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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

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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.

<table>
<thead>
<tr>
<th>TOP FIVE RECOMMENDED NEW STRATEGIES</th>
<th>PHASING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Weather Responsive Variable Speed Systems</strong>&lt;br&gt;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.</td>
<td>Near Term (1-3 yrs)&lt;br&gt;(1 location)</td>
</tr>
<tr>
<td><strong>Proposed High Priority Location</strong>&lt;br&gt;• Cabbage Hill and Meacham (MP 217-252)&lt;br&gt;• Additional locations noted as medium and low priority</td>
<td></td>
</tr>
<tr>
<td><strong>2. Enhanced Delineation</strong>&lt;br&gt;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.</td>
<td>Near Term (1-3 yrs)&lt;br&gt;hot spot locations&lt;br&gt;Mid-Term (3-5 yrs)&lt;br&gt;additional locations</td>
</tr>
<tr>
<td><strong>Proposed High Priority Locations</strong>&lt;br&gt;• Several crash hot spot locations (see map on page 13)</td>
<td></td>
</tr>
<tr>
<td><strong>3. Curve Treatments</strong>&lt;br&gt;Install static signs with flashing beacons at curves with high crash frequency.</td>
<td>Near Term (1-3 yrs)&lt;br&gt;hot spot locations&lt;br&gt;Mid-Term (3-5 yrs)&lt;br&gt;additional locations</td>
</tr>
<tr>
<td><strong>Proposed High Priority Locations</strong>&lt;br&gt;• Several crash hot spot locations (see map on page 14)</td>
<td></td>
</tr>
<tr>
<td><strong>4. Chain-Up Area: Real-time Parking Availability</strong>&lt;br&gt;Install a system at chain-up areas that informs vehicles, especially trucks, where there is available space to park and install chains.</td>
<td>Mid–Long-Term (3-5 yrs)</td>
</tr>
<tr>
<td><strong>Proposed High Priority Locations</strong>&lt;br&gt;• Westbound chain-up area at MP 280</td>
<td></td>
</tr>
<tr>
<td><strong>5. Remotely Operated Gates</strong>&lt;br&gt;Install gates at select locations, either on ramps or on the interstate, that can be controlled remotely to facilitate the road closure process.</td>
<td>Mid-Term (3-5 yrs)&lt;br&gt;on-ramp locations&lt;br&gt;Long-Term (5+ yrs)&lt;br&gt;freeway locations</td>
</tr>
<tr>
<td><strong>Proposed High Priority Locations</strong>&lt;br&gt;• On-ramps throughout the corridor&lt;br&gt;• Mainline at typical points of closure</td>
<td></td>
</tr>
</tbody>
</table>
Additionally, 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.
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.

<table>
<thead>
<tr>
<th>Traffic Volumes</th>
<th>I-84</th>
<th>I-82</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crash Trends</th>
<th>I-84</th>
<th>I-82</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crash trends are inversely related to seasonal trends, with crash numbers quadrupling during winter months.</td>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key Crash Causes</th>
<th>I-84</th>
<th>I-82</th>
</tr>
</thead>
<tbody>
<tr>
<td>• weather conditions (60%)</td>
<td>• speed (52%)</td>
<td></td>
</tr>
<tr>
<td>• speed (70%)</td>
<td>• fatigue (43%)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key Crash Types</th>
<th>I-84</th>
<th>I-82</th>
</tr>
</thead>
<tbody>
<tr>
<td>• roadway or lane departure crashes (65%)</td>
<td>• fixed object crashes (36%)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Conditions</th>
<th>I-84</th>
<th>I-82</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hot Spots</th>
<th>I-84</th>
<th>I-82</th>
</tr>
</thead>
<tbody>
<tr>
<td>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).</td>
<td>Southbound near the Columbia River crossing.</td>
<td></td>
</tr>
</tbody>
</table>
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 Transportation System (ITS) devices currently operate along the corridor, as indicated in the

<table>
<thead>
<tr>
<th>Existing ITS devices along I-84 and I-82</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Message Signs</td>
</tr>
<tr>
<td>Closed Circuit TV Cameras</td>
</tr>
<tr>
<td>Snow Zone Signs</td>
</tr>
<tr>
<td>Actuated Curve Feedback Signs</td>
</tr>
<tr>
<td>Road Weather Information System Stations</td>
</tr>
<tr>
<td>Highway Advisory Radio</td>
</tr>
<tr>
<td>Weather Responsive Variable Speed Limit (VSL) System</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Operation Area</th>
<th>Key Needs Identified</th>
</tr>
</thead>
</table>
| 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.                                                                                                                      |
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 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

<table>
<thead>
<tr>
<th>SEGMENT</th>
<th>ANNUAL AVERAGE CRASHES PER MILE*</th>
<th>CRASH RATE PER MILLION VMT**</th>
<th>PERCENT RELATED TO:</th>
<th>VSL SYSTEM RECOMMENDED? PRIORITY?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cabbage Hill-Meacham</td>
<td>3.2</td>
<td>0.9</td>
<td>73%</td>
<td>72%</td>
</tr>
<tr>
<td>2. Grande Ronde River</td>
<td>3.0</td>
<td>0.9</td>
<td>55%</td>
<td>45%</td>
</tr>
<tr>
<td>3. Ladd Canyon</td>
<td>2.7</td>
<td>0.8</td>
<td>70%</td>
<td>56%</td>
</tr>
<tr>
<td>4. Burnt River Canyon</td>
<td>1.7</td>
<td>0.5</td>
<td>68%</td>
<td>63%</td>
</tr>
<tr>
<td>5. I-82 from I-84 to Washington state line</td>
<td>1.8</td>
<td>0.4</td>
<td>57%</td>
<td>48%</td>
</tr>
<tr>
<td>Baker Valley Area (for comparison purposes)</td>
<td>2.0</td>
<td>0.6</td>
<td>72%</td>
<td>45%</td>
</tr>
</tbody>
</table>

*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.

**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

<table>
<thead>
<tr>
<th>CRASH SEVERITY</th>
<th>ASSOCIATED COST (ODOT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal</td>
<td>$2,300,000</td>
</tr>
<tr>
<td>Disability Injury</td>
<td>$2,300,000</td>
</tr>
<tr>
<td>Moderate Injury</td>
<td>$79,200</td>
</tr>
<tr>
<td>Minor Injury</td>
<td>$79,200</td>
</tr>
<tr>
<td>Property Damage Only (PDO)</td>
<td>$19,400</td>
</tr>
</tbody>
</table>
Weather Responsive Variable Speed System

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieves Best</td>
<td>Achieves Best</td>
<td>Achieves Some</td>
<td>Achieves Some</td>
</tr>
</tbody>
</table>

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
Enhanced Roadway Delineation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieves Best</td>
<td>Achieves Best</td>
<td>Does Not Achieve</td>
<td>Does Not Achieve</td>
</tr>
</tbody>
</table>

**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**

![Enhanced Delineation Benefit Cost Analysis](image)

Segments with crashes during compromised visibility conditions that result in average annual damage:
- Reduces curves crashes during dark conditions by 30% (ODOT CMF – RD 13)
- Reduces crashes during other compromised visibility conditions by 10%.

**Enhanced Delineation**

- Study Corridor
- State Boundary
- Region Number & Boundary
- District Number & Boundary

**Note:** I-84 Crash Data: 2012-2014 (3 years)  
I-82 Crash Data: 2010-2014 (5 years)
Curve Treatment

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieves Best</td>
<td>Achieves Best</td>
<td>Does Not Achieve</td>
<td>Does Not Achieve</td>
</tr>
</tbody>
</table>

**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
Chain-up Areas: Real-time Parking Availability

**Goal 1:** Improve Safety
Achieves Best

**Goal 2:** Improve Communications
Achieves Best

**Goal 3:** Improve Road Closure Process & Reduce Impacts
Achieves Little

**Goal 4:** Improve Resource Efficiency
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

<table>
<thead>
<tr>
<th>Average Annual Benefit</th>
<th>Average Annual Cost</th>
<th>B/C Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>$18,000</td>
<td>$75,000</td>
<td>0.2 to 0.3*</td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Goal 1: Improve Safety</th>
<th>Goal 2: Improve Communications</th>
<th>Goal 3: Improve Road Closure Process &amp; Reduce Impacts</th>
<th>Goal 1: Improve Resource Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieves Most</td>
<td>Does Not Achieve</td>
<td>Achieves Best</td>
<td>Achieves Best</td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Average Annual Benefit</th>
<th>Average Annual Cost</th>
<th>B/C Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>*see note below</td>
<td>$35,000 (ramp gate)</td>
<td>*see note below</td>
</tr>
<tr>
<td></td>
<td>$200,000 (freeway gate system)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial Capital Cost</th>
<th>Annual O&amp;M</th>
</tr>
</thead>
<tbody>
<tr>
<td>$215,000 (ramp gate)</td>
<td>$1,000 (ramp gate)</td>
</tr>
<tr>
<td>$1,300,000 (freeway gate system)</td>
<td>$5,000 (freeway gate system)</td>
</tr>
</tbody>
</table>

**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.
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 an online portal showing available truck parking.
- Provide a shuttle between additional parking and services.
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

<table>
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<tr>
<th>PHASING</th>
<th>POTENTIAL PROJECTS</th>
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| **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.
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.

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.