed Systems

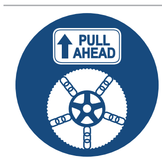
Install variable message signs over travel lanes that display the speed limit adjusted for current weather and roadway conditions. The speed limit signs would adjust automatically based on current conditions.

Enhanced Delineation

Install enhanced delineation along areas with curves, compromised visibility, or high crash areas. Option to also install a single solid white lane line along curve segments with high rates of side swipe crashes to discourage drivers from changing lanes.

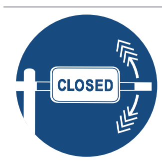
Curve Treatments

Install static signs with flashing beacons at curves with high crash frequency.



Chain-Up Area: Real-time Parking Availability

Install a system at chain-up areas that informs vehicles, especially trucks, where there is available space to park and install chains.



Remotely Operated Gates

Install gates at select locations, either on ramps or on the interstate, that can be controlled remotely to facilitate the road closure process

Variable Speed Study Results

As part of the I-84 Boardman to Ontario Corridor Management Plan, four segments of I-84 between Boardman and Ontario are being considered for a variable speed zone, as well as the I-82 segment between the Washington state line and the I-84 interchange. A variable speed zone may be established on a section of interstate highway based on an engineering study of the characteristics such as congestion, road conditions, reduced visibility, or weather conditions .

Based on initial evaluations, weather responsive variable speed systems are warranted for all five study segments with varying degrees of priority. A weather responsive variable speed system (VSL) uses to real-time weather data such as temperature, visibility, and roadway grip factor to determine the safe operating speed during the given conditions.

Table 1 provides a summary of the five segments and key decision factors, as well as a comparison to the segment in Baker Valley where a weather responsive VSL system was installed in 2016. Figure 4 illustrates the segments and recommendations. The benefit cost analysis for the variable speed systems are discussed in the next section of this report.

A weather responsive variable speed system primarily addresses safer driving during adverse weather conditions such as snow, ice, rain, and fog. In eastern Oregon, the biggest safety improvements will likely occur during winter months. Other strategies may be warranted to address safety problems during non-adverse weather times, and multiple strategies can work in conjunction with a variable speed system to further improve safety such as curve warning systems, improved traveler information, and enhanced delineation or pavement marking through high crash areas.

In each of the five segments analyzed, over half of the crashes occurred during winter months (October through March) and were speed related. Additionally, three of these segments have crash rates over double the statewide average (0.33) for rural interstate freeways, between 2012 and 2014. These conditions indicate that each segment could benefit from a weather responsive variable speed system.

Table 1. Summary of Variable Speed Segments and Recommendations

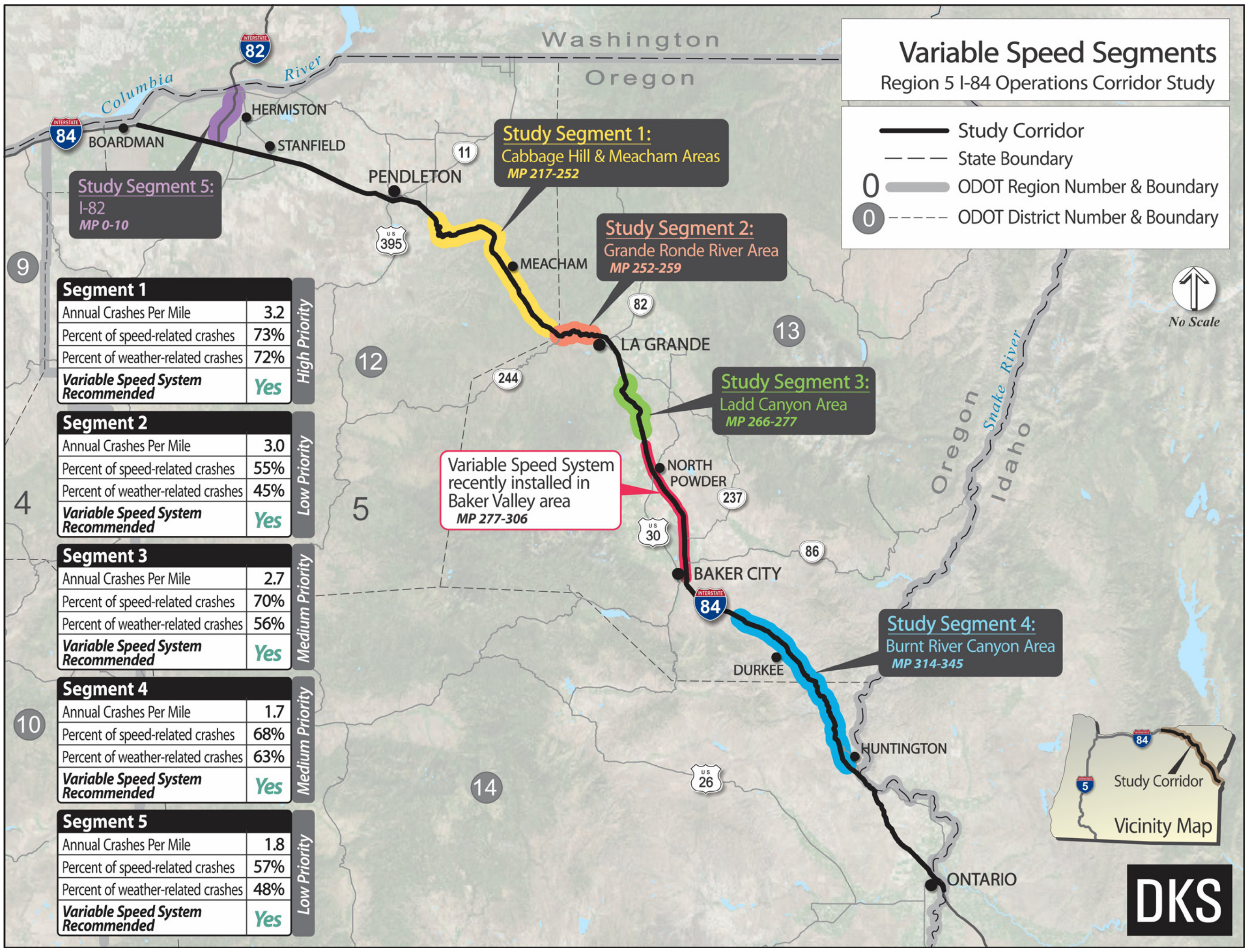
SEGMENT	ANNUAL AVERAGE CRASHES PER MILE*	CRASH RATE PER MILLION VMT**	PERCENT RELATED TO:			VSL SYSTEM RECOMMENDED? PRIORITY?
			SPEED	WEATHER	WINTER MONTHS***	
1. Cabbage Hill-Meacham	3.2	0.9	73%	72%	76%	YES, High
2. Grande Ronde River	3.0	0.9	55%	45%	68%	YES, Low
3. Ladd Canyon	2.7	0.8	70%	56%	73%	YES, Medium
4. Burnt River Canyon	1.7	0.5	68%	63%	72%	YES, Medium
5. I-82 from I-84 to Washington state line	1.8	0.4	57%	48%	65%	YES, Low
Baker Valley Area (for comparison purposes)	2.0	0.6	72%	45%	75%	Installed in 2016

*I-84 crash data 2012-2014, I-82 crash data 2010-2014

** Average Rural Intersection Rate (2012-2014) = 0.33

*** (October-March)

Figure 4. Variable Speed Systems Analysis and Recommendations



Variable speed limit sign installed along the Baker Valley area

Benefit Cost Analysis

Based on the screening process, the project team identified five strategies for further benefit cost evaluation. Based on these results, the project team then prioritized the proposed strategies.

Benefit Cost Analysis Process

For the benefit cost analysis, the project team determined annualized benefits and annualized costs for each strategy.

Annualized Cost

The **annualized cost** incorporated three elements: capital cost, service life and annual operations and maintenance costs.

Annualized Benefit

The **annualized benefit** focused mainly on the potential for each strategy to reduce crashes. Other benefits such as reducing delay, emissions, or improving operational efficiency are not included in the benefits calculation. In Oregon, each type of crash severity is associated with a cost, as shown in Table 2.

To determine the monetary benefits associated with a strategy, the project team used case studies and research to estimate how each strategy could reduce crashes along the corridor, and then applied that reduction to the actual distribution of crash severities.

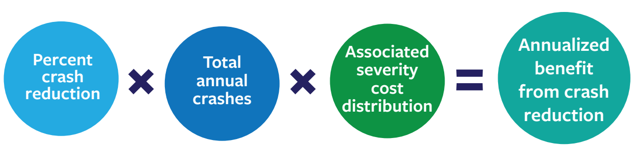


Table 2. Crash Severity Cost

CRASH SEVERITY	ASSOCIATED COST (ODOT)
Fatal	$2,300,000
Disability Injury	$2,300,000
Moderate Injury	$79,200
Minor Injury	$79,200
Property Damage Only (PDO)	$19,400

Evaluation Summary

The evaluation summary and benefit cost results for each of the five strategies are detailed on the following pages and include:

- a description of the strategy
- a summary of how well the strategy achieves each of the project goals
- key benefits
- system requirements
- recommended agency partnerships
- results from the benefit cost analysis
- figures identifying specific locations recommended for implementation

Weather Responsive Variable Speed System

Goal 1: Improve Safety	Goal 2: Improve Communications	Goal 3: Improve Road Closure Process & Reduce Impacts	Goal 4: Improve Resource Efficiency
Achieves Best	Achieves Best	Achieves Some	Achieves Some

Description

Adjust the speed limit (regulatory or advisory) automatically based on real-time weather conditions. The variable speeds would be displayed on dynamic message signs over the travel lanes (on overhead gantries or cantilever supports) with the potential for a dynamic message sign over each lane.

Benefits

Reduction in weather related crashes by 20% (ODOT CMF – H46)

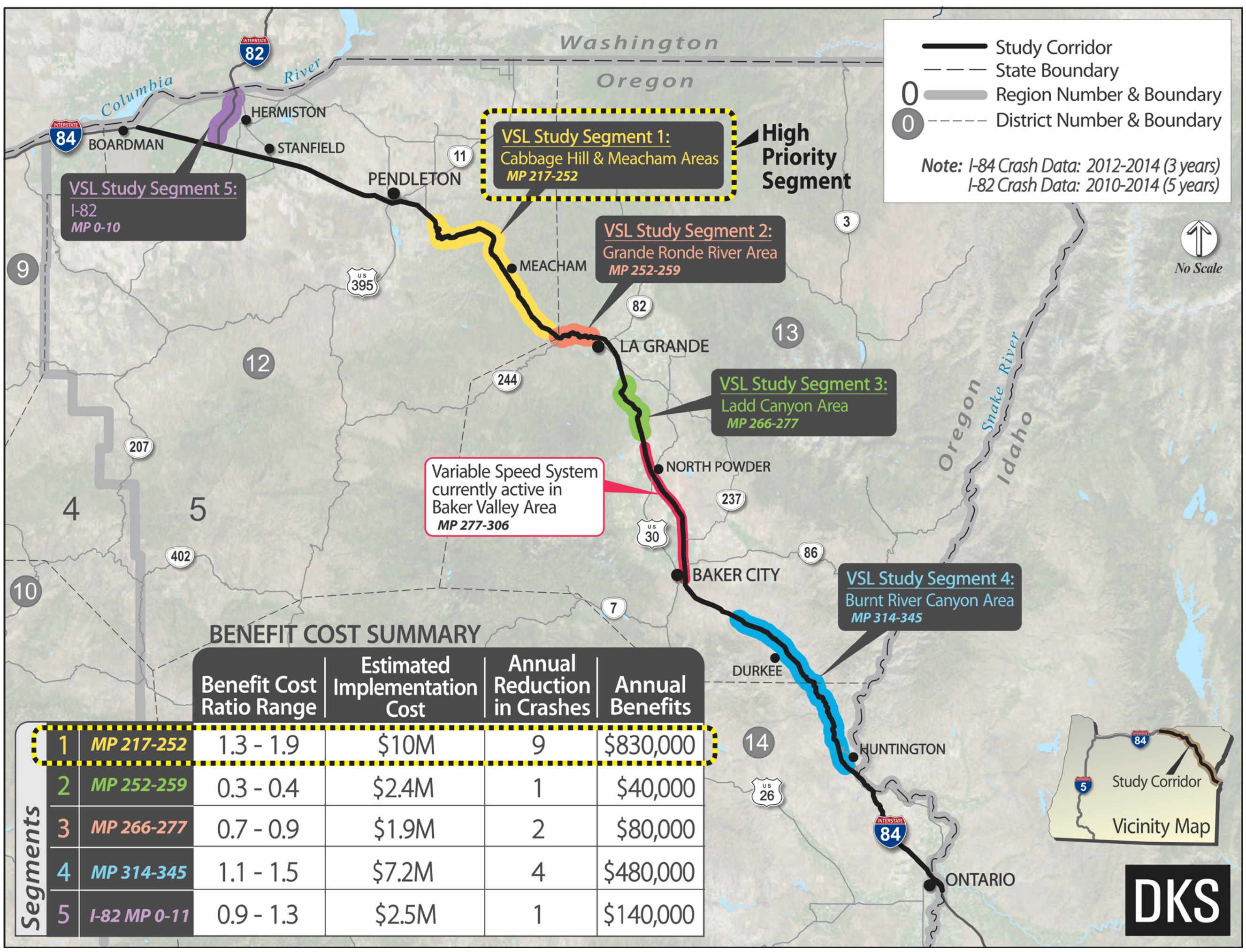
System Requirements/ Software Enhancements

ODOT is already using software for the application in the Baker Valley area and working through refinements than can be applied to future VSL projects.

Agency Resources & Partnerships

- ODOT
- Oregon State Police

Figure 5. Variable Speed System Recommended Locations and Benefit Cost Results



BENEFIT COST SUMMARY

Segments		Benefit Cost Ratio Range	Estimated Implementation Cost	Annual Reduction in Crashes	Annual Benefits
1	MP 217-252	1.3 - 1.9	$10M	9	$830,000
2	MP 252-259	0.3 - 0.4	$2.4M	1	$40,000
3	MP 266-277	0.7 - 0.9	$1.9M	2	$80,000
4	MP 314-345	1.1 - 1.5	$7.2M	4	$480,000
5	I-82 MP 0-11	0.9 - 1.3	$2.5M	1	$140,000

Enhanced Roadway Delineation

Goal 1: Improve Safety	Goal 2: Improve Communications	Goal 3: Improve Road Closure Process & Reduce Impacts	Goal 4: Improve Resource Efficiency
Achieves Best	Achieves Best	Does Not Achieve	Does Not Achieve

Description

Install enhanced delineation along areas with curves, compromised visibility, or high crash areas. Enhanced delineation can be positioned on posts on a guardrail, linear tape on a guardrail, or posts in the ground. Option to also install a single solid white lane line along curve segments with high rates of side swipe crashes to discourage drivers from changing lanes.

Benefits

Reduces curves crashes during dark conditions by 30% (ODOT CMF – RD 13)

Reduces crashes during other compromised visibility conditions by 10%.

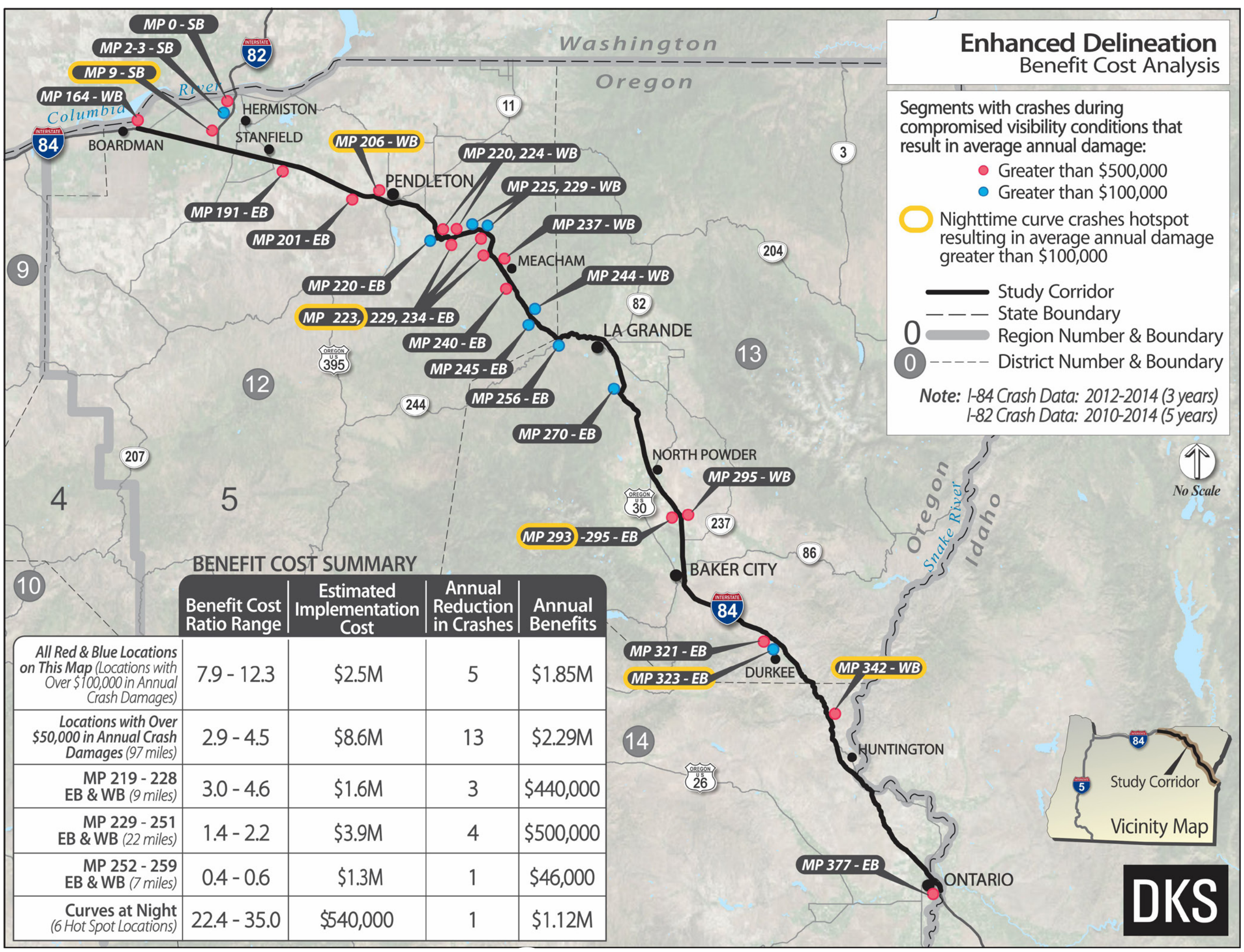
System Requirements/ Software Enhancements

None identified

Agency Resources & Partnerships

ODOT would need to maintain the delineation and replace as it becomes damaged.

Figure 6. Enhanced Roadway Delineation Recommended Locations and Benefit Cost Results



BENEFIT COST SUMMARY

	Benefit Cost Ratio Range	Estimated Implementation Cost	Annual Reduction in Crashes	Annual Benefits
All Red & Blue Locations on This Map *(Locations with Over $100,000 in Annual Crash Damages)*	7.9 - 12.3	$2.5M	5	$1.85M
Locations with Over $50,000 in Annual Crash Damages *(97 miles)*	2.9 - 4.5	$8.6M	13	$2.29M
MP 219 - 228 EB & WB *(9 miles)*	3.0 - 4.6	$1.6M	3	$440,000
MP 229 - 251 EB & WB *(22 miles)*	1.4 - 2.2	$3.9M	4	$500,000
MP 252 - 259 EB & WB *(7 miles)*	0.4 - 0.6	$1.3M	1	$46,000
Curves at Night *(6 Hot Spot Locations)*	22.4 - 35.0	$540,000	1	$1.12M

Curve Treatment

Goal 1: Improve Safety	Goal 2: Improve Communications	Goal 3: Improve Road Closure Process & Reduce Impacts	Goal 4: Improve Resource Efficiency
Achieves Best	Achieves Best	Does Not Achieve	Does Not Achieve

Description

Install static signs at key curve locations with flashing beacons to help drivers see and understand the roadway conditions. More advanced forms of this strategy could include only turning the flashing beacon signs on during certain conditions, or moving to a variable message sign that displays speed feedback information to passing drivers (similar to system currently operating in the Burnt River Canyon area).

Benefits

Reduces curve related crashes by 10% (ODOT CMF RD 10)

System Requirements/ Software Enhancements

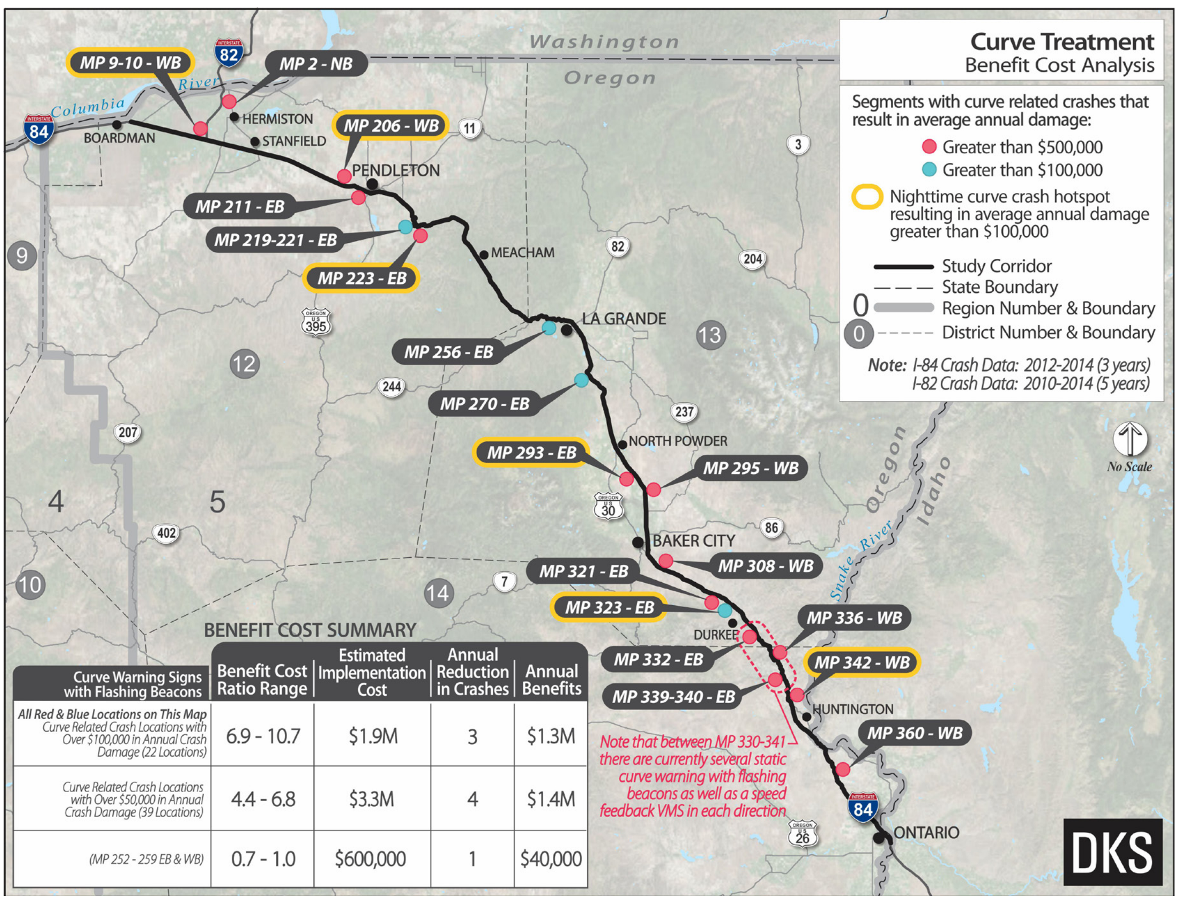
If solar powered beacons are used and on all the time, no additional software or enhancements are necessary.

If a more advanced system is selected, in which the beacons only turn on during certain conditions, software enhancements may be necessary.

Agency Resources & Partnerships

none identified

Figure 7. Curve Treatment Recommended Locations and Benefit Cost Results



BENEFIT COST SUMMARY

Curve Warning Signs with Flashing Beacons	Benefit Cost Ratio Range	Estimated Implementation Cost	Annual Reduction in Crashes	Annual Benefits
All Red & Blue Locations on This Map Curve Related Crash Locations with Over $100,000 in Annual Crash Damage (22 Locations)	6.9 - 10.7	$1.9M	3	$1.3M
Curve Related Crash Locations with Over $50,000 in Annual Crash Damage (39 Locations)	4.4 - 6.8	$3.3M	4	$1.4M
(MP 252 - 259 EB & WB)	0.7 - 1.0	$600,000	1	$40,000

Chain-up Areas: Real-time Parking Availability

Goal 1: Improve Safety	Goal 2: Improve Communications	Goal 3: Improve Road Closure Process & Reduce Impacts	Goal 4: Improve Resource Efficiency
Achieves Best	Achieves Best	Achieves Little	Achieves Little

Description

Install a system at chain up areas that informs drivers (particularly freight haulers) where room is available to park and install chains.

Benefits

Reduction in heavy vehicle related crashes

Reduction in crashes at chain up areas

Average Annual Benefit	Average Annual Cost $75,000		B/C Range
$18,000	Initial Capital Cost $1,500,000	Annual O&M $10,000	0.2 to 0.3*

System Requirements/ Software Enhancements

New software will be necessary for this strategy. Presently, the specific software cannot be identified. During the concept of operations process this element will be addressed.

Agency Resources & Partnerships

- ODOT maintenance and operations
- Oregon State Police
- Trucking associations

*The benefit cost ratio for this strategy does not capture the complete picture. A crash involving a semi-truck can severely impact roadway operations. The reported crashes only account for severity of injury, and not the full impact of a crash on delay to other drivers.

View of the westbound chain-up area near mile post 280

Remotely Operated Gates

Goal 1: Improve Safety	Goal 2: Improve Communications	Goal 3: Improve Road Closure Process & Reduce Impacts	Goal 1: Improve Resource Efficiency
Achieves Most	Does Not Achieve	Achieves Best	Achieves Best

Description
Install gates at select locations that can be controlled remotely to facilitate the road closure process. Gates may be installed at on-ramp locations, and potentially across the freeway, although further review is necessary for a remotely operated gate across the freeway.

Benefits
Improves maintenance crew safety

Allows faster closing of the freeway and reduces the number of vehicles entering hazardous driving conditions, which in turn may reduce crashes and allow quicker opening of the freeway.

Improve efficiency

Average Annual Benefit	Average Annual Cost		B/C Range
*see note below	$35,000 (ramp gate) $200,000 (freeway gate system)		*see note below
	Initial Capital Cost $215,000 (ramp gate) $1,300,00 (freeway gate system)	**Annual O&M** $1,000 (ramp gate) $5,000 (freeway gate system)	

System Requirements/ Software Enhancements
ODOT has existing software for remotely operated gates, some minor modifications may be necessary. Cameras should also be installed at locations to monitor activity while closing.

Agency Resources & Partnerships
- ODOT Maintenance and Operations
- Oregon State Police

* Benefit cost ratio only assumes reduced staff hours necessary for a closure. A more detailed analysis is necessary to determine which crashes could be prevented by installing remotely operated gates, as well as reducing the risk of a crew member getting injured while setting up cones on the freeway for a closure.

Enhance Existing Operations

In addition to recommending new strategies for implementation to improve safety and operations, the project team also evaluated how to enhance existing strategies that ODOT Region 5 currently operates. Three strategies rose to the top for further enhancements.

TRAVELER INFORMATION DURING CLOSURES

Improve traveler information provided to travelers and businesses during a road closure.

Key improvement ideas

- Provide as much detail as possible about the cause of the closure.
- Enhance TripCheck with links to information services during a closure.
- Capitalize on existing Highway Advisory Radio (HAR) equipment and add updated traveler communication devices.
- Send push notifications when necessary.
- Form an emergency management communication team.
- Create a TIM team that meets regularly.
- Expand situational software use for internal ODOT information.

LOCAL TRAFFIC SORTING PROCESS DURING CLOSURES

Improve the traffic sorting system for local traffic to proceed past a secondary closure if the traveler's destination comes before the primary point of closure.

Key improvement ideas

- Create a preclearance program.
- Provide public outreach and education to local travelers.
- Optimize sorting locations.
- Post real-time information directing travelers to sorting stations.
- Add volunteers to staff sorting stations.

TRUCK PARKING MANAGEMENT PLAN DURING CLOSURES

Identify the components and stakeholders necessary to develop a Truck Parking Management Plan during roadway closures.

Key improvement ideas

- First invest in ways to keep the freeway open as long as safely possible.
- Create a truck parking management plan.
- Alert traffic as far upstream as possible.
- Create additional truck parking locations through agreements and incentives.
- Develop on online portal showing available truck parking.
- Provide a shuttle between additional parking and services.

Phased Implementation Plan

Based on the benefit cost analysis and discussions with ODOT, the proposed phasing for the five recommended strategies are shown in Table 3.

This phasing plan targets first those projects with the highest benefit cost ratios. The near-term projects consist of curve warning applications and enhanced delineation at high priority locations. These projects are both relatively low cost, with high benefits, and few implementation challenges. The variable speeds along the Cabbage Hill and Meacham area (segment 1 of the variable speed segments analyzed) presents some implementation challenges especially related to connecting with power and communications, but the potential to reduce nine crashes a year provides the highest benefit cost ratio of the variable speed segments analyzed.

Table 3. Proposed Phasing

PHASING	POTENTIAL PROJECTS
Near-Term (1-3 years)	• Variable speeds for I-84 Segment 1 (MP 217-252) • Curve warning applications at high priority locations • Enhanced delineation at high priority locations
Mid-Term (3-5 years)	• Remotely operated gates at on-ramps (locations to be determined) • Curve warning and enhanced delineation for medium priority locations • Variable speeds for medium priority locations: I-84 Segment 4 Burnt River Canyon (MP 314-345), and I-84 Segment 3 Ladd Canyon (MP 266-277)
Long-Term (over 5 years)	• Chain-up area real-time parking information • Remotely operated gates on I-84 mainline

After implementing the near-term projects, roadway performance should be monitored. Based on performance results, projects may be modified. For example, if the curve warning signs with flashing beacons do not effectively reduce crashes in an area, then it may be worth exploring a more advanced strategy such as the VMS that provide speed feedback information and tell drivers to slow down through the curves. As funding becomes available, the future phases should be implemented as feasible.

Next Steps

As funding becomes available, ODOT will implement the high priority (near-term) strategies. Typically a Concept of Operations is developed before implementing a TSMO solution. However, in the case of this project, there is a statewide Concept of Operations for the Variable Speed System that will apply to this corridor. The curve treatment and enhanced delineation strategies are straightforward and do not require a Concept of Operations.

Four of the strategies that are relatively new to ODOT will be further explored in an Operations Feasibility Study.

NEW STRATEGIES IDENTIFIED IN THE IMPLEMENTATION PLAN

Chain-Up Area: Real-time Parking Availability

Remotely Operated Gates (on-ramps and on the freeway)

EXISTING STRATEGIES RECOMMENDED FOR FURTHER ADVANCEMENT IDENTIFIED IN ENHANCE EXISTING STRATEGIES MEMO

Local Traffic Sorting System – Preregistration Process

Truck Parking Management Opportunities

The purpose of the feasibility study is to identify challenges, system considerations, operations and maintenance considerations, and provide example applications to better inform ODOT's decisions for implementing each strategy. Based on the outcome of the Operations Feasibility Study, the scope and implementation details can be refined and then a Concept of Operations developed.