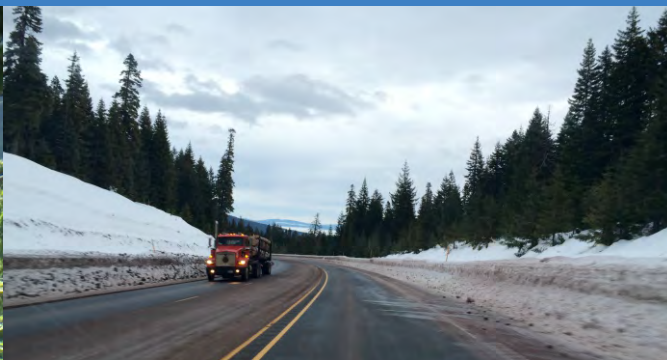
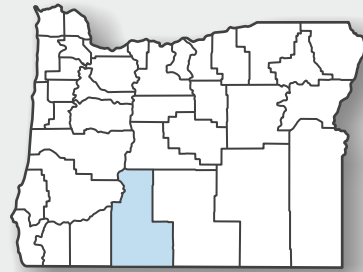


Klamath County Intelligent Transportation System (ITS) Plan



Prepared for



Prepared by



July 2016

Blank Page

Acknowledgements

ODOT Project Manager

Rick Williams Oregon Department of Transportation – Region 4

Technical Advisory Committee

Mark Barrett	ODOT Region 4 Traffic
Kelly Brennan	City of Klamath Falls
Ryan Groshong	ODOT
Dave Hirsch	ODOT Region 4
Roger Lindgren	Oregon Institute of Technology (OIT)
Joel McCarroll	ODOT Region 4
Galen McGill	Oregon Department of Transportation ITS Unit
Nathaniel Price	Federal Highway Administration (FHWA)
Mike Stinson	ODOT District 11
Stan Strickland	Klamath County
Mark Willrett	City of Klamath Falls
James Wittenberg	ODOT

Additional Stakeholders

Chuck Brannan	ODOT – Incident Response Patrol
Chuck Cox	City of Klamath Falls
Sean Denniston	National Park Service
Keith Endicott	Klamath 911
Phil Grant	ODOT – Klamath Falls Port of Entry
Kirsten Hardin	National Park Service
Dave Henslee	Klamath Falls Police Department
John Ketchum	Keno Fire Department
David Moyer	ODOT – Incident Response
Ernie Palmer	Basin Transit
Shawn Stephens	ODOT – Transportation Maintenance Manager
Jason Westfall	Oregon State Police
Dale Wetzel	Bear Cat Trucking

Consultant Team – DKS Associates

Deena Platman	Chris Muhs
Jennifer Bachman	Danella Whitt
Carl Olson	Renee Zmuda

Table of Contents

Executive Summary.....	1
Introduction.....	2
Visions, Goals, and Objectives	2
Vision	3
Goals and Objectives.....	3
ITS Needs Assessment Summary.....	3
Strengths and Challenges	6
Strengths.....	6
Challenges.....	6
WorkShop Summary	7
ITS Deployment Plan	8
Summary of Project Information	8
Connected Vehicle Considerations.....	9
High priority strategies.....	9
Traffic Operations and Management	10
Weather Event Management	16
Maintenance and Construction Management	19
Emergency and Incident Management.....	21
Public Transportation Management.....	23
Freight Management	24
Proposed ITS Devices	25
ITS Communications Plan	27
Methodology	27
Existing communication infrastructure in Klamath County	27
Communications Plan Recommendations	27
Backbone Infrastructure	28
Shared communications	29
Communications in a Connected Vehicle Future	30
Use Cases	30
Application of the Communications Plan	37
Pre-Design Planning Review	37
Final Planning Review	38
Communications Plan Updates.....	38

Appendices	39
Appendix A: Deployment Plan Matrix	
Appendix B: Existing Conditions Memorandum	
Appendix C: Needs Assessment Memorandum	
Appendix D: Signal Maintenance Agreement	

List of Figures

Figure 1: Existing and Proposed ITS Devices	26
Figure 2: Communication Option for Connecting non-ODOT ITS devices to ODOT’s Central System.....	32
Figure 3: Communication Option Connecting City or County ITS Devices to Local Agency System	33
Figure 4: Existing and Proposed Traffic Signals and Communications in Klamath Falls	34

List of Tables

Table 1: High Priority Needs.....	5
Table 2: Communication Options.....	28
Table 3: Standard Bandwidth Requirements for Select ITS Devices	30

Blank Page

EXECUTIVE SUMMARY

Intelligent Transportation System (ITS) strategies improve the safety, operation, and efficiency of the roadway network by enabling system management and operation techniques. ITS strategies focus on improving operations of existing infrastructure, which is typically a lower cost solution than simply building additional capacity. This ITS Plan focuses on improving the operations and safety for the Klamath County roadway network.

The ITS Plan for Klamath County is a collaborative process between ODOT, Klamath County, City of Klamath Falls, and FHWA. It focuses on both the urban and rural areas, and offers ITS strategies to improve transportation throughout the county. The key goals of the Klamath County ITS plan are to improve the safety and efficiency of the transportation system, improve multi-modal traveler information, and to improve partnerships between agencies that operate the transportation network.

The ITS Plan includes both a Deployment Plan and Communications Plan:

Deployment Plan - Prioritized list of 43 ITS strategies for the area to implement as funding becomes available.

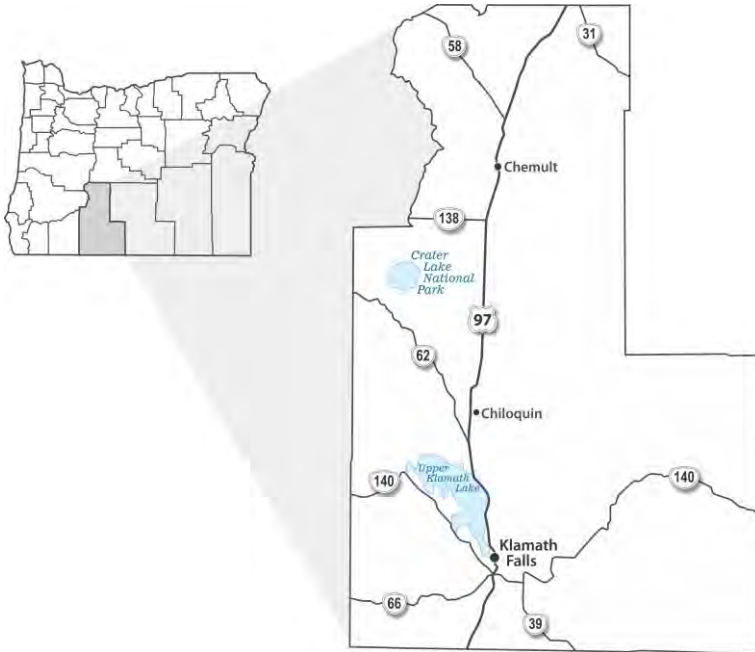
Communications Plan - Framework for determining how best to connect the ITS devices to the transportation network.

The ITS Deployment Plan organizes the strategies into six categories. The highest priority strategies are listed here:

- **Traffic Operations and Management**
 - Connect all of the traffic signals in Klamath County to the ODOT central signal system
 - Connect existing cameras to the ODOT TripCheck system and install additional cameras
 - Install variable message signs at key locations, mostly along US 97
 - Install enhanced pedestrian crossings
 - Install bicycle and pedestrian detection and counters at select locations
- **Weather Event Management**
 - Install additional road weather information systems (RWIS) and ice detection systems
 - Install automated changeable snow zone signs
- **Maintenance and Construction Management**
 - Improve telematics technology on fleet vehicles
- **Emergency and Incident Management**
 - Connect the 9-1-1 Dispatch Center direction with ODOT and OSP
 - Develop traffic incident management (TIM) team
 - Improve interoperable communication procedures
 - Implement situational software
- **Public Transportation Management**
 - Improve real-time transit information
 - Automate transit vehicle on-board data tracking and logging
- **Freight Management**
 - Provide truck signal dilemma zone protection at key signalized intersections
 - Automate freight restriction notifications to drivers
 - Provide real-time truck parking availability information for truck parking facilities

INTRODUCTION

The Klamath County ITS Plan identifies and prioritizes ITS investments that address the needs, goals, and objectives of the region over the next five years. As funding becomes available, the document should serve as a guide to help determine which strategies to implement, where they apply, and how they will operate. Due to rapidly changing technology, ITS plans should be treated as living documents with updates occurring every five years or more frequently if necessary.



Klamath County is located in south central Oregon with a population of about 70,000 people. The largest city in Klamath County is Klamath Falls, where about one-third of the county's population resides. Beyond Klamath Falls the county is largely rural. The county is home to Crater Lake National Park and the Volcanic Legacy Scenic Byway. The main north-south thoroughfare is US 97. To the east, OR 140 (Lake of the Woods Highway) connects to Medford and OR 66 connects to Ashland. To the west, OR 140 connects to Lakeview.

The Deployment Plan lists a set of prioritized ITS investments for Klamath County that represent the needs of the area's stakeholders and is consistent with the goals and objectives

developed as part of this ITS plan. The Communications provides guidelines for connecting ITS devices to the communications network.

Development of the Klamath County ITS Plan was a collaborative process with stakeholders representing key agencies and interests in the county:

- ODOT
- Federal Highway Administration
- City of Klamath Falls
- Klamath County
- Police Departments (OSP and Klamath Falls)
- National Park Service
- Freight
- Public Transit

A core group of stakeholders served as the technical advisory committee (TAC), providing input at every step of the process. During the project initiation phase a broader group of stakeholders were interviewed to ensure needs were captured across all realms of the transportation network. Then during the later phases of the project, the project team held a stakeholder workshop to get feedback on the proposed ITS strategies.



VISIONS, GOALS, AND OBJECTIVES

The project team and stakeholders created a vision and supporting goals and objectives to guide the selection and prioritization of ITS strategies deployed in the Klamath County ITS Plan.

The purpose and general guidelines for developing the vision, goals, and objectives are described below:

Vision: The purpose of a vision is to describe the desired end-state. Ideally a vision statement is a concise one sentence statement that describes the clear long-term change resulting from the Klamath County ITS Plan.

Goals: Goals help establish the direction of the plan. The goals need to align with the vision, but do not indicate how the goal will be achieved.

Objectives: Objectives should be specific steps necessary to achieve the goals.

Vision

Transportation system operators in Klamath County use advanced, connected technologies and coordinated management techniques to actively manage and operate its transportation system, enhancing the safety and efficiency of multi-modal travel.

Goals and Objectives

Goal 1: Enhance safety for all roadway users

- a) Reduce weather related, wildlife, and other types of crashes
- b) Reduce incident detection, response and clearance times
- c) Enhance safety for pedestrians and bicyclists at roadway crossings

Goal 2: Enable the efficient management of the transportation system

- a) Improve communication between agencies
- b) Enhance maintenance and operational efficiencies
- c) Improve communications between the 911 call center, ODOT TOCs, and incident responders to provide responders with better information prior to arriving at an incident scene
- d) Actively monitor and manage performance of the transportation system

Goal 3: Enhance multi-modal traveler information

- a) Deliver accurate and reliable real-time road condition and weather information to all travelers
- b) Develop real-time freight traveler information
- c) Develop real-time transit information
- d) Develop pedestrian and bicycle information database

Goal 4: Build cooperation and partnership across stakeholders who manage and operate the transportation system

- a) Share resources between local and regional agencies
- b) Establish and facilitate regular coordination and cooperation
- c) Coordinate and integrate ITS projects across agencies and service providers in Klamath County
- d) Promote public and private partnerships for ITS deployment, operations, and maintenance

ITS NEEDS ASSESSMENT SUMMARY

The project team documented the existing transportation conditions for Klamath County at the onset of the project. The existing conditions memorandum¹ provides an overview of the current transportation system, operations, and inventory throughout the county to establish the baseline conditions that the ITS project will build upon. The full existing conditions memorandum is attached as Appendix B.

Once the baseline conditions were documented and understood, stakeholders identified intelligent transportation system (ITS) needs for Klamath County. The needs assessment process included input from the technical advisory members as well as interviews with staff from the following six organizations: Basin Transit,

¹ Klamath County ITS Project – Existing Conditions Memorandum. Prepared by ODOT. November 2015.

City of Klamath Falls (street and maintenance divisions), ODOT Maintenance, ODOT Incident Response Patrol, ODOT Klamath Falls Port of Entry, and Keno Fire Department.

A complete listing of needs is included in the “User Needs Assessment Memorandum”², attached in Appendix C. The needs are organized into one of six categories:

- Traffic Operations and Management
- Weather Event Management
- Maintenance and Construction Management
- Emergency and Incident Management
- Public Transportation Management
- Freight Management

Table 1 summarizes the high priority needs in each of the six categories.

² Klamath County ITS Plan – User Needs Assessment Memorandum. Prepared by DKS Associates. February 2016.

Table 1: High Priority Needs

Traffic Operations and Management
• Provide remote access to traffic signals in the county through ODOT's central system • Ability to interconnect to field equipment and access video detection • Improve pedestrian and bicycle crossings and data collection • Address run-off-the road crashes • Continue updating traffic signal controllers from 170s to 2070s • Address speed disparity for travel conditions • Ability to view local agency cameras on TripCheck • Provide drivers with route information prior to key junctions (such as detours or closures) • Provide drivers with active warnings when wildlife is present in or near the roadway • Ability to monitor performance of the transportation system and share data with participating agencies (counts, video, etc.)
Weather Event Management
• Address weather-related crashes • Provide better real-time road weather conditions across the county • Improve ice detection system • Ability to change snow zone signs remotely
Maintenance and Construction Management
• Ability to automate vehicle maintenance logs • Ability to automate infrastructure maintenance logs (traffic signal controllers, street lights, cameras, VMS, etc.)
Emergency and Incident Management
• Ability to connect the 9-1-1 dispatch center with ODOT and OSP • Provide traveler information via portable VMS during events. • Improve radio communications interoperability • Ability to transmit photos and video from an incident scene
Public Transportation Management
• Provide transit riders with real-time bus arrival information • Provide transit riders with automated notifications if weather or other events affect transit routes • Improve pedestrian crossings to reach bus stops • Provide an updated website for Basin Transit
Freight Management
• Reduce the likelihood of trucks running red lights through the Klamath Falls area (truck signal dilemma zone protection) • Provide an automated method to alert truck drivers about restrictions along routes (width, height, weight, etc.) • Provide real-time parking availability information to truck drivers

Strengths and Challenges

During the interviews and project meetings, the project team identified strengths and challenges that may affect ITS opportunities for Klamath County. The following two sections highlight key strengths and challenges.

Strengths

- Staff longevity and strong working relationships between agencies.
- Funding available for the 9-1-1 dispatch interconnect project.
- Low to moderate levels of congestion expected through 2033 projections.
- Completed Variable Speed Study for US 97 with recommendation for a weather responsive variable speed system.
- Several traffic signals already upgraded to 2070 controllers.
- Some video detection is already in place.
- Current use of advanced situational software by Keno fire department.

Challenges

- Lack of existing communication infrastructure.
- Lack of reliable cellular coverage throughout the County.
- Lack of power connection options to remote equipment locations.
- Outdated and malfunctioning field equipment.
- Severe winter weather and mountainous terrain.
- Long stretches of roadway with no alternate route options.
- Funding challenges, particularly for on-going maintenance.

WORKSHOP SUMMARY

Based on the key needs identified by stakeholders, the project team developed an initial set of 51 proposed strategies for the deployment plan. Then through the process of stakeholder input a final set of 43 strategies are included in the Deployment Plan.

On March 2, 2016, a workshop was held to discuss the proposed strategies for the Klamath County ITS Plan. In addition to the technical advisory committee which consisted of staff from ODOT, FHWA, City of Klamath Falls, Klamath Co, and Oregon Institute of Technology, the stakeholder audience was expanded to include participants from Oregon State Police, Fire Departments, Klamath Falls Police Department, Basin Transit, Crater Lake National Park, ODOT Incident Responders, ODOT Freight, and a Freight Operations Company. The main purpose of the workshop was to obtain feedback from participants about the proposed strategies, begin to prioritize the strategies, and identify any missing strategies.

The workshop began with a short presentation to provide the project background and explain what ITS strategies are to those unfamiliar with the topic. Then participants broke into three groups that rotated between three poster stations, each with two poster boards of proposed strategies. The participants asked questions, reviewed, and provided feedback on all the strategies. Each rotation lasted about 30 to 40 minutes.

After the activity, participants reconvened and presented a brief summary of the input received during the sessions.



Photo: March 2016 Workshop

ITS DEPLOYMENT PLAN

This section includes a summary of the ITS Deployment Plan for Klamath County. The Deployment Plan is essentially a list of prioritized strategies to be implemented within Klamath County. The strategies are organized in six categories and then grouped by priority (high, medium, or low).

The six categories, consistent with the needs assessment organization, are:

- Traffic Operations and Management (TM)
- Weather Event Management (W)
- Maintenance and Construction Management (MC)
- Emergency and Incident Management (EM)
- Public Transportation Management (P)
- Freight Management (F)

The letter(s) following each category are used to note the reference number of projects within a category (example TM01, TM02, etc.).

The strategies selected for the ITS Deployment Plan are prioritized as high, medium or low, which correlates to whether the strategy will be implemented in the near term (next two-three years), mid-term (three to five years), or longer term (beyond five years). The prioritization is based on feedback from stakeholders, as well as feasibility of implementation which is highly reflective of project cost and associated benefits. Although the “high” priority strategies are typically implemented before “low” priority strategies, if funding and opportunities arise to implement a lower priority strategy the opportunity should be embraced.

Information about the high priority strategies are included in this section of the report; the full Deployment Plan Matrix is attached in Appendix A and includes more detailed information for all the strategies (high, medium, and low priority).

This section provides an overview of what information is provided for each strategy, and a summary of the high priority strategies.

Summary of Project Information

For each deployment strategy the following information is provided in the full Deployment Plan Matrix:

- Project Number – for reference purposes only.
- Project Name
- Description – describes the purpose of the strategy and identifies specific locations where the strategy will be implemented if applicable.
- Priority – high, medium, or low. High priority represent strategies targeted for implementation within the next two-three years; medium priority represent strategies targeted for implementation within the next three to five years; and low priority strategies correlate to implementation beyond five years.
- Responsible party(s) – these parties are identified as being the key champions to pursue and implement the strategy.
- Expected benefits and costs - both qualitative and quantitative benefits are included, and costs are broken down into initial capital cost and ongoing annual operations and maintenance costs (such as

ongoing maintenance, staffing, and equipment replacement costs). The benefits and costs were derived from a combination of four key resources:

- ITS benefits database³. This database houses case studies from all over the world including both benefits and costs associated with specific deployments. A detailed cost spreadsheet that includes both initial capital costs and ongoing operations and maintenance costs is maintained by this site.
 - Crash Modification Factors (CMFs) Clearinghouse⁴ provides information about how strategy (also called a countermeasure) will effect crashes. The CMFs are based on before and after studies that determine how a strategy effected crashes (types, severity, frequency) after it was implemented. That factor can then be applied to future applications to predict how the strategy effects future crashes at a given location or along a corridor.
 - Tool for Operations Benefit Cost Analysis (TOPS-BC). This tool was created by the FHWA Office of Operations as a sketch-planning analysis tool for TSMO related strategies. It provides both costs and benefits on an annualized basis to produces a benefit: cost ratio.
 - Past project experience and construction bids in Oregon
- Feasibility and project dependencies - describes information relevant to implementing the strategy.
 - Potential for connected vehicle application – In the full matrix this category is either checked as a “yes” or left blank. For the high priority strategies with potential connected vehicle applications, this section provides a more detailed explanation of the related application (see the *Connected Vehicle Considerations* section in the next paragraph).

Connected Vehicle Considerations

Several strategies have a potential connected vehicle element, meaning that the strategy could involve vehicles communicating with roadside devices or with other vehicles. Connected vehicle technology is emerging and quickly advancing. By identifying which strategies are likely to have a connected vehicle element in this Deployment Plan, the goal is to highlight the opportunity so it can be addressed during project design. If a strategy has connected vehicle potential, the appropriate strategy from the Connected Vehicle Reference Implementation Architecture (CVRIA)⁵ is noted with a brief description of the application.

High Priority Strategies

This section summarizes the high priority projects in each of the six categories. For a complete listing of deployment projects see Appendix A.

³ Website maintained by the US DOT ITS Joint Program Office: <http://www.itsbenefits.its.dot.gov/>. Accessed July 12, 2016.

⁴ Website maintained by the US DOT Federal Highway Administration: <http://www.cmfclearinghouse.org/>. Accessed July 12, 2016

⁵ Website: <http://www.iteris.com/cvria/html/applications/applications.html>. Accessed June 23, 2016.

Traffic Operations and Management

Traffic Operation and Management strategies target ways to improve communications, traffic signal operations, surveillance, and traveler information throughout the roadway network.

Figure 1 shows the proposed locations for several of the ITS devices proposed in this section including camera, variable message signs, Figure 4 in the Communications Plan section illustrates traffic signal and communication upgrades within the City of Klamath Falls. These projects are described in MC02 and MC05.

TM01 Install communications and maintain up to date communications map

Install roadside communication connections to ITS field devices and maintain a current map of all communications and ITS devices. See “*Communications Plan*” section of this report.

Expected Benefits:

- Operational efficiencies (varies by device)

Lead Agencies

ODOT, Klamath Falls

Capital Cost

Variable by project

Annual O&M Cost

Variable

TM02 Connect traffic signals in Klamath County to ODOT central traffic signal server

Key traffic signal locations that need to be connected to the ODOT central traffic signal server (see Figure 4):

- Foothills Rd/Washburn Way (planned)
- Altamont Dr. & Hilyard, Bristol
- Washburn & Crosby, Hilyard, Trail crossing, Bristol

Expected Benefits:

- Operational efficiency, allowing ODOT to immediately view and respond to signal operation issues

Lead Agencies

ODOT

Capital Cost

Varies based on communication method

Annual O&M Cost

variable

TM03 Provide City of Klamath Falls access to ODOT's central signal system

Provide the ability for Klamath Falls and Klamath County to access ODOT's central signal system. Access rights to be determined.

Expected Benefits:

- Improve efficiency and ability to analyze and adjust traffic signal operations.

Lead Agencies

ODOT, Klamath Falls

Capital Cost

N/A

Annual O&M Cost

Staff time

TM04 Install new PTZ cameras at select intersections and connect to TripCheck

Key locations:

- Signal detection cameras along 6th Street
- 6th / Washburn - currently uses video detection
- US 97 271.2 @ truck weight station
- Shasta Way / 6th - currently uses video detection
- Onyx & Washburn - currently uses video detection
- Campus/Dahlia - currently uses video detection

Expected Benefits:

- Improve access to real-time information for operators and travelers

Lead Agencies

ODOT

Capital Cost

Minimal

Annual O&M Cost

\$1,000

TM05 Update signal controllers to current standard

Highest priority locations (see Figure 4):

- ODOT traffic signals at: OR140/OR66 and US97B/Biehn Street
- City of Klamath Falls traffic signals along 6th Street, Washburn Way, and Shasta Way

Lower priority locations:

- Klamath Falls downtown core which operates on fixed timing (Klamath Ave and Main Street traffic signals)

Expected Benefits:

- Capable of advance features and remote access

Lead Agencies

ODOT, Klamath Falls

Capital Cost

Dependent on intersection and required upgrades

Annual O&M Cost

Variable, dependent on communications

TM06 Install enhanced pedestrian crossings (mid-block and/or intersections)

Install AVL and activity logging capabilities (sanding, de-icing, and spraying) in maintenance and construction
Install enhanced mid-block pedestrian crossings such as pedestrian hybrid beacons (PHB), rectangular rapid flashing beacons (RRFBs), or full traffic signals. Each location needs to be studied to determine appropriate treatment.

Locations:

- OCE crossings - Homedale, Altamont, OR 39 (funded)
- S 6th Street (funded)
- Campus Dr./Daggett Ave (near OIT) - note that this intersection is currently being evaluated for a roundabout
- Campus Dr./Campus Dr. (near OIT)

Expected Benefits:

- Decrease in pedestrian crashes
- A study based on HAWK signals showed a 69% decrease in pedestrian-vehicle crashes, CMF ID: 2922). Note - this study placed HAWK signals AT intersections, not mid-block.
- PHB can achieve 98% driver compliance and a 58% reduction in pedestrian crashes (ODOT)
- RRFB can achieve 85% driver compliance during the day and 90% at night.

Lead Agencies

ODOT, Klamath Falls

Capital Cost

\$20,000 (RRFB)

\$100,000 (full signal mid-block)

Annual O&M Cost

\$1,000

Connected Vehicle Potential: *Pedestrian Mobility or Pedestrian in Signalized Crosswalk Warning* applications – using mobile devices (such as smartphones) to detect pedestrians, warn motorists of pedestrian presence, and customize crossing times for persons with special needs.

TM07 Install bicycle and/or pedestrian detection and counters

Locations:

- OCE trail or all crossing Summers, Washburn, Hwy 39, Madison.
- Along Kit Carson Trail roadway crossings

Expected Benefits:

- Improve understanding of how bicycles and pedestrians utilize specific corridors
- Use data to seek funding opportunities

Lead Agencies

ODOT, Klamath Falls

Capital Cost

\$6,000 (radar detection and data collection)

Annual O&M Cost

\$400/detector

Connected Vehicle Potential: *Pedestrian Mobility* application – using mobile devices (such as smartphones) to detect pedestrians.

TM08 Install Variable Message Signs (VMS) at key junctions

Install variable message signs prior to key junction points to inform drivers of road conditions and detours. (See Figure 1 for locations)

Locations:

- SB on US 97 north of Crescent Cutoff Road
- NB on US 97 prior to OR 58 junction
- SB US 97 at MP 204 (part of VSL project)
- SB on US 97 north of OR 138 (NB VMS already in place)
- NB and SB on US 97 at MP 223 (part of VSL project)
- NB US 97 at Silver Lake Road (Emergency Route)
- NB on US 97 at MP 244 (part of VSL project)
- NB on US 97 at Sprague River Rd (SB already in place near Chiloquin)

- SB on US 97 north of Klamath Falls
- EB on OR 140 prior to West Side Rd (approx. MP 43)
- Crater Lake Park approaches - NB on OR 62 and WB on OR 138 - link to ODOT system

Expected Benefits:

- Improve traveler information and driver's ability to make informed decisions
- A study in rural Missouri showed that 94% of drivers took the action indicated on the VMS
- Decrease mean driving speed and crash severity when VMS are used to communicate weather information and roadway conditions
- Another study in rural Missouri used VMS to notify drivers about a significant detour during a bridge closure. 41% of drivers learned of the closure via VMS (media was also used to inform drivers - TV, radio, newspaper, etc.)

Lead Agencies

ODOT

Capital Cost

\$40,000 to \$100,000 per sign (ITS database)

additional costs:

- mounting structure \$100,000 to \$200,000 range
- communication cost is highly variable and dependent on location options

Annual O&M Cost

\$5,000

additional cost if communication is leased

Connected Vehicle Potential: *Advanced Traveler Information Systems* application – send traveler information directly to vehicle.

TM09 Install cameras with live feed capabilities

Install cameras to be used for both operational purposes and traveler information purposes. (See Figure 1)

Locations:

- Silver Lake Road MP 27
- Dead Indian Memorial MP 30.6
- Williamson River Road MP 17
- OR 140 to Medford near MP 20-24
- OR 39 – need one near Merrill
- OR 66 – mile post 43
- OR 62 – mile post 83.6

Expected Benefits:

- Travelers perceive enhanced safety by being better prepared for roadway conditions
- Lower traveler frustrations due to better real-time information
- Potential to improve incident response if the incident is within view of a camera

Lead Agencies
ODOT

Capital Cost
\$7,000 - \$20,000 per camera

additional cost if mounting pole
and foundation are needed
(~\$20,000)

Annual O&M Cost
\$2,000

TM10 Connect the Crater Lake National Park camera to TripCheck

Connect the camera at Crater Lake (on Munson Valley Road at Park Entrance) to the ODOT TripCheck system and display snow zone information and also alert travelers about the lack of gas stations in the park vicinity. The National Park Service regularly assists travelers who run out of gas.

Expected Benefits:

- Improve traveler information
- Decrease occurrences of travelers running out of gas in the park

Lead Agencies
ODOT, NPS

Capital Cost
N/A

Annual O&M Cost
\$5,000

TM11 Operations / Coordination Team

Implement a team of traffic operators between ODOT, Klamath Falls, and Klamath County to convene regularly with the purpose of sharing information and moving towards more efficient operations. Frequency of meetings to be determined.

Expected Benefits:

- Improved understanding of roles and responsibilities between partner agencies
- Opportunities to advance and gain support for projects among partner agencies

Lead Agencies

ODOT

Capital Cost

N/A

Annual O&M Cost

Staffing time

Weather Event Management

Weather Event Management strategies address ways to detect hazardous roadway conditions early and communicate that information to travelers. These strategies also target operational efficiencies during hazardous weather conditions.

Figure 1 (in the *ITS Communications Plan* section of this report) shows the proposed locations for the ITS devices proposed in this section.

W01 Install Road Weather Information Systems (RWIS) with ice detection at key locations

Key RWIS locations (see Figure 1):

- OR 140 to Medford near MP 20-24
- OR 39 – near Merrill
- OR 66 – mile post 43
- OR 62 Crater Lake Hwy – mile post 83.6
- Potential Camera/Weather Station @ Crater Lake with images shared in Trip Check (see TM09)

Expected Benefits:

- Travelers perceive enhanced safety by being better prepared for roadway conditions
- Lower traveler frustrations due to better real-time information
- Expected B:C ratios 2:1 to 10:1
- Improved weather information leads to more efficient application of anti-icing chemicals, reduced maintenance costs, reduced delay, and increases safety (US DOT)

Lead Agencies

ODOT

Capital Cost

\$25,000 to \$40,000 (ITS database and US DOT)

additional costs: communications, cameras, or other sensors

Annual O&M Cost

\$5,000

additional cost if communication services are leased

Connected Vehicle Potential: *Road Weather Motorist Alert and Warning* or *Spot Weather Impact Warning* applications – collect and distribute road weather warnings and information directly through connected vehicles.

W02 Install activated ice warning signs at key locations

Install activated ice warning signs at key locations that notify drivers (via VMS, flashing beacons, or other means) when roadway conditions are icy. For optimal benefit, detection segments should be short and warning systems frequent. Ice detection could use an existing or proposed RWIS station, or a grip factor sensor at the sign location. (See Figure 1)

Locations:

- OR 140 MP 19-40 Lake of the Woods - existing RWIS and ice detection near MP 35 and 36
- OR 140 MP 51-59 (Doak Mountain) - existing RWIS station at MP 54
- US 97 MP 178-204 (north of Chemult) - existing RWIS stations near MP 204 and 185)
- US 97 MP 229-235 - note this is within VSL project area, existing RWIS at north end
- US 97 MP 241-246 (Spring Creek Hill) - note this is within VSL project area, existing RWIS at north end
- US 97 MP 258-267 (Modoc Point to Shady Pine Rd) - existing RWIS at north end
- US 97 MP 283-288 Klamath Straights
- OR 66 west of Keno MP 32-45 (proposed RWIS nearby)
- OR 58 MP 70-83 Crescent Lake Highway

Expected Benefits:

- Ice Curve Warning System reduced ice-related crashes by 18% (CMF ID: 4114, 2 star)

Lead Agencies

ODOT

Capital Cost

\$5,000 to \$45,000 (cost does NOT include power or communications)

Lower price range assumes use of nearby RWIS station or installing grip factor only sensors at sign location.

Higher price range assumes full RWIS station with project.

Annual O&M Cost

\$5,000

Connected Vehicle Potential: *Road Weather Motorist Alert and Warning or Spot Weather Impact Warning* applications – collect and distribute road weather warnings and information directly through connected vehicles.

W03 Install automatic snow VMS signs

Install dedicated signs for snow conditions, not general variable message signs. Signs could use a rotator drum or an electronic display. (See Figure 1)

Locations:

- US 97 NB near mile post 240-243 (high volumes)
- OR 140 WB near mile post 41 (possibly the worst conditions)
- OR 140 EB mile post 25-35 (may be located in Jackson County)
- OR 140 near Bly Mountain Pass mile post 53-57
- WB on OR 58 at the bottom of Odell Butte

Expected Benefits:

- Improves efficiency of maintenance personnel, allowing more time for plowing and less time traveling to remote locations to change signs.

Lead Agencies

ODOT

Capital Cost

\$25,000 to \$70,000 per sign (basic VMS type of sign)

additional costs:

- mounting structure \$10,000 (standard post) to \$200,000 (cantilever or gantry)
- communication cost is highly variable and dependent on location options

Annual O&M Cost

\$5,000

additional cost if communication is leased

Connected Vehicle Potential: *Road Weather Motorist Alert and Warning* application – provide road condition and chain requirements directly to vehicles.

Maintenance and Construction Management

Maintenance and Construction Management strategies strive to improve the efficiency of maintenance fleets and operations through automation and telematics.

MC01 Automated Vehicle Location (AVL) and Logging Capabilities

Install AVL and activity logging capabilities (sanding, de-icing, and spraying) in maintenance and construction vehicles, and create an automated process for trucks to log sanding, deicing, and pesticide spray information. The system should also be capable of tracking the amount of solution remaining in the maintenance vehicle tank.

Expected Benefits:

- Improve maintenance efficiency
- Range of benefit to cost ratios from 2.6:1 to 24:1
- Improve planning capabilities and resource allocation

Lead Agencies

ODOT, Klamath Falls, Klamath Co.

Capital Cost

\$5,000 to \$15,000 per vehicle
(assumes some retrofitting
necessary); If implemented with
telematics there are cost savings

Annual O&M Cost

\$1,000 per vehicle

Connected Vehicle Potential: *Road Weather Information for Maintenance and Fleet Management Systems* application – Collect information from fleet vehicles about weather and road conditions as well as tracking vehicle status and material distribution stats.

MC02 Implement telematics technology on fleet vehicles

This project is similar to MC01, but adds telematics capabilities that can be used to track vehicle performance and vehicle maintenance. Telematics technology has a range of capabilities. For maintenance vehicles some of the key features to implement are tracking performance and fuel use, automatic notifications when vehicle maintenance is necessary, and improve routing efficiency.

Expected Benefits:

- Reduce fuel costs by 20-25%
- Improve vehicle maintenance
- Reduce idle time by 20-30%

Lead Agencies:

ODOT, Klamath Falls, Klamath Co.

Capital Cost

\$5,000 to \$15,000 per vehicle
(assumes some retrofitting
necessary)
If implemented with AVL there are
cost savings

Annual O&M Cost

\$1,000 per vehicle

Connected Vehicle Potential: *Road Weather Information for Maintenance and Fleet Management Systems* application – Collect information from fleet vehicles about weather and road conditions as well as tracking vehicle status and material distribution stats.

MC03 Automated Asset Management Tool

Install software that enables automated maintenance logs and proactive management of system health (notifications of equipment failure) for ITS infrastructure:

- Traffic signal controllers
- Street lights
- Cameras
- VMS
- RWIS

Expected Benefits:

- Improve operational efficiency

Lead Agencies

ODOT, Klamath Falls

Capital Cost

varies based on system

Annual O&M Cost

varies based on system

Connected Vehicle Potential: *Infrastructure Management* application – monitors the performance of infrastructure equipment.

Emergency and Incident Management

Emergency and Incident Management strategies focus on improving response during an incident, reducing incident clearance times and increasing safety for both responders and travelers.

EM01 9-1-1 Dispatch Interconnect

Connect the 9-1-1 dispatch center with ODOT and OSP through a software update (no construction required). This system will automate data transfer between Klamath Co 9-1-1 dispatch, ODOT, and OSP. Each agency can choose (through automated filters) what information to publish to the system. Once the data is on the CAD system it is available to all subscribers. Each agency can determine what data they want to automatically pull from the database. For example, ODOT can create a setting for notifications of specific type of incident on an ODOT facility. Likewise, OSP can automate their side to only publish roadway related activity and not all police activity to the system.

Expected Benefits:

Based on Deschutes Co Pilot project:

- Reduce incident response time by 30%
- Shorten incident duration by 38%
- Reduce dispatch response time by 25%
- Reduce interagency calls by 60%

Lead Agencies

ODOT

Capital Cost

None (funded through a grant that Deschutes County received)

Annual O&M Cost

None (funded through a grant that Deschutes County received)

EM02 Develop Traffic Incident Management (TIM) Team

Develop a TIM team for the Klamath County area that includes responders from ODOT, Fire, Tow (OTTA), Law Enforcement, County, Cities, and 911 dispatch. Establish regular meetings and communication with the TIM Team.

Expected Benefits:

- Faster incident clearance
- Improve coordination between responder partners
- Improve understanding of partner roles

Lead Agencies

ODOT

Capital Cost

Staff time

Annual O&M Cost

Staff time

EM03 Interoperable Communication Procedures

Implement standard protocols for using radios between agencies. This strategy could be a task for the TIM Team to develop.

Expected Benefits:

- Faster incident clearance, gets responders to the scene and where they are needed at the scene faster.
- Improves on-scene communication

Lead Agencies

ODOT

Capital Cost

Staff time to prepare protocol and provide training

Annual O&M Cost

Ongoing staff time for training and updating

Connected Vehicle Potential: *Incident Scene Pre-Arrival Staging Guidance for Emergency Responders* application – provides situational awareness and coordination among emergency responders.

EM04 Situational Software

Integrate the Intterra Situational Awareness software during incident or emergency response. The software can track where each of the response agencies/vehicles is (en route, at the scene, and during clean up) and improve communication between responders.

Expected Benefits:

- Faster incident clearance
- Improve on-scene communication
- Improve incident scene management

Lead Agencies

Keno Fire Dept, ODOT, OSP

Capital Cost

n/a (annual license fee)

Annual O&M Cost

\$56,000 (currently paid for by a federal grant)

Connected Vehicle Potential: *Incident Scene Pre-Arrival Staging Guidance for Emergency Responders* application – provides situational awareness and coordination among emergency responders.

EM05 Portable Variable Message Signs (VMS)

Purchase additional portable VMS to use during events and incidents

Expected Benefits:

- Reduce out of direction travel
- Reduce traveler frustration by improving traveler knowledge
- Reduce driver speeds by 3.6 mph upstream of work zones (study in rural Missouri)
- When used in conjunction with radar, a study in Virginia found a 50% reduction in speeding vehicles through work zones, with a decrease in vehicle speeds of up to 9 mph within a work zone

Lead Agencies

ODOT

Capital Cost

\$15,000 to \$20,000 (ITS database)

Annual O&M Cost

\$1,500

Public Transportation Management

Public Transportation Management strategies target ways to improve the transit experience for a transit user as well as improve operations of the transit fleet.

P01 Real-time transit information and notifications

Provide transit users with real-time information about next arrivals, significant delays, route changes, or other trip related information. Information can be provided through website access, displays at transit stations, or a smart phone app.

The real-time transit information should extend beyond Basin Transit to include Quail Trail Public Transit which provides daily service between Chiloquin and Klamath Falls.

Expected Benefits:

- Improve travel experience for transit user
- Potential for increased ridership and revenue
- Improve schedule adherence by 9 to 23% using AVL/CAD systems (study based on information from Portland, Milwaukee, and Baltimore)

Lead Agencies

Basin Transit

Capital Cost

\$200 to \$700/vehicle for AVL device
\$15,000 for interface (ITS database)

Annual O&M Cost

\$500/vehicle

Connected Vehicle Potential: *Dynamic Transit Operations* or *Transit Connection Protection* applications – allows transit users to access real-time transit information and allows transit users to communicate with transit vehicles to transmit a hold request.

P02 Automated transit vehicle on-board data tracking and logging

Install on-board devices to automatically track and log boardings, de-boardings, use of lift, etc.

Explore the option of "piggy-backing" with a larger transit agency for data tracking transit equipment.

Expected Benefits:

- Improve transit management and resource allocation

Lead Agencies

Basin Transit

Capital Cost

\$1000/vehicle (as an add-on)
\$8,000/vehicle (as a stand-alone installation)

Annual O&M Cost

\$200/vehicle

Freight Management

Freight Management strategies target improved safety for all roadway users as well as providing information to freight drivers to make more efficient decisions.

F01 Truck signal dilemma zone protection

Install detection at traffic signals along designated freight routes through Klamath Falls that identify approaching heavy vehicles and speed, and either extend green or conflicting red to prevent collision potential.

Locations:

- OR 140/Washburn Way
- OR 66/OR 140 Interchange
- Crater Lake Parkway
- Washburn Way/6th Street
- Homedale Rd/OR 140

Expected Benefits:

- Improve safety by 20% with dilemma zone protection (study based on all vehicles, not limited to trucks)
- Decrease truck stops and decrease emissions
- If used with truck signal priority, truck travel times would likely improve

Lead Agencies

ODOT

Capital Cost

\$8,000/intersection

Annual O&M Cost

\$1,000/intersection

Connected Vehicle Potential: *Freight Signal Priority* application – detects freight vehicles and adjusts signal timing to reduce stops and delay, and enhance safety at intersections.

F02 Automated freight restrictions

Provide automated push messages to truck drivers to alert drivers of restrictions (height, weight, length, and width) along route choices.

Noted areas of concern:

- Railroad structure on Hwy 39
- Restricted width on US 97 near N Klamath interchange and between Algoma Rd and Shady Pine Rd
- Structures along OR 66, OR 140, US 97

Expected Benefits:

- Reduce out of direction travel due to last minute rerouting

Lead Agencies

ODOT Motor Carrier

Capital Cost

\$4,000/vehicle (communication and tracking equipment)
Additional cost if a central system is required

Annual O&M Cost

--

Connected Vehicle Potential: *Freight Specific Dynamic Travel Planning or Oversize Vehicle Warning* application – provides pretrip and enroute travel planning, routing, and freight parking information; transmits in-vehicle warnings if freight vehicle is approaching infrastructure for which it is oversized.

F03 Real-time freight parking info

Noted truck parking areas: Chiloquin Casino (north of Klamath Falls), rest area at Midland (south of Klamath Falls), Pilot Travel centers (Klamath Falls and Chemult)

Expected Benefits:

- Reduce illegal truck parking
- Reduce truck driver frustration
- Improve freight route planning
- Potential to reduce violations of truck drivers exceeding hours of service rules

Lead Agencies

ODOT, Private Partnerships

Capital Cost

\$50,000 to \$100,000 (ITS database)
monitoring system and database

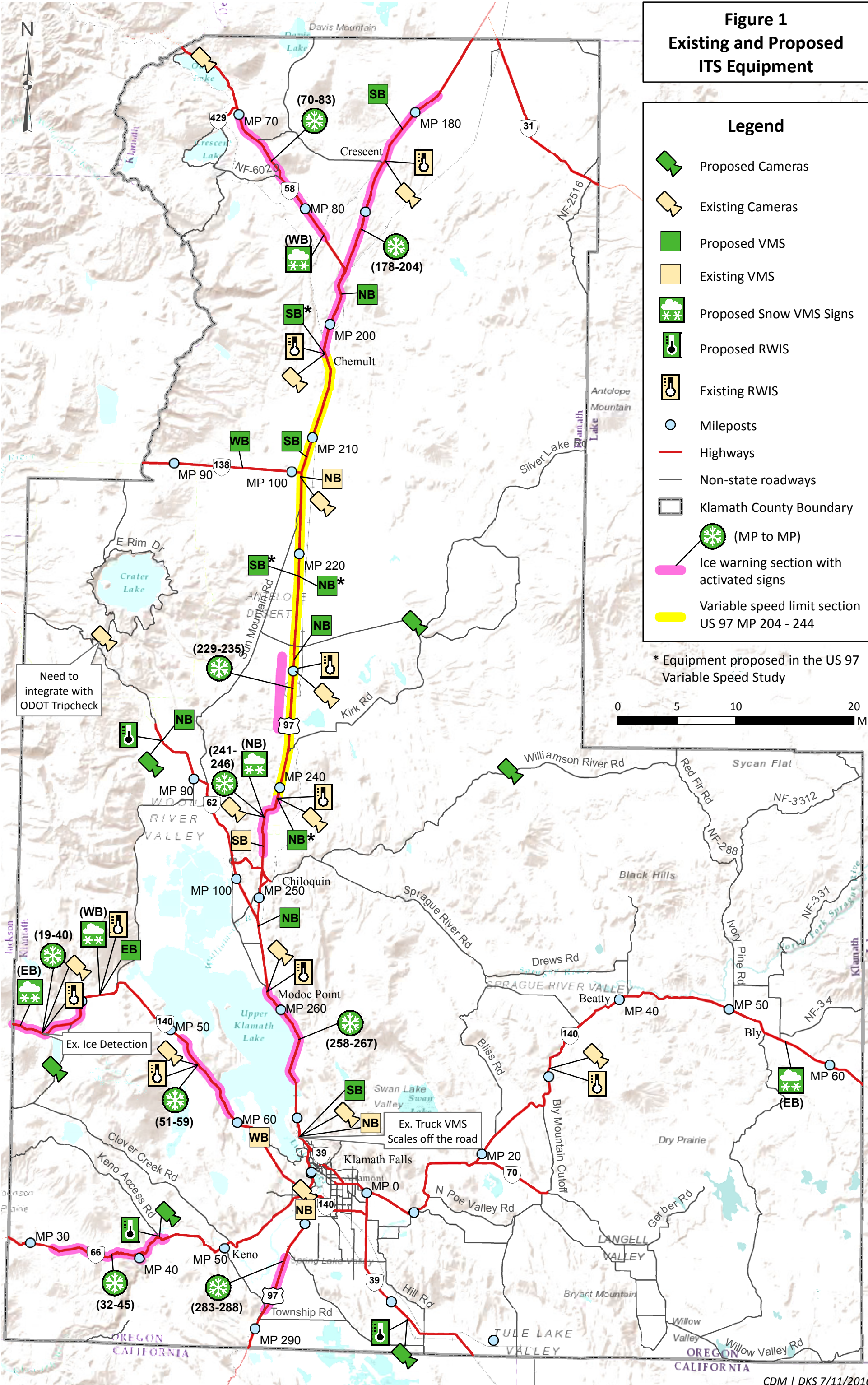
Annual O&M Cost

\$5,000

Connected Vehicle Potential: *Freight Specific Dynamic Travel Planning* application – provides pretrip and enroute travel planning, routing, and freight parking information.

Proposed ITS Devices

The existing and proposed ITS devices are shown in Figure 1. including: cameras, RWIS stations, VSM, and ice detection sensors.



ITS COMMUNICATIONS PLAN

Communications infrastructure connects field devices to regional centers, allowing operators to monitor devices and make changes remotely. This in turn improves the efficiency of the transportation system. Especially in regions with expansive rural areas, like Klamath County, communications to remote ITS devices can greatly improve operational efficiency by reducing staff time spent driving to the devices to implement commands or check the status of a device that can be accomplished remotely once communications are in place. The communications plan for Klamath County is intended as a guide for supporting the communications needs of ITS devices deployed in the county.

Methodology

This communications plan emphasizes understanding the unique needs and available resources for each device and location. For each installation, there are many competing factors to consider: cost, reliability, flexibility, connection speed, bandwidth needs, and the amount of data being transferred over time. This communications plan presents a framework for examining which devices should be connected and key considerations for each device. **Decisions on specific technologies and communication modes will be evaluated on a project-by-project basis.**

One of the challenges to building a communications system in Klamath County is its rural nature. Unlike urban settings, some devices that need to connect to the communications network may be relatively isolated from existing communication infrastructure.

For example, variable message signs require highly reliable connections such as fiber optic cable. However, for a VMS installation in a remote area, the cost to build a 50-mile segment of fiber optic cable to connect the device is prohibitive. In this case, alternatives to fiber optic cable should be evaluated such as leased services, cellular connections, or even dial up modem connections. Alternatives should be considered in this manner on a project-by-project basis.

The communications plan should be considered a “living document” that is updated on a regular basis as communication needs change due to technology improvements and communications network expansion.

Existing Communication Infrastructure in Klamath County

Within the City of Klamath Falls, existing communications to field devices are provided through a variety of means including fiber optic cable, twisted-pair copper wire, and wireless networks. Beyond city limits, ITS devices are connected primarily through cellular or dial-up routers with some dedicated point to point circuits. Cameras are connected through either cellular or 1.5 MB DSL connection, and some variable message signs even use a dial-up connection.

Verizon is the primary cellular carrier in Klamath County, with US Cellular and ATT also operating in the region. Within Klamath County, many rural areas lack cellular coverage. Where cellular coverage is available it usually available at 3G speeds.

Communications Plan Recommendations

This section describes communications recommendations for Klamath County, both the urban area around Klamath Falls and the more rural areas of the county.

Backbone Infrastructure

A variety of methods should be evaluated for connecting ITS field devices to the backhaul system in order to determine which method best meets the needs for each ITS device and location. Advantages and disadvantages of each communications infrastructure option are shown in **Error! Reference source not found..**

Table 2: Communication Options

Communication Option	Typical Bandwidth	Advantages	Disadvantages
Building new fiber optic cable 	Up to 10 Gbps	- High reliability - High bandwidth - No interference - Asset for in-kind trade	- High initial cost - Repeaters needed every 50 miles
Sharing or leasing fiber	Up to 10 Gbps	- Lower cost option for fiber - Low capital cost	- Possible recurring operational costs - Requires coordination and agreements between agencies
Building new twisted pair copper lines 	5 to 35 Mbps (35 Mbps for up to ¼ mile, 5 Mbps up to 1 mile)	- Moderate reliability - Works for both digital and analog transmission - Lower cost than fiber	- Lower bandwidth than fiber - Repeaters needed every 3 miles
Building new wireless communication links 	2 Mbps to 6 Gbps	- Works well with clear line of sight - Inexpensive	- Lower bandwidth than fiber - Susceptible to interference - Bandwidth capacity related to distance
Leased cellular services	3G = minimum of 200 kbps 4G = Up to 1 Gbps	- Low initial cost 3G network capable of sending still images - Good option for rural areas without fiber or twisted pair copper lines	- Monthly fee (service not owned by agency) - Low reliability - Low bandwidth, limited data transfer capacity (typ. 50 MB/month)

Option	Typical Bandwidth	Advantages	Disadvantages
Leased digital subscriber line (DSL) 	512 kbps to 1.5 Mbps	▪ Low initial cost ▪ High bandwidth options ▪ Good option for rural areas without fiber or twisted pair copper lines that have commercial infrastructure	▪ Monthly fee (service not owned by agency)
Dial Up Modem 	56 kbps	▪ High reliability ▪ Good option for rural areas where phone lines exist but other communications are sparse	▪ Limited bandwidth ▪ Monthly fee

Shared Communications

Sharing communications can greatly reduce costs due to shared infrastructure, but it also introduces the need for interagency agreements. Shared communications can have two meanings, only the first of which is permitted by ODOT:

- 1) **Sharing common infrastructure (like conduit or fiber optic cable line)** ✓
- 2) Sharing a network (like a particular strand in a fiber optic cable, which introduces security concerns and is **NOT** the current ODOT practice) ✗

For example, the ODOT network is separate from the Klamath Falls network. Cable, however, can be shared. Cable can be either fiber optic cable, in which case each individual strand is its own network, or copper, in which case each copper line is its own network. Note that a limited number of copper lines (networks) can be placed in the same conduit before electromagnetic interference becomes too high to carry the signal.

ODOT ITS devices are on a private ODOT network. The ODOT network travels through the Department of Administrative Service (DAS). Through agreements, non-ODOT agencies can connect ITS field devices to ODOT's central system and gain monitoring and remote access capabilities via a virtual private network (VPN) connection through DAS to ODOT's central system. This connection can benefit local agencies by providing a monitoring/remote access platform without requiring the agency to invest in a central system of their own.

When agencies connect devices to the ODOT system, comprehensive agreements need to be in place that address:

- Access: who is allowed to physically access the device in the field? Who is allowed to access the device through the network and what are they allowed to do?
- Maintenance: who maintains and fixes the equipment?
- Ownership: who owns the equipment?

- Utility cost: who pays to supply electricity to the equipment?

Communications in a Connected Vehicle Future

When installing roadside ITS devices, future communications for connected vehicle capabilities should be considered. The two main wireless forms of communication used for connected vehicle applications include dedicated short range communications (DSRC) and cellular 4G networks (or 5G in the future). DSRC is a two-way wireless communications capability that transmits data with low latency (milliseconds) and can be used for safety applications. The low latency of DSRC makes it ideal for safety critical communications, such as crash prevention. Other wireless communications such as 4G and 5G have relatively low latency and can be used for communications where a higher latency tolerance is acceptable.

The Deployment Plan for the Klamath County ITS Plan identifies strategies with potential for connected vehicle applications (see the Deployment Plan project list in Appendix A). For the strategies with connected vehicle potential it will be important to consider which wireless communications should be installed with the device to make it compatible with connected vehicle applications in the near future.

Use Cases

The following sections describe the communications recommendations for specific ITS devices including: traffic signals, cameras, variable message signs (VMS), and road weather information systems (RWIS).

To better understand the general bandwidth needs of these ITS elements, Table 3 provides an overview and typical range for select ITS devices.

Table 3: Standard Bandwidth Requirements for Select ITS Devices

ITS Device	Description	Approximate Bandwidth Needs	Typical Monthly Data Usage
Traffic signal controllers	Data requirements vary depending on how frequently logs are transmitted and the amount of data	56 kbps - 10 Mbps	50 MB (logs only) 0.5 GB (active monitoring such as UDOT performance metrics)
Cameras – live streaming	Streaming live video up to 30 frames per second	200 kbps – 2 Mbps	>150 GB/month
Cameras – still images	Sending a still image every 3 to 5 minutes	100 kbps – 1 Mbps	0.5 GB/month
Traffic monitoring camera controls	Camera control for pan-tilt-zoom functions	56 kbps	minimal
Variable message signs – low bandwidth	Post a preselected message	< 56 kbps	Minimal (status updates)

ITS Device	Description	Approximate Bandwidth Needs	Typical Monthly Data Usage
Variable message signs – med bandwidth	Post a configurable message (no graphics) in one color	< 56 kbps	Minimal (status updates)
Variable message signs – high bandwidth	Post a configurable message that includes graphics and multiple colors	56 kbps - 200 kbps	Minimal (status updates)
Road weather information system (RWIS)	Send weather and roadway condition information to a central server every 10 to 15 minutes	~56 kbps	Up to 50 MB/month

Traffic signals

There are currently 50 traffic signals that operate in Klamath County, all within the Klamath Falls urban growth boundary. ODOT operates and maintains all of the traffic signals in Klamath County owned by ODOT or Klamath County. In the City of Klamath Falls, the city maintains all of its signals, but ODOT programs and operates all of the signals outside of the downtown core (Klamath Avenue and Main Street). Within the downtown core, the city operates and maintains the traffic signals. Almost all of ODOT's and Klamath County's traffic signals use 2070 controllers with Voyage, and most are connected to ODOT's central signal system on TransSuite.



One of the primary needs of the traffic signal system is to connect all of the county's traffic signals to the central signal system, which will provide ODOT with remote access to those signals. Typically, the connection to TransSuite is achieved by routing the network from the city's signal controller through an ODOT switch, which then puts the traffic signal on the ODOT network and provides ODOT operators with access to the traffic signal. In this scenario, the traffic signal controller is no longer on the City or County's network. For a City or County operator to gain access to the traffic signal, a VPN access would need to be set up and access rights would need to be negotiated with ODOT. Figure 2 demonstrates this communication flow.

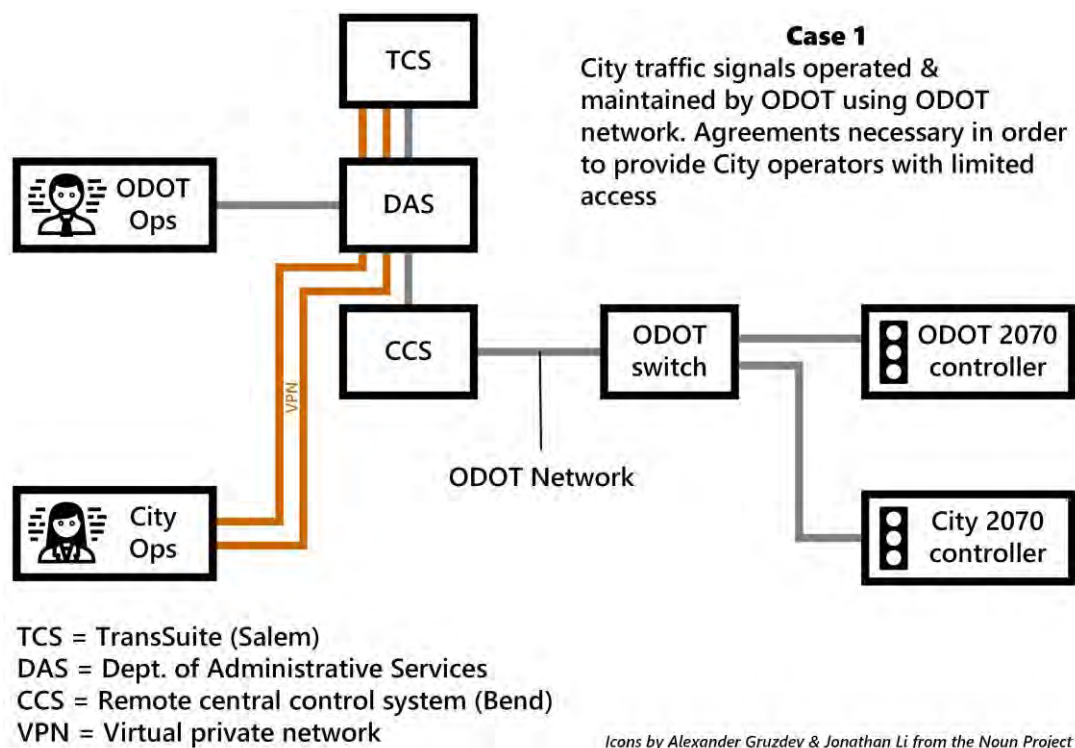


Figure 2: Communication Option for Connecting non-ODOT ITS devices to ODOT’s Central System

When a traffic signal is connected to the central signal system, it allows an ODOT operator to access it remotely making adjustments and troubleshooting as necessary. Again, with a VPN connection it would be possible for City or County operators to also access the traffic signal, assuming access rights are configured to allow that.

Alternatively, if the City of County wanted to maintain and operate their own signals without going through ODOT’s central signal system, communications from the signal controller could travel through a City owned switch and back to a server operated by the City. Using this method, the City operators could use the local controller software, but would not have access to TransSuite. This communication flow is depicted in Figure 3.

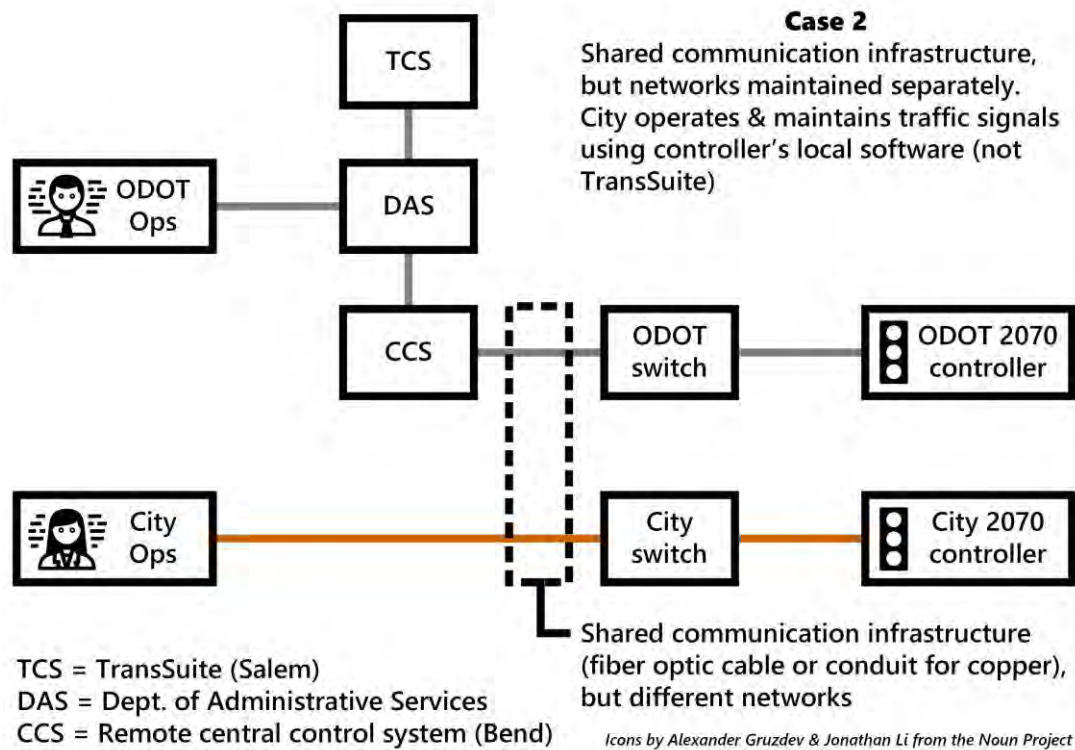
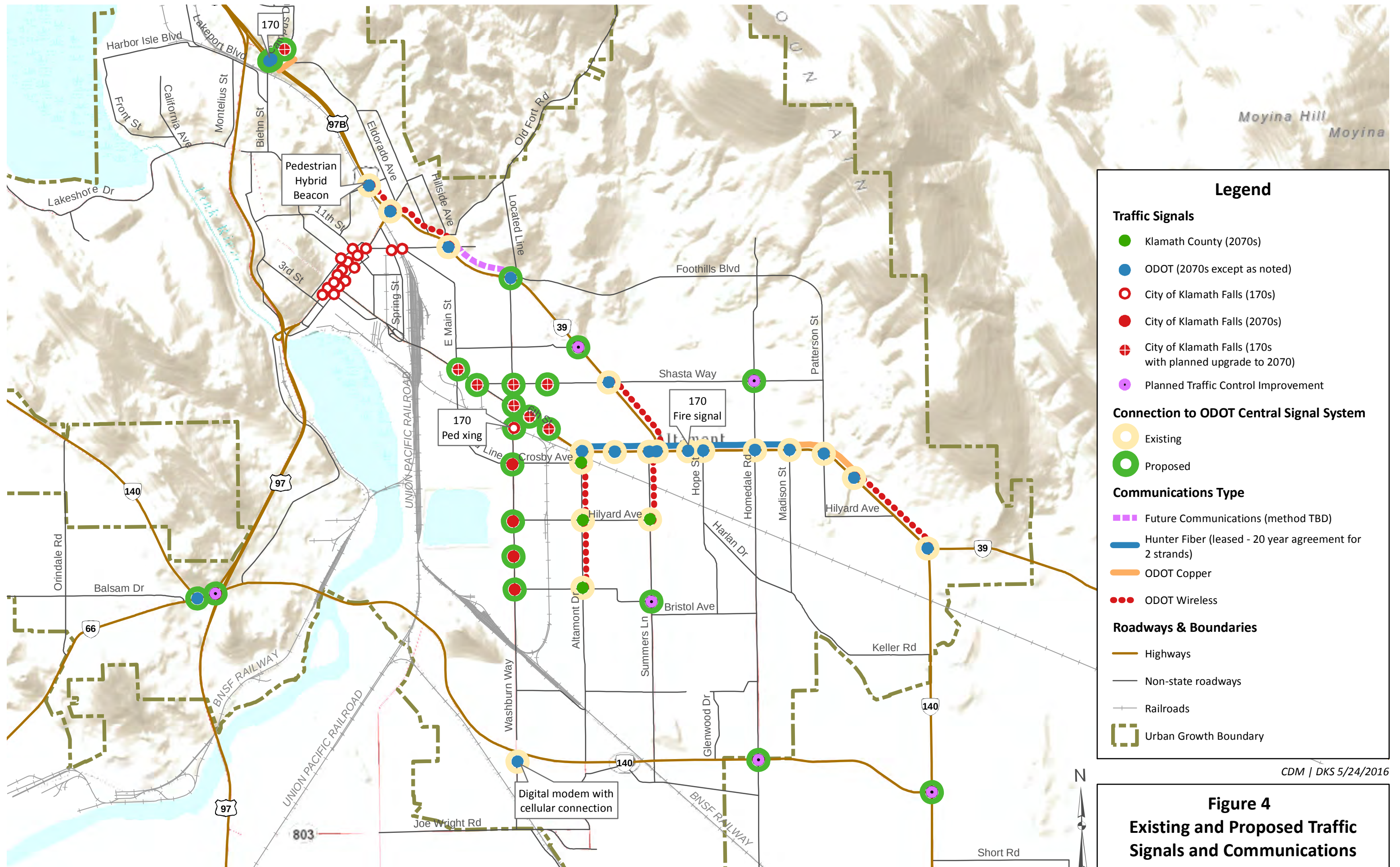


Figure 3: Communication Option Connecting City or County ITS Devices to Local Agency System

Figure 4 shows the traffic signals in the Klamath Falls area and illustrates the signals currently connected to ODOT's central signal system and the proposed connections. Currently most of ODOT's signals and all of Klamath County's signals (four) are connected to ODOT's central signals system. While ODOT maintains and operations all of the county's signals, several of Klamath Fall's signals are not connected to the central signal system which creates operational inefficiencies. An intergovernmental agreement (IGA) between Klamath Falls and ODOT is necessary to advance connecting Klamath Falls traffic signals to ODOT's central signal system.



The Deployment Plan identifies the traffic signals that are high priority to connect to the central signal system. To summarize, the highest priority signals to connect to the central signal system are the few remaining ODOT signals not yet connected (OR 140/OR 66 and US97/Biehn Street). There are several City of Klamath Falls traffic signals along 6th Street, Washburn Way, and Shasta Way that are also high priority to connect to the central signal system.

The traffic signals in the downtown core of Klamath Falls should eventually be upgraded to 2070's and connected to the central signal system, however, due to the grid roadway network operating fixed timings through that area, those signals are a lower priority to connect than the others identified.

The type of communication used to connect each of the identified signals needs to be evaluated on a project by project basis. Options to consider include fiber optic cable, VDSL over twisted pair copper, wireless connections, and leased cellular backhaul or other leased service.

Traffic Cameras

In Klamath County there are traffic cameras in both rural and urban (City of Klamath Falls) areas. In rural areas the main function of traffic cameras is to help visualize roadway conditions during weather events, not actively manage traffic. With this function in mind, a still frame every few minutes accomplishes the need and live streaming is generally unnecessary. In the City of Klamath Falls traffic cameras can be used to provide current roadway conditions and actively manage traffic, in which case streaming capabilities should be considered.



Existing rural traffic cameras use either a cellular connection (mostly 3G) or 1.5 mb/sec DSL connection, which is adequate for sending still frames every two minutes. As cellular communications advance to 4G and even 5G in the Klamath County area, those speeds will be more than adequate for transmitting still frame images and could likely support live streaming (but would be subject to the carrier's data streaming costs).

Proposed traffic cameras can continue to use cellular or DSL connections, especially in remote areas where other options are not feasible. All of the proposed traffic cameras in the Deployment Plan are intended to be viewed by both system operators and travelers via ODOT's TripCheck website.

In Klamath Falls the interest in traffic cameras with live streaming capabilities may be warranted to actively monitor and manage traffic. If live streaming is warranted, a higher bandwidth connection, such as fiber or copper is recommended. Some traffic signals in Klamath Falls use video detection, which can easily be linked to ODOT's TripCheck website. ODOT has a method and agreement in place for agencies interested in linking traffic signal detection cameras to ODOT's system. One stipulation by ODOT is that the agency regularly maintains the camera, as to avoid significant down time.

Variable Message Signs (VMS)

Reliability is a critical consideration for VMS communications. The VMS proposed in the Deployment Plan are located prior to key junctions to inform drivers of conditions, closures, or incidents ahead and direct travelers to an alternate route if necessary. During an incident, which is likely when the VMS would be activated, travelers tend to use cellular communications which can take up the cellular bandwidth preventing ODOT from updating a sign with critical information. For this reason, communications to VMS should consider using highly reliable methods that accommodate the necessary bandwidth, even if speed is slightly compromised. The bandwidth needs vary depending on the type of message to be displayed, such as a message from a preselected list versus a configurable message that includes graphics (see Table 3). The only data that the VMS would likely send back to the operator would be status updates.

As VMS are installed, each location needs to consider available communication resources.



Road Weather Information System (RWIS) stations

There are currently eight RWIS stations, an ice detection system and two ice warning signs with flashing beacons, that operate in Klamath County. The devices connect to the RWIS server located in Salem, which connects to TripCheck to post real time weather information. The weather data collected includes temperature, wind speed, wind direction, humidity, and road surface temperature.

Due to the remote locations of the existing and proposed RWIS stations, cellular communications are ideal.

There are two other projects in the Deployment Plan that will use information from RWIS stations to function:

- A weather responsive variable speed limit (VSL) system is being recommended from Chemult to Spring Hill Creek (mile posts 204 to 244)
- Automatic changeable snow zone signs



Devices for the VSL system and the automatic changeable snow zone signs would likely link to the data on the Salem server, and use that data to adjust speeds and displayed messages. There is potential for RWIS data to directly link to devices such as variable speed signs or VMS, but that discussion and policy implementation needs to occur at a statewide level.

Weather Responsive Variable Speed Limits

The weather responsive VSL strategy will comply with ODOT's Concept of Operations for Statewide Variable Speed Systems in Oregon⁶ and the ODOT Region 4 US 97 Variable Speed Study⁷. The US 97 Variable Speed Study identified two sections that would benefit from a variable speed system, one of those sections is in Klamath County from mile post 204 to 244. The system would use data from the RWIS stations (communicating back to a central server in Salem), and add sensors along the roadway to detect vehicle speeds, volumes, and pavement grip factor. Additional VMS and cameras are also slated to be installed with the project to help monitor the roadway and inform drivers of conditions. The study recommends using hardwire communications for the VSL devices, but does not preclude cellular communications.

Automatic Traffic Recorders (ATRs)

ATRs are technically not part of ODOT's ITS network, but since they are devices that require communications this Communications Plan will include a discussion of them. In Klamath County most ATRs are connected via dial-up or cellular connections. Data usage and bandwidth needs are relatively low. Data is collected once a day. If the data were ever to be used for real-time information, new internal equipment would be necessary.

Application of the Communications Plan

This plan provides the guidelines to be used in the development of the detailed design for each section of the communications network. As the opportunity arises to construct a section of the network (through funding or provision of facilities by a third party) the detailed design for that section will be completed.

The ITS Communications plan addresses the configuration and implementation approach, but it does not determine exact routing, equipment selection, and capacities. These aspects of the communications network are best finalized during detailed design, allowing the most up to date requirements to be incorporated in sizing and current transmission equipment selection.

The following approach is recommended for each detailed design:

Pre-Design Planning Review

The purpose of the pre-design planning review is to ensure that the concepts and principles of the communications plan are considered in the detailed design. For example, if a road is being reconstructed, and it is known to be on a planned backbone communications route, this approach will ensure that the detailed design (even if it is only a small section of the ultimate backbone) provides for the future needs. These provisions could accommodate the future capacity with the initial installation or provide conduit and equipment mounting space for future installation.

A "Pre-Design Planning Review" document should be prepared before the start of the detailed design, typically at the same time as the documents are prepared to seek project budget. This document is typically two pages or less. The Pre-Design Planning Review explains the following:

⁶ Oregon Statewide Variable Speed System, Concept of Operations. Version 0-4. Prepared by DKS Associates. March 2015

⁷ ODOT Region 4 US 97 Variable Speed Study. Prepared by DKS Associates. June 2013

- Key elements of the design required by the communications plan. These elements include provisions for future growth and provisions for geographic areas beyond those served by the detailed design.
- Aspects of the design that will not follow the communications plan, with justification for these changes.

Final Planning Review

After the completion of the detailed design of the specific network segment, the pre-design planning review should be finalized to include any changes that have been made during the detailed design. The final planning review will document any provisions made in the detailed design to support the communications plan (Ex: spare capacity, routing, or configuration considerations). It will also justify deviations that have been made to the communications plan.

An important aspect of the final planning review will be to identify if there is a need to update the master communications plan, either in whole, or in part.

Communications Plan Updates

As sections of the network are implemented and as technology and communications requirements change, the communications plan should be updated. At any given time, the “current” communications plan will consist of the plan itself and any planning reviews that have been conducted. A current list should be maintained with the communications plan and updated as needed.

Maintaining an up to date map of all ITS devices and communications (similar to Figure 4) will improve communications planning moving forward. The communications and ITS device map will help identify areas where communications can be shared (see “Shared Communications” section for more information), thus reducing costs for participating agencies.

APPENDICES

Appendix A: Deployment Plan Matrix

Appendix B: Existing Conditions Memorandum

Appendix C: Needs Assessment Memorandum

Appendix D: Signal Maintenance Agreement

Appendix A: Deployment Plan Matrix

Traffic and Operation Management									
Ref #	Proposed Strategy	Description/Location(s)	Priority	Responsible Party(s)	Expected Benefits	Feasibility (Institutional and Technical) and Project Dependencies	Connected Vehicle Potential?	Capital Cost	Annual O&M Cost
TM01	Install communications and maintain up to date communications map.	Install roadside communication connections to ITS field devices and maintain a current map of all communications and ITS devices. See Communications Plan	High	ODOT, Klamath Falls	• Operational efficiencies (varies by device)	• This strategy will in part be guided by the Communications Plan . • Communication options vary by project.		variable by project	variable
TM02	Connect traffic signals in Klamath County to ODOT central traffic signal server	See Figure 4 for all locations. Key locations: • Foothills Rd/Washburn Way (planned) • Altamont Dr. & Hilyard, Bristol • Washburn & Crosby, Hilyard, Trail crossing, Bristol	High	ODOT	• Operational efficiency, allowing ODOT to immediately view and respond to signal operation issues	• ODOT currently operates and maintains all traffic signals in Klamath County with the exception of the Klamath Falls downtown core. For signals not accessible by ODOT remotely, addressing operational issues requires significantly more staff time. • Inter agency agreements are in process • Primary cost is communications • Mainly City of Klamath Falls signals that need to be connected. • Most of the ODOT and Klamath Co signals are connected to ODOT's central server already.		varies based on communication method	variable
TM03	Provide City of Klamath Falls access to ODOT's central signal system	Provide the ability for Klamath Falls and Klamath County to access ODOT's central signal system. Access rights to be determined.	High	ODOT, Klamath Falls	• Improve efficiency and ability to analyze and adjust traffic signal operations.	• This connection can be accomplished without additional infrastructure. • IGA agreement is necessary		n/a	staff time
TM04	Install new PTZ cameras at select intersections and connect to TripCheck	Key locations: • Signal detection cameras along 6th Street • 6th / Washburn - currently uses video detection • US 97 271.2 @ truck weight station • Shasta Way / 6th - currently uses video detection • Onyx & Washburn - currently uses video detection • Campus/Dahlia - currently uses video detection	High	ODOT	• Improve access to real-time information for operators and travelers	• ODOT currently has a method to add cameras to its system, however, existing cameras will likely be replaced with infrared cameras in the next 5-10 years which do not produce an adequate image for TripCheck. • ODOT does require local agencies to maintain cameras to ensure feed is operable		minimal	\$1,000
TM05	Update signal controllers to current standard.	Highest priority locations: • ODOT traffic signals at: OR140/OR66 and US97B/Biehn Street • City of Klamath Falls traffic signals along 6th Street, Washburn Way, and Shasta Way Lower priority locations: • Klamath Falls downtown core which operates on fixed timing (Klamath Ave and Main Street traffic signals)	High	ODOT, Klamath Falls	• Capable of advance features and remote access	• Most ODOT and county signals are already 2070s, the city's signals need to be upgraded.		dependent on intersection and required upgrades	variable, dependent on communications
TM06	Install enhanced pedestrian crossings (mid-block and at intersections)	Install enhanced mid-block pedestrian crossings such as pedestrian hybrid beacons (PHB), rectangular rapid flashing beacons (RRFBs), or full traffic signals. Each location needs to be studied to determine appropriate treatment. Locations: • OCE crossings - Homedale, Altamont, OR 39 (funded) • S 6th Street (funded) • Campus Dr./Daggett Ave (near OIT) - note that this intersection is currently being evaluated for a roundabout • Campus Dr./Campus Dr. (near OIT)	High	Klamath Falls, ODOT	• Decrease in pedestrian crashes • A study based on HAWK signals showed a 69% decrease in pedestrian-vehicle crashes, CMF ID: 2922). Note - this study placed HAWK signals AT intersections, not mid-block. • PHB can achieve 98% driver compliance and a 58% reduction in pedestrian crashes (ODOT) • RRFB can achieve 85% driver compliance during the day and 90% at night.	• Each location needs to be evaluated to determine whether an RRFB is appropriate, or whether the location needs a full signal (such as locations with higher speeds and more than three lanes). Higher driver compliance is associated with a full signal. • Note - there is an existing HAWK signal at the Crater Lake Parkway/Portland Street intersection	Yes	\$20,000 (RRFB) \$100,000 (full signal mid-block)	\$1,000
TM07	Install bicycle and/or pedestrian detection and counters	Locations: • OCE trail or all crossing Summers, Washburn, Hwy 39, Madison. • Along Kit Carson Trail roadway crossings	High	Klamath Falls, ODOT	• Improve understanding of how bicycles and pedestrians utilize specific corridors • Use data to seek funding opportunities	• Radar or video detection is ideal for pedestrian and bicycle detection, although some technologies do not differentiate between a bicycle and a pedestrian.	Yes	\$6,000 (radar detection and data collection)	\$400/detector
TM08	Install Variable Message Signs (VMS) at key junctions	Install variable message signs prior to key junction points to inform drivers of road conditions and detours. See Figure 1 for locations. Locations: • SB on US 97 north of Crescent Cutoff Road • NB on US 97 prior to OR 58 junction • SB US 97 at MP 204 (part of VSL project) • SB on US 97 north of OR 138 (NB VMS already in place) • NB and SB on US 97 at MP 223 (part of VSL project) • NB US 97 at Silver Lake Road (Emergency Route) • NB on US 97 at MP 244 (part of VSL project) • NB on US 97 at Sprague River Rd (SB already in place near Chiloquin) • SB on US 97 north of Klamath Falls • EB on OR 140 prior to West Side Rd (approx. MP 43) • Crater Lake Park approaches - NB on OR 62 and WB on OR 138 - link to ODOT system	High	ODOT	• Improve traveler information and driver's ability to make informed decisions • A study in rural Missouri showed that 94% of drivers took the action indicated on the VMS • Decrease mean driving speed and crash severity when VMS are used to communicate weather information and roadway conditions • Another study in rural Missouri used VMS to notify drivers about a significant detour during a bridge closure. 41% of drivers learned of the closure via VMS (media was also used to inform drivers - TV, radio, newspaper, etc.)	• Klamath County has 4 VMS located along US 97 and OR 140 • Additional equipment such as RWIS or other sensors could attach to the VMS, optimizing communication and power sources. • Four of the proposed VMS could be used for the Variable Speed Limit project between MP 204 and 244	Yes	\$40,000 to \$100,000 per sign (ITS database) additional costs: • mounting structure \$100,000 to \$200,000 range • communication cost is highly variable and dependent on location options	\$5,000 additional cost if communication is leased

TM09	Install cameras with live feed capabilities	Install cameras to be used for both operational purposes and traveler information purposes. Locations: • Silver Lake Road MP 27 • Dead Indian Memorial MP 30.6 • Williamson River Road MP 17 • OR 140 to Medford near MP 20-24 • OR 39 – near Merrill • OR 66 – mile post 43 • OR 62 – mile post 83.6	High	ODOT	• Travelers perceive enhanced safety by being better prepared for roadway conditions • Lower traveler frustrations due to better real-time information • Potential to improve incident response if the incident is within view of a camera	• There are currently 11 CCTV cameras located along US 97, OR 140, and OR 58 • Cameras would be available to the public via ODOT's TripCheck website		\$7,000 - \$20,000 per camera additional cost if mounting pole and foundation are needed (~\$20,000)	\$2,000
TM10	Connect Crater Lake National Park camera to TripCheck and display snow zone and gas information	Connect the camera at Crater Lake (on Munson Valley Road at Park Entrance) to the ODOT TripCheck system and display snow zone information and also alert travelers about the lack of gas stations in the park vicinity. The National Park Service regularly assists travelers who run out of gas.	High	ODOT, NPS	• Improve traveler information • Decrease occurrences of travelers running out of gas in the park	• Live webcam view is already available through the National Park Service website, agreement between ODOT and NPS is needed		n/a	\$500
TM11	Operations / Coordination Team	Implement a team of traffic operators between ODOT, Klamath Falls, and Klamath County to convene regularly with the purpose of sharing information and moving towards more efficient operations. Frequency of meetings to be determined.	High	ODOT	• Improved understanding of roles and responsibilities between partner agencies • Opportunities to advance and gain support for projects among partner agencies	• Requires staffing time from agencies to attend meetings		n/a	staffing time
TM12	Implement weather responsive variable speed limits on US 97 (per completed study)	Key segments: • US 97 Chemult to Spring Creek Hill (MP 204-244) Klamath County portion • US 97 Bend to La Pine (MP 143-164) - outside Klamath County Project includes installation of (see Variable Speed Limit Study for proposed locations): • VMS • speed and volume sensors • variable speed signs • grip factor sensors	Med		• Benefit cost ratios ranging from 1.1:1 to 1.9:1 for weather based VSL system (Finland) • Reduce weather related crashes due to drivers traveling too fast for the adverse conditions • OR 217 VSL resulted in a 20% decrease in crashes after one year • In general VSL systems can reduce crashes by 8% to 30% (weather and congestion based crashes)	• Variable speed study for US 97 was completed in 2013 and is shelf-ready for design, awaiting funding. That study assumed the inclusion of: VSL signs, VMS, supplemental signs, grip factor sensors, RWIS, speed and volume sensors, ATRs, and cameras. • Medium priority is mostly due to high capital cost	Yes	\$2 to \$5 million (US 97 MP 204-244 includes about 20 ground mounted signs, 4 VMS, 12 speed and vol sensors, 3 grip factor sensors, RWIS, cameras, and communications) Additional cost if overhead gantry signs are installed	\$20,000 to \$50,000 (maintaining signs, RWIS, and other sensors)
TM13	Central data storage/sharing system	Create a central data storage system that can be shared between agencies. Data may include counts, video, speeds, travel time, etc. Prior to creating a storage and sharing system a study needs to be conducted to determine how the process would operate.	Med		• Improve efficiency for sharing data between agencies	• Potential to expand Portal • A study would be necessary to determine mechanism for the storage and sharing process		minimal if Portal is used > \$100,000 if a new data management system is necessary. Further refinement necessary	TBD
TM14	Install wildlife detection system	Wildlife detection systems are typically either "area-cover" systems that use microwave or infrared sensors to cover a broad area, or "break-the-beam" systems that are triggered when a microwave, laser, or infrared beam is broken. Locations: • US 97 near MP 174, 190, and 206 (per Mule Deer Study) • US 97 - near Klamath Falls (widespread area)	Low		• Reduction of wildlife-vehicle collisions by up to 80% • Detection reliability of 95% for large animals using a buried cable intrusion detection method (electromagnetic detection field)	• Low interest in strategy due to widespread geographic need and concern about reliability of the technology	Yes	Highly variable \$100,000 to \$750,000 per mile	\$5,000 to \$40,000
TM15	Install dynamic curve speed warning signs	Dynamic feedback signs can measure the speed of individual vehicles and post messages such as "SLOW DOWN. YOUR SPEED IS OVER 60 MPH. CURVE AHEAD" Locations: • OR 66	Low		• Reduction of single vehicle crashes by 50% (2015) • Speed reduction in 68% of drivers (rural CA, 2000) • Ice Curve Warning System reduced ice-related crashes by 18% (CMF ID: 4114, 2 star)	• Based on data from the "Road Departure Crash Plan" no high crash curves for run off the road crashes were identified in Klamath County	Yes	\$15,000 (basic sign with beacons) \$100,000 (overhead mounted feedback message sign)	\$1,000
TM16	Install LED Street Lighting with controllers	Install LED street lights at select locations using controller technology that can expand to include other ITS applications.	Low	ODOT, Klamath Falls	• Potential to use smart control system for lighting as an asset management tool	• Installing LED lights with a 7 pin receptacle allows the lighting controller to expand capabilities. For example cameras and parking systems could be added at truck parking areas, or expand wireless communications using a radio network plug-in. • Klamath Falls is starting to replace LED but don't have the smart 7 pin receptacles, looking to add in a couple of years • Pacific Power operates streetlights outside of Klamath. • ODOT limited lumination but looking at more pedestrian crossing lighting • ODOT does not plan to improve lighting at chain up areas		\$15,000 to \$20,000 per streetlight. Assume an extra \$1,000 to \$5,000 for additional ITS devices that could expand capabilities using the lighting controller.	\$500/street light

Weather Event Management									
Ref #	Proposed Strategy	Description/Location(s)	Priority	Responsible Party(s)	Expected Benefits	Feasibility (Institutional and Technical) and Project Dependencies	Connected Vehicle Potential?	Capital Cost	Annual O&M Cost
W01	Install Road Weather Information Systems (RWIS) with ice detection at key locations.	Key RWIS locations (same as some camera locations): • OR 140 to Medford near MP 20-24 • OR 39 – near Merrill • OR 66 – mile post 43 • OR 62 Crater Lake Hwy – mile post 83.6 • Potential Camera/Weather Station @ Crater Lake with images shared in Trip Check (see TM09)	High	ODOT	• Travelers perceive enhanced safety by being better prepared for roadway conditions • Lower traveler frustrations due to better real-time information • Expected B:C ratios 2:1 to 10:1 • Improved weather information leads to more efficient application of anti-icing chemicals, reduced maintenance costs, reduced delay, and increases safety (US DOT)	• Klamath Co currently has 11 RWIS stations along US 97 and OR 140 • Planned variable speed limit project will add RWIS stations along US 97	Yes	\$25,000 to \$40,000 (ITS database and US DOT) additional costs: communications, cameras, or other sensors	\$5,000 additional cost if communication services are leased
W02	Install activated ice warning signs at key locations.	Install activated ice warning signs at key locations that notify drivers (via VMS, flashing beacons, or other means) when roadway conditions are icy. For optimal benefit, detection segments should be short and warning systems frequent. Ice detection could use an existing or proposed RWIS station, or a grip factor sensor at the sign location. Locations: • OR 140 MP 19-40 Lake of the Woods - existing RWIS and ice detection near MP 35 and 36 • OR 140 MP 51-59 (Doak Mountain) - existing RWIS station at MP 54 • US 97 MP 178-204 (north of Chemult) - existing RWIS stations near MP 204 and 185) • US 97 MP 229-235 - note this is within VSL project area, existing RWIS at north end • US 97 MP 241-246 (Spring Creek Hill) - note this is within VSL project area, existing RWIS at north end • US 97 MP 258-267 (Modoc Point to Shady Pine Rd) - existing RWIS at north end • US 97 MP 283-288 Klamath Straights • OR 66 west of Keno MP 32-45 (proposed RWIS nearby) • OR 58 MP 70-83 Crescent Lake Highway	High	ODOT	• Ice Curve Warning System reduced ice-related crashes by 18% (CMF ID: 4114, 2 star)	• Providing power and communications to remote signs and sensors may increase cost significantly. Where feasible, cost savings can be achieved by locating signs and sensors in close proximity. • Ice detection can be accomplished using a full RWIS station (higher cost) or grip factor sensors (lower cost). • Note that there are some sections where the activated ice warning signs overlap the proposed variable speed limit section. Depending on project phasing, agency should consider installing devices that could be used for both projects. • An ice warning system on OR 140 at Butte Creek is already in place. That system includes two signs with flashing beacons (one sign in each direction, about 20 miles apart). System could be improved with more frequent activated warning signs, each with smaller detection segments.	Yes	\$5,000 to \$45,000 (cost does NOT include power or communications) Lower price range assumes use of nearby RWIS station or installing grip factor only sensors at sign location. Higher price range assumes full RWIS station with project.	\$5,000
W03	Install automatic changeable snow zone and chain restriction signs	Install dedicated signs for snow conditions, not general variable message signs. Signs could use a rotator drum or an electronic display. Locations: • US 97 NB near mile post 240-243 (high volumes) • OR 140 WB near mile post 41 (possibly the worst conditions) • OR 140 EB mile post 25-35 (may be located in Jackson County) • OR 140 near Bly Mountain Pass mile post 53-57 • WB on OR 58 at the bottom of Odell Butte	High	ODOT	• Improves efficiency of maintenance personnel, allowing more time for plowing and less time traveling to remote locations to change signs.	• When determining communications to these signs reliability needs to be considered. • A sign that displays both chain conditions with additional information could be considered. For example, through the section of US 97 identified for variable speed limits (MP 204-244) a VMS sign could reserve half for chain conditions and half for variable speed conditions. Example dual display sign recently installed at the junction of US 26 and OR 216 (Wapinitia Hwy)	Yes	\$25,000 to \$70,000 per sign (basic VMS type of sign) additional costs: • mounting structure \$10,000 (standard post) to \$200,000 (cantilever or gantry) • communication cost is highly variable and dependent on location options	\$5,000 additional cost if communication is leased
W05	Install sensors that automatically notify agencies and travelers when rock fall occurs	Location: • US 97 around Upper Klamath Lake • Additional rock slide signs on OR140	Med	ODOT	• Faster response time	• Relatively low benefit cost ratio • Anchored mesh over hazardous locations may be more beneficial • Extensive sensor/detection necessary for full coverage	Yes	Variable depending on system	Variable
W06	Install heating elements or fixed spray anti-icing system in pavement to automatically de-ice	This strategy should be evaluated as new infrastructure is build, especially new bridges. Existing locations to consider include: • Bridges • Hwy 97 @ Riverside • Wall St. Bridge downtown into high school.	Low	ODOT, Klamath Co, City of Klamath Falls	• Reduce crashes by 25-100% (based on fixed anti-icing systems deployed on bridges in Utah, Minnesota, and Kentucky).	• Maintenance concerns • Note – there are geothermal heating elements at Esplanade Ave/Crater Lake Parkway		highly variable \$22,000 to \$4,000,000	roughly \$5,000 (not including de-icer spray)
W07	Variable Speed Limit Study - OR 140 Lake of the Woods	Conduct a variable speed limit study along OR 140, the Lake of the Woods area.	Low	ODOT	• Benefit cost ratios ranging from 1.1:1 to 1.9:1 for weather based VSL system (Finland) • Reduce weather related crashes due to drivers traveling too fast for the adverse conditions • OR 217 VSL resulted in a 20% decrease in crashes after one year • In general VSL systems can reduce crashes by 8% to 30% (weather and congestion based crashes)			\$50,000	n/a

Maintenance and Construction									
Ref #	Proposed Strategy	Description/Location(s)	Priority	Responsible Party(s)	Expected Benefits	Feasibility (Institutional and Technical) and Project Dependencies	Connected Vehicle Potential?	Capital Cost	Annual O&M Cost
MC01	Automated Vehicle Location (AVL) and logging capabilities (sanding, de-icing, and spraying)	Install AVL and activity logging capabilities in maintenance and construction vehicles, and create an automated process for trucks to log sanding, deicing, and pesticide spray information. The system should also be capable of tracking the amount of solution remaining in the maintenance vehicle tank.	High	ODOT, Klamath Falls, Klamath Co.	- Improve maintenance efficiency - Range of benefit to cost ratios from 2.6:1 to 24:1 - Improve planning capabilities and resource allocation	- Pilot snowplow project in ODOT Region 5 - Potential to connect information in real-time to a public website to inform travelers which roads have been plowed, or where pesticide was sprayed.	Yes	\$5,000 to \$15,000 per vehicle (assumes some retrofitting necessary) If implemented with telematics there are cost savings	\$1,000 per vehicle
MC02	Implement telematics technology on fleet vehicles	This project is similar to MC01, but adds telematics capabilities that can be used to track vehicle performance and vehicle maintenance. Telematics technology has a range of capabilities. For maintenance vehicles some of the key features to implement are tracking performance and fuel use, automatic notifications when vehicle maintenance is necessary, and improve routing efficiency.	High	ODOT, Klamath Falls, Klamath Co.	- Reduce fuel costs by 20-25% - Improve vehicle maintenance - Reduce idle time by 20-30%	- Vehicles need to be equipped with GPS units - Depending on the desired telematics capabilities, vehicles need to be equipped with a variety of sensors	Yes	\$5,000 to \$15,000 per vehicle (assumes some retrofitting necessary) If implemented with AVL there are cost savings	\$1,000 per vehicle
MC03	Automated Asset Management Tool	Install software that enables automated maintenance logs and proactive management of system health (notifications of equipment failure) for ITS infrastructure: - Traffic signal controllers - Street lights - Cameras - VMS - RWIS	Med	ODOT, Klamath Falls	Improve operational efficiency	- For traffic signals TransSuite can track operation logs if connected to the central system - ODOT uses Micromain for ITS equipment and traffic signal equipment	Yes	varies based on system	
MC04	Purchase software that optimizes snow plow routes and resources	During storm events or adverse weather conditions, software can help to optimize plow routes and distribution of limited resources.	Med	ODOT, Klamath Falls, Klamath Co.	- Optimize resources - Minimizes staff planning time	- Further software development is desired before adopting this strategy - NOAA currently has a system where they coordinate with ODOT and keep agencies informed when severe weather events are detected	Yes	\$50,000 (ITS database)	\$2,000 to \$5,000 (ITS database)

Emergency and Incident Management									
Ref #	Proposed Strategy	Description/Location(s)	Priority	Responsible Party(s)	Expected Benefits	Feasibility (Institutional and Technical) and Project Dependencies	Connected Vehicle Potential?	Capital Cost	Annual O&M Cost
EM01	9-1-1 Dispatch Interconnect	Connect the 9-1-1 dispatch center with ODOT and OSP through a software update (no construction required). This system will automate data transfer between Klamath Co 9-1-1 dispatch, ODOT, and OSP. Each agency can choose (through automated filters) what information to publish to the system. Once the data is on the CAD system it is available to all subscribers. Each agency can determine what data they want to automatically pull from the database. For example, ODOT can create a setting for notifications of specific type of incident on an ODOT facility. Likewise, OSP can automate their side to only publish roadway related activity and not all police activity to the system.	High	Klamath 9-1-1, OSP, ODOT	Based on Deschutes Co Pilot project: • Reduce incident response time by 30% • Shorten incident duration by 38% • Reduce dispatch response time by 25% • Reduce interagency calls by 60%	• Implemented in several other Oregon counties including Deschutes. • Klamath County uses use the same CAD software as other agencies along the 97 corridor. Software updates have already been completed. • Training and testing of the system would be necessary, requiring a time commitment from staff. • If situational software use expands, there are opportunities to interface it with 9-1-1 dispatch interconnect system • Project funding is currently available, but ongoing maintenance and operations funding is a concern		None (funded through a grant that Deschutes County received)	None (funded through a grant that Deschutes County received)
EM02	Develop Traffic Incident Management (TIM) Team	Develop a TIM team for the Klamath County area that includes responders from ODOT, Fire, Tow (OTTA), Law Enforcement, County, Cities, and 911 dispatch. Establish regular meetings and communication with the TIM Team.	High	ODOT	• Faster incident clearance • Improve coordination between responder partners • Improve understanding of partner roles	• Requires a time commitment from responders		staff time	staff time
EM03	Interoperable Communication Procedures	Implement standard protocols for using radios between agencies. This strategy could be a task for the TIM Team to develop.	High	ODOT	• Faster incident clearance, gets responders to the scene and where they are needed at the scene faster. • Improve on-scene communication	• Responders in Klamath Co currently operate on multiple frequencies and technologies (microwave, digital, radio). • Requires agencies to share frequencies • On-going training is critical • If a TIM Team is developed, this could be a task for the TIM Team	Yes	Staff time to prepare protocol and provide training	ongoing staff time for training and updating
EM04	Situational Software	Integrate the Intterra Situational Awareness software during incident or emergency response. The software can track where each of the response agencies/vehicles is (en route, at the scene, and during clean up) and improve communication between responders.	High	Keno Fire Dept, ODOT, OSP	• Faster incident clearance • Improve on-scene communication • Improve incident scene management	• Keno Fire Department is already using Intterra Situational Awareness software. Access provided to several other counties (Wasco, Jackson, Josephine, and Deschutes). Responders can access the information on any mobile device. Software includes HazMat data. • Intterra is currently funded through a federal grant, the annual fee of \$56,000 is fully covered for another 8 to 10 years. It is free to agencies right now. • Software is currently used for fires and flooding, but could be expanded to traffic incident management. • The software is currently connected to a federal CAD system. • There might be an opportunity to interface with a 9-1-1 CAD and interconnect system. • To implement for TIM, law enforcement vehicles would need to be equipped with AVL compatible with the software.	Yes	n/a (annual license fee)	\$56,000 (currently paid for by a federal grant)
EM05	Portable Variable Message Signs (VMS)	Purchase additional portable VMS to use during events and incidents	High	ODOT	• Reduce out of direction travel • Reduce traveler frustration by improving traveler knowledge • Reduce driver speeds by 3.6 mph upstream of work zones (study in rural Missouri) • When used in conjunction with radar, a study in Virginia found a 50% reduction in speeding vehicles through work zones, with a decrease in vehicle speeds of up to 9 mph within a work zone			\$15,000 to \$20,000 (ITS database)	\$1,500
EM06	Sharing On-Scene Photos and Video	Invest in technology that allows first responders to send and receive photos and video from an incident scene, including the tow partners.	Med	ODOT, OSP	• Increase the percent of time tow companies arrive with correct equipment • Faster incident clearance	• Possible privacy issues to address	Yes	\$200 to \$1,000 per vehicle	minimal
EM07	Automated infrastructure integrity notification	Install devices that automatically notify responsible agency if infrastructure is damaged. As new infrastructure is build, this strategy should be evaluated on a case by case basis. Example: structural integrity of a bridge or structure following an earthquake, or rock fall on the roadway or railroad tracks.	Low		• Improves efficiencies responding to damaged infrastructure	• If the 9-1-1 CAD interconnect project is implemented, agencies could be automatically notified whenever a crash or incident occurs on their facility, providing immediate notification if infrastructure is damaged due to a crash. • Additional technologies would be required to detect incidents such as rock fall or earthquake damage.		variable	

Public Transportation									
Ref #	Proposed Strategy	Description/Location(s)	Priority	Responsible Party(s)	Expected Benefits	Feasibility (Institutional and Technical) and Project Dependencies	Connected Vehicle Potential?	Capital Cost	Annual O&M Cost
P01	Real-time transit information and notifications	Provide transit users with real-time information about next arrivals, significant delays, route changes, or other trip related information. Information can be provided through website access, displays at transit stations, or a smart phone app. The real-time transit information should extend beyond Basin Transit to include Quail Trail Public Transit which provides daily service between Chiloquin and Klamath Falls.	High	Basin Transit	• Improve travel experience for transit user • Potential for increased ridership and revenue • Improve schedule adherence by 9 to 23% using AVL/CAD systems (study based on information from Portland, Milwaukee, and Baltimore)	• This strategy requires installing automatic vehicle location (AVL) technology on the transit fleet and updating the computer aided dispatch (CAD) system. • Equipment acquired for this strategy could also be used for the data tracking/logging and transit signal priority. • Strategy would benefit from partnership between Basin Transit and Quail Trail Public Transit. • Apollo cameras used on Basin Transit buses may have AVL capabilities	Yes	\$200 to \$700/vehicle for AVL device \$15,000 for interface (ITS database)	\$500/veh
P02	Automated transit vehicle on-board data tracking and logging	Install on-board devices to automatically track and log boardings, de-boardings, use of lift, etc. Explore the option of "piggy-backing" with a larger transit agency for data tracking transit equipment.	High	Basin Transit	• Improve transit management and resource allocation			\$1000/vehicle (as an add-on) \$8,000/vehicle (as a stand alone installation)	\$200/vehicle
P03	Update the Basin Transit Website	Update the Basin Transit website to be more user friendly and include real-time information such as delays, route changes, and time of next arrivals.	Med	Basin Transit	• Improve traveler experience for transit user • Potential for increased ridership and revenue •	• If real time information is available (P01) the website could be updated to include that information. • Link commercial options to access Crater Lake and the Quail Trail Public Transit		\$30,000	\$4,000
P04	Transit equipment price agreements	Explore the option of "piggy-backing" with a larger transit agency for transit equipment not already covered by the statewide price agreement.	Med	Basin Transit	• Cost savings	• ODOT already has statewide price agreements in place for some transit equipment including transit stop amenities (shelters, trash cans, etc.)		staff time	staff time
P05	Transit Signal Priority (TSP)	Provide an early green, queue jump, or extended green for transit vehicles to help reduce transit delay.	Low	Basin Transit	• Decrease transit delay - studies show up to a 40% reduction • Improve transit travel time by 1.5 to 7.5% • Decrease bus fuel use and emissions	• Low interest do to relatively small transit fleet (eight buses) that travel through Klamath Falls. Transit through other areas of the county do not encounter traffic signals. • Current 2070 controllers in Klamath County (using Voyage software on the TransSuite server) support transit signal priority • Necessary equipment includes: transmitters on the buses (these could be either manual or automatic) and receivers at the signals. Equipment is available on state equipment list. • TSP could increase delay for side streets.		\$5,000 per intersection if existing software and controllers can be used (such as the 2070s) \$25,000 to \$30,000 per intersection if new equipment is needed. Additional cost for transponders on buses	

Freight Management									
Ref #	Proposed Strategy	Description/Location(s)	Priority	Responsible Party(s)	Expected Benefits	Feasibility (Institutional and Technical) and Project Dependencies	Connected Vehicle Potential?	Capital Cost	Annual O&M Cost
F01	Truck signal dilemma zone protection	Install detection at traffic signals along designated freight routes through Klamath Falls that identify approaching heavy vehicles and speed, and either extend green or conflicting red to prevent collision potential. Locations: • OR 140/Washburn Way • OR 66/OR 140 Interchange • Crater Lake Parkway • Washburn Way/6th Street • Homedale Rd/OR 140	High	ODOT	• Improve safety by 20% with dilemma zone protection (study based on all vehicles, not limited to trucks) • Decrease truck stops and decrease emissions • If used with truck signal priority, truck travel times would likely improve	• Additional detection (such as radar) would be necessary to enable traffic signals with this capability. • Current 2070 traffic signals operating Voyage software on the TransSuite central signal system can accommodate dilemma zone protection (170 Controllers cannot accommodate this feature). • Potential to also provide truck signal priority with this strategy	Yes	\$8,000/intersection	\$1,000
F02	Automated freight restrictions	Provide automated push messages to truck drivers to alert drivers of restrictions (height, weight, length, and width) along route choices. Noted areas of concern: • Railroad structure on Hwy 39 • Restricted width on US 97 near N Klamath interchange and between Algoma Rd and Shady Pine Rd • Structures along OR 66, OR 140, US 97	High	ODOT Motor Carrier	• Reduce out of direction travel due to last minute rerouting	• To provide push notifications, an in-vehicle device would be necessary to receive the notification and also transmit the vehicle location and proposed route.	Yes	\$4,000/vehicle (communication and tracking equipment) Additional cost if a central system is required	
F03	Real-time freight parking info	Noted truck parking areas: Chiloquin Casino north of K Falls, rest area at Midland (S of K Falls), Pilot Travel centers (K Falls, and Chemult)	High	ODOT, Private Partnerships	• Reduce illegal truck parking • Reduce truck driver frustration • Improve freight route planning • Potential to reduce violations of truck drivers exceeding hours of service rules	• Requires coordination with private sector facilities that provide truck parking • Parking stalls could be equipped with sensors that allow truck drivers to access occupancy information remotely • Potential to provide parking reservation service • Potential to add a parking system in conjunction with a lighting system. Acuity Brands has a product that plugs into the light receptacle and can use cellular communications to monitor parking availability. • Truck parking study underway by OSU	Yes	\$50,000 to \$100,000 (ITS database) monitoring system and database	\$5,000
F04	Communicate truck route through Klamath Falls	Sensor and warning sign for detection of over height trucks. Key areas to consider: • Overpass at Veteran's Park on George Nurse Way • 6th Street overpasses • Esplanade Avenue	Med		• Reduce the occurrence of underpasses getting damaged by trucks that do not meet height restrictions	Truck routes communicated through Navigation software Klamath Falls is re-designating truck routes	Yes		

Appendix B: Existing Conditions Memorandum

STATE OF OREGON

MEMO

Department of Transportation

Region 4 Traffic

63055 N Hwy 97

Bend, Oregon 97701

(541) 388-6180 FAX (541) 388-6231

Date: November 16, 2015

TO: Klamath County ITS Project

FROM: Mark Barrett, PE
Region 4 Traffic

SUBJECT: Klamath County ITS Project
Existing Conditions Memorandum

Introduction

The purpose of this memorandum is to provide an overview of the current transportation system conditions in Klamath County and to develop an inventory of the physical, operational, traffic safety, and travel characteristics of the transportation corridors in the study area. This inventory includes a summary of the following:

- Study Area Corridors
- Recurrent Congestion Locations
- High Crash Locations
- Transit Operations
- Traffic Signal Control
- Intelligent Transportation System (ITS) elements
- Communications Network
- Emergency Management
- Incident Management
- Special Events
- Freight Movement
- Traveler Information

The main goal of the inventory is to establish the baseline conditions in the study area that will be used for building an intelligent transportation system based on regional transportation user needs.

Study Area

The study area consists of consist of State Highways, City of Klamath Falls roadways, and Klamath County roadways. Throughout Klamath County, there are several mountainous passes as well as key weather locations, which were identified by ODOT District 11 as sections that experience hazardous weather conditions or other terrain related issues:

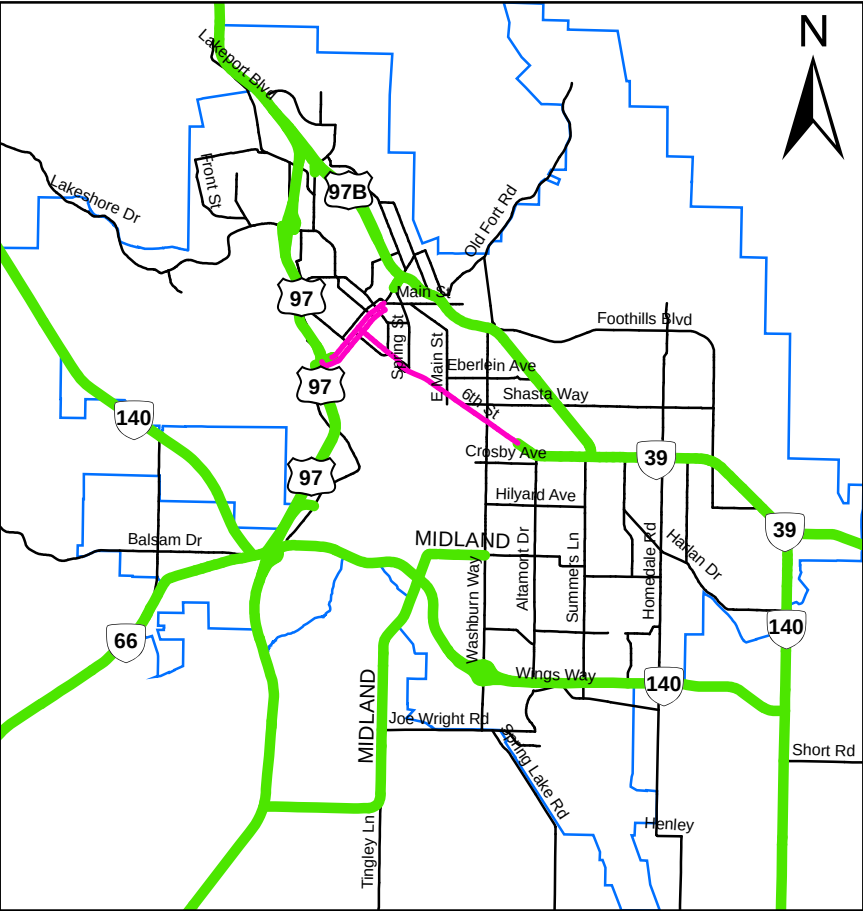
- The Dalles-California Hwy (US97): Chapman Street – Chemult (MP 178-204)
- The Dalles-California Hwy (US97): Passing Lanes – Thunderbeast Park (MP 229-235)
- The Dalles-California Hwy (US97): Spring Creek Hill – Passing Lanes (MP 241.5-245.7)
- The Dalles-California Hwy (US97): Modoc Point – Shady Pine Road (MP 258-267)

- The Dalles-California Hwy (US97): Klamath Straits (MP 282.9-288.2)
- Willamette Hwy (OR58): Crescent Lake Highway – Gilchrist Jct (MP 70-83)
- Lake of the Woods Hwy (OR140) near Butte Creek (MP 19-40.4)
- Lake of the Woods Hwy (OR140): Doak Mtn. – Geary Canal (MP 51.6-58.9)
- Klamath Falls-Lakeview Hwy (OR140) at Bly Mountain Summit (MP 25.6-34.4)
- Crater Lake Hwy (OR62): Crater Lake Park – Fort Klamath (MP 83.7-89.0)

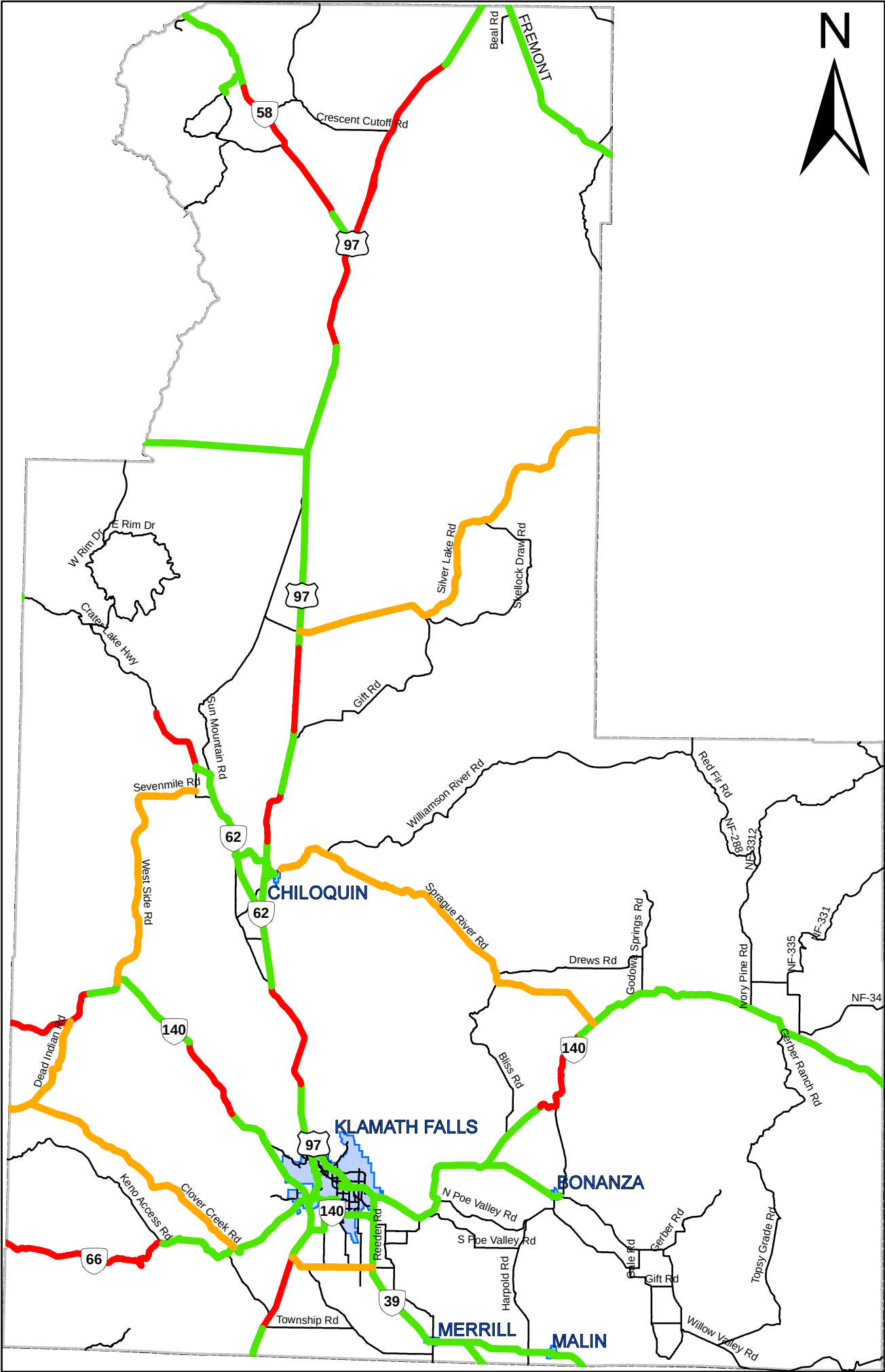
Additionally, the study area includes Klamath County roadways that can function as emergency route pairs that are existing routes that can serve as connections to communities and can be used to detour State Highway traffic to alternate routes when portion of the highway are closed due to an incident (fire/crash/etc.):

- Clover Creek Road and Dead Indian Memorial Road – alternate route from Klamath Falls to the Rogue Valley / Ashland.
- Westside Road – alternate route for eastbound traffic to get to Fort Klamath and/or US97 and is the preferred route for over-dimensional loads since OR140 is restricted.
- Cross Road – alternate route from US97 to OR39 (south of Klamath Falls)
- Sprague River Road – connection to Community of Sprague River and serves as an alternate route between US97 and OR140.
- Silver Lake Road – alternate route connection between US97 near Chiloquin and OR31 near Silver Lake.

Currently, none of the emergency routes above have ITS devices in operation to support their use. **Figure 1-1** illustrates the corridors to be evaluated for potential implementation of ITS devices (ITS Corridors).



Klamath Falls Urban Area Inset



DEFINITIONS:
Klamath County Emergency Routes: existing routes that serve as connections to communities and can be used to detour State Highway traffic to alternate routes when portions of the highway are closed due to an incident (fire/crash/etc).
Weather/Terrain Location: sections of highway that experience hazardous weather conditions or other terrain related issues (rockfall/wind/landslide/etc), as identified by ODOT District Staff.

Legend

Klamath County Emergency Routes

City of Klamath Falls ITS Corridors

ITS Corridors

Weather/Terrain Location

Urban Growth Boundary

County

KLAMATH COUNTY

Intelligent Transportation Systems

Figure 1-1

STUDY AREA

Date: 11/16/2015

Baseline traffic volumes and heavy vehicle percentages on key study corridors are summarized in **Table 1**. The 2013 average annual daily traffic volume flows on State Highways are portrayed on **Figure 1-2**.

Table 1-1: Study Area Corridors

#	Corridor	Limits	Max. 2013 2-Way ADT*	Max. 2033 2-Way ADT**	Heavy Vehicles ***
1	US97: The Dalles-California	MP 172.19 to MP 291.73 (La Pine to California)	10900	13000	36%
2	OR58: Willamette	MP 70.00 to MP 86.57 (Crescent Lake – US97)	1800	2100	40%
3	OR138: North Umpqua	MP 87.38 to MP 100.82 (Crater Lake Park – US97)	1100	1400	31%
4	OR62: Crater Lake	MP 83.63 to MP 103.95 (Crater Lake Park – US97)	760	780	18%
5	OR422: Chiloquin Hwy	MP 0 to MP 5.29 OR62 to Chiloquin / US97	1800	2500	13%
6	OR140: Lake of the Woods	MP 32.25 to MP 68.76 (Lake of the Woods – OR66)	2200	2700	25%
7	OR66: Green Springs	MP 43.73 to MP 59.09 (Klamath River – US97)	10500	13300	13%
8	US97B: Klamath Falls – Malin	MP -6.87 to MP -2.24 US97 – OR39	21200	24700	5%
9	OR39/140: Klamath Falls- Lakeview	MP 2.5 to MP 63.42 (Klamath Falls – Quartz Mtn)	19000	24400	12%
10	OR70: Dairy-Bonanza	MP 0 to MP 6.97 (Dairy – Bonanza)	1400	1600	28%
11	OR39: Klamath Falls-Malin	MP 0 to 27.1 (Lakeview Jct. to Merrill)	7000	8900	27%
12	OR39: Hatfield	MP 16.5 to MP 18.93 (Malin to Hatfield)	2300	2700	29%
13	OR140: South Klamath Falls	MP 0 to MP 5.97 (US97 to OR39)	9400	15100	17%

* ADT values taken from ODOT 2013 Transportation Volume Tables.

** Future ADT values are approximate values taken from ODOT's 2033 Future Volume Tables.

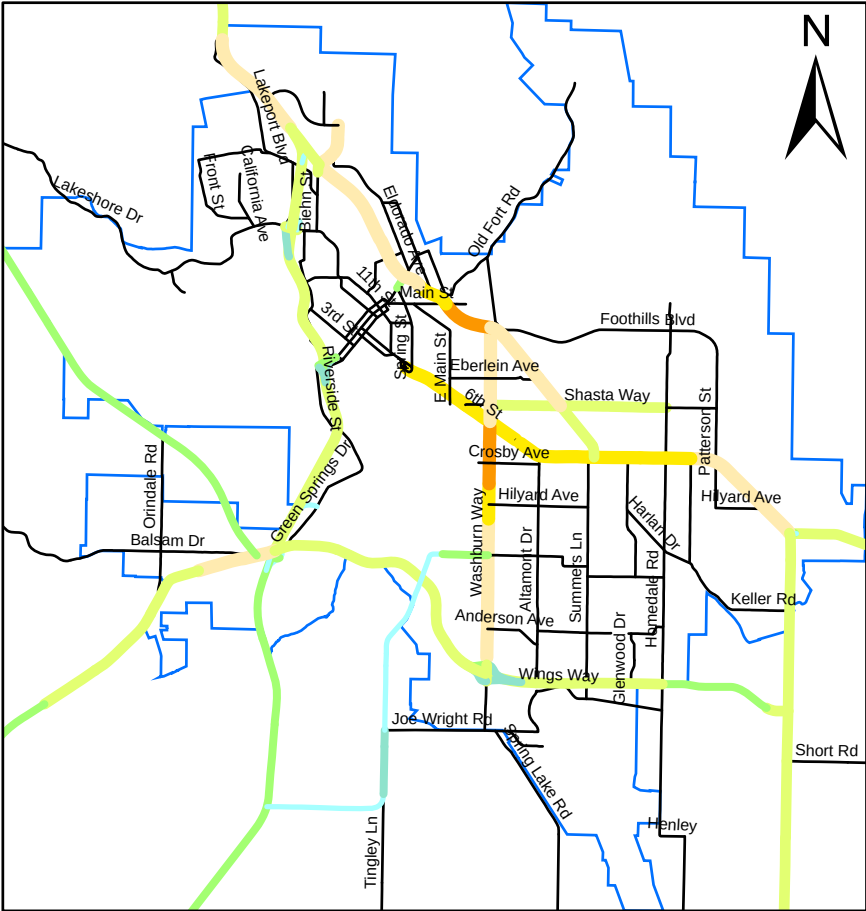
*** Heavy Vehicle Percentages are average values taken from ODOT 2013 Traffic Volumes and Vehicle Classification

Overall, roadways in Klamath County experience relatively small-scale seasonal variations throughout the year. Based on annual data from Automatic Traffic Recorders, State Highways in Klamath County experience the following seasonal patterns:

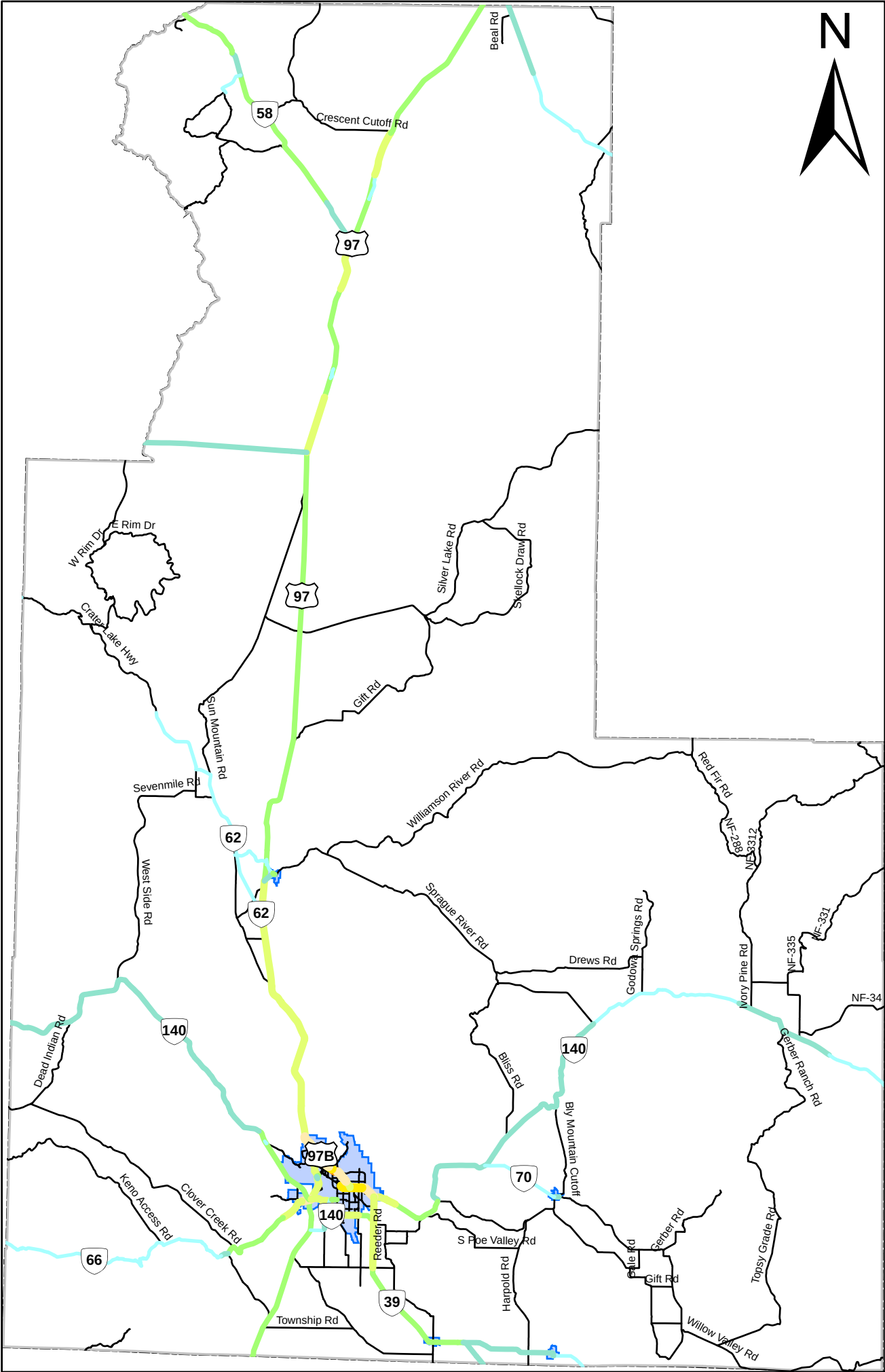
- **The Dalles-California Highway (US97)** – Recreational Summer/Summer route characterized by mid-high level summer peaks in traffic patterns.
- **Klamath Falls-Lakeview Highway (OR140)** – Recreational Summer route characterized by high summer peaks in recreational areas.

- ***Klamath Falls-Malin Highway (OR39/US97 Bus.)*** – Within the City of Klamath Falls urban area, this highway functions as a Commuter route characterized by small seasonal changes in traffic patterns due to commuting between city pairs. Outside of the City of Klamath Falls, this route experiences Agricultural traffic patterns characterized by peaking in the late summer and fall harvest months.
- ***Crater Lake Highway (OR62)*** – Recreational Summer route characterized by high summer peaks in recreational areas.
- ***South Klamath Falls Highway (OR140)*** – Commuter route characterized by small seasonal changes in traffic patterns.

Key regional facilities located within the study area are depicted on **Figure 1-3**. The items shown include emergency management facilities (fire stations, police stations, hospitals, and emergency operations centers), schools, and ODOT Facilities (engineering offices and maintenance).



Klamath Falls Urban Area Inset



Legend

Traffic Flow

Aadt

0 - 1000 AADT

1001 - 2500 AADT

2501 - 5000 AADT

5001 - 10000 AADT

10001 - 15000 AADT

15001 - 20000 AADT

20001 - 30000 AADT

30001 - 50000 AADT

50001 - 75000 AADT

75001 + AADT

Urban Growth Boundary

County

KLAMATH COUNTY
Intelligent Transportation Systems

Figure 1-2

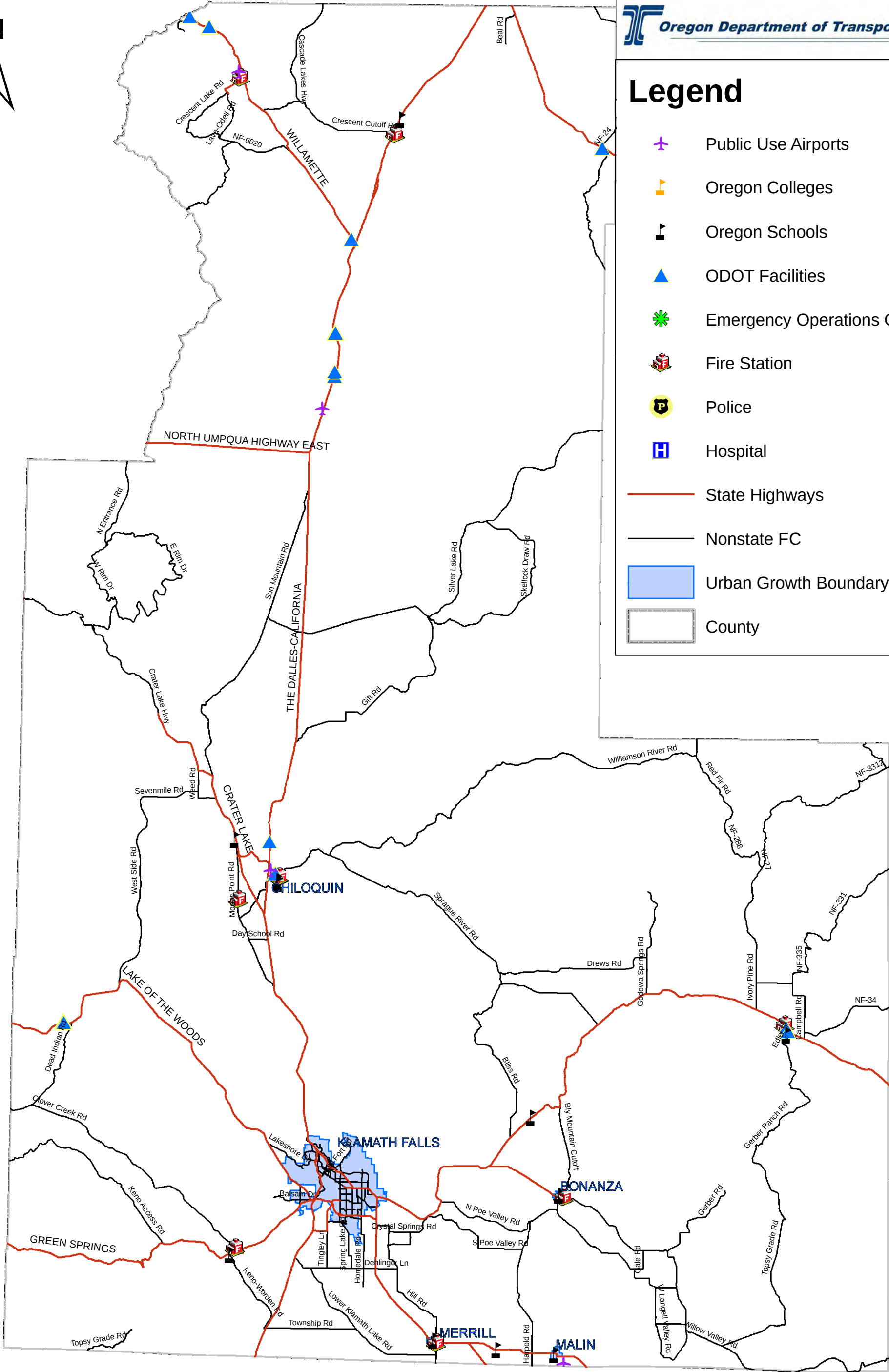
2013 TRAFFIC FLOW

Date: 11/9/2015



Legend

-  Public Use Airports
-  Oregon Colleges
-  Oregon Schools
-  ODOT Facilities
-  Emergency Operations Center
-  Fire Station
-  Police
-  Hospital
-  State Highways
-  Nonstate FC
-  Urban Growth Boundary
-  County



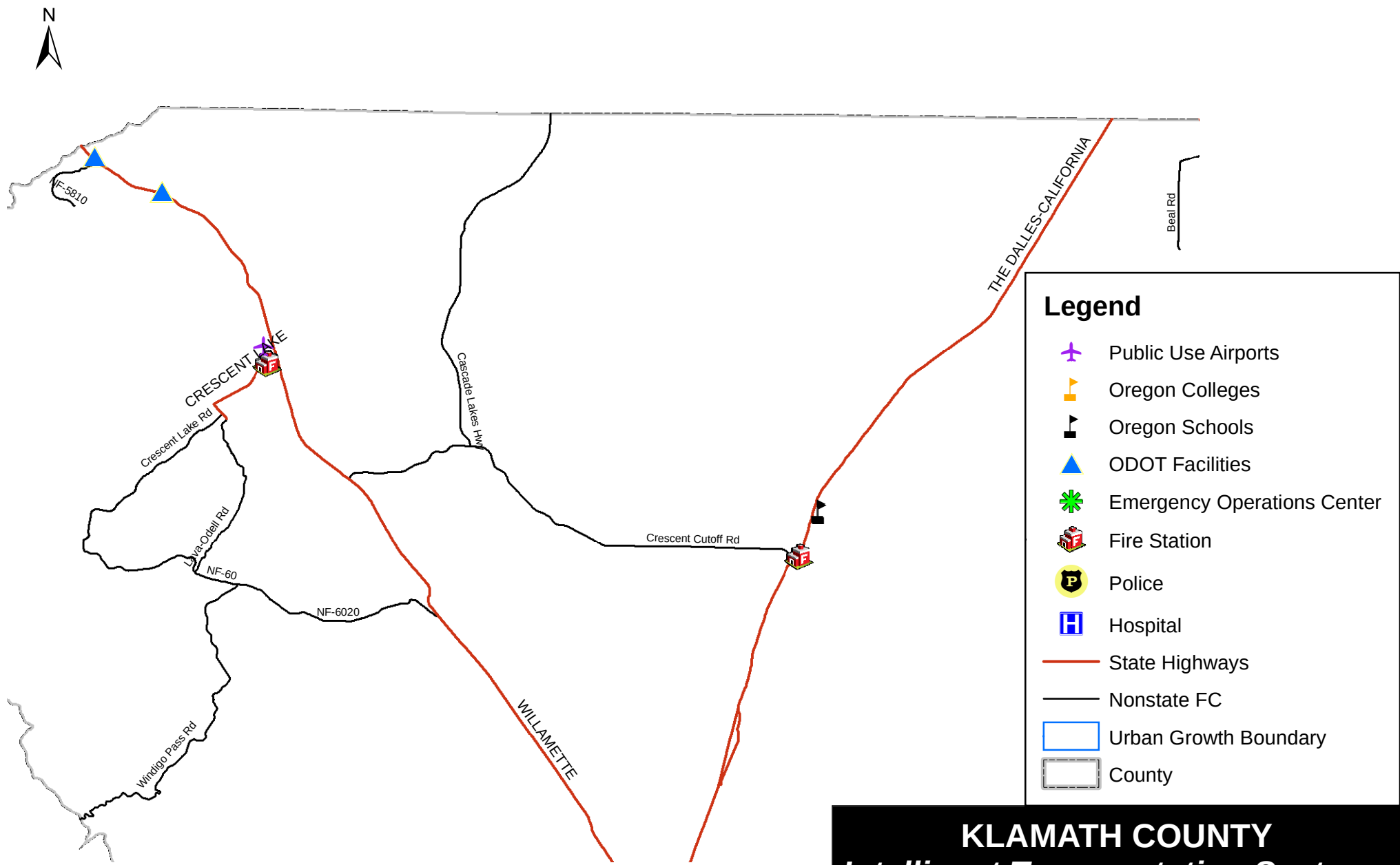
KLAMATH COUNTY

Intelligent Transportation Systems

Figure 1-3

REGIONAL FACILITIES

Date: 11/2/2015



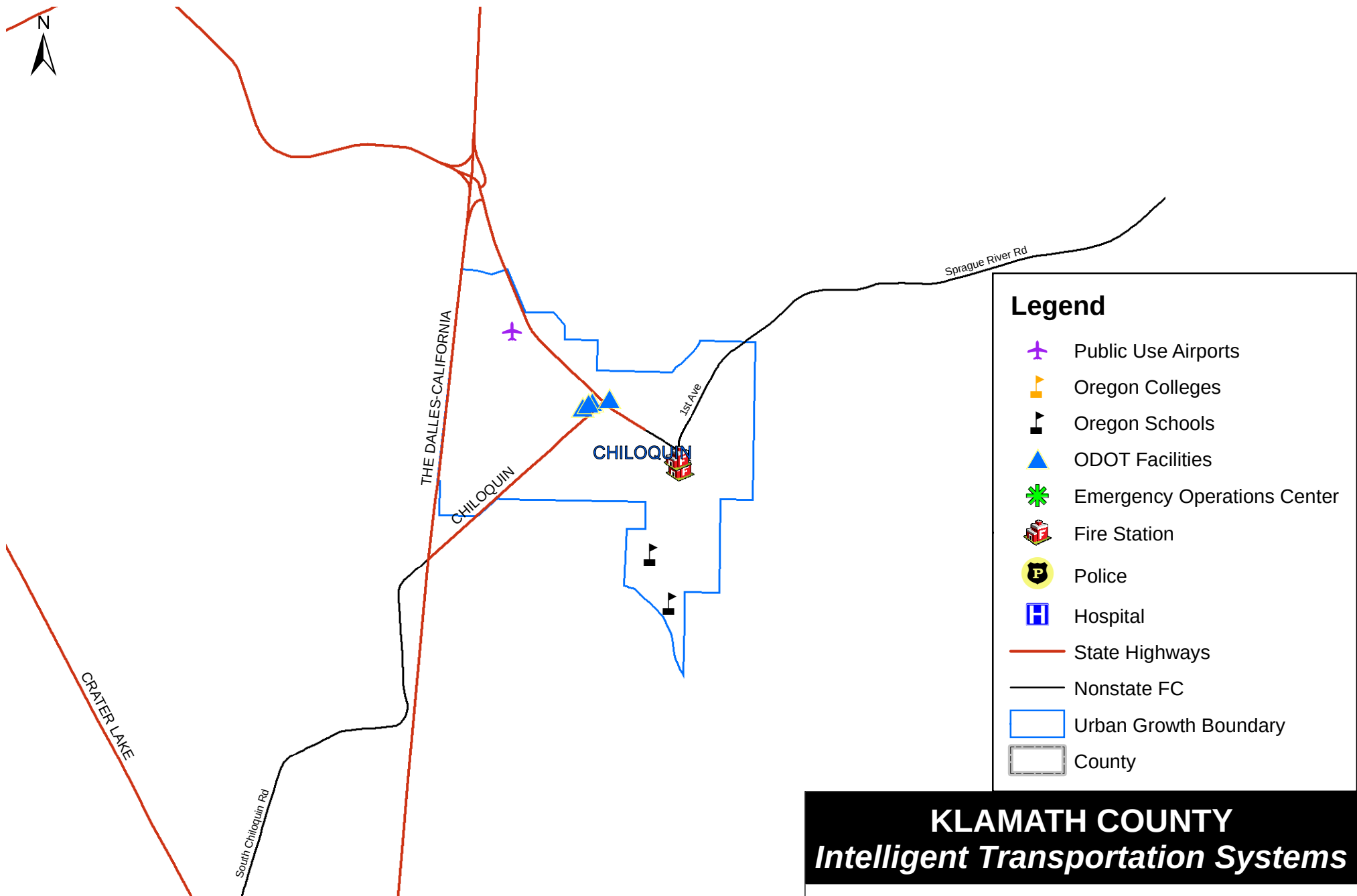
KLAMATH COUNTY

Intelligent Transportation Systems

Figure 1-3A

REGIONAL FACILITIES - CRESCENT

Date: 10/12/2015

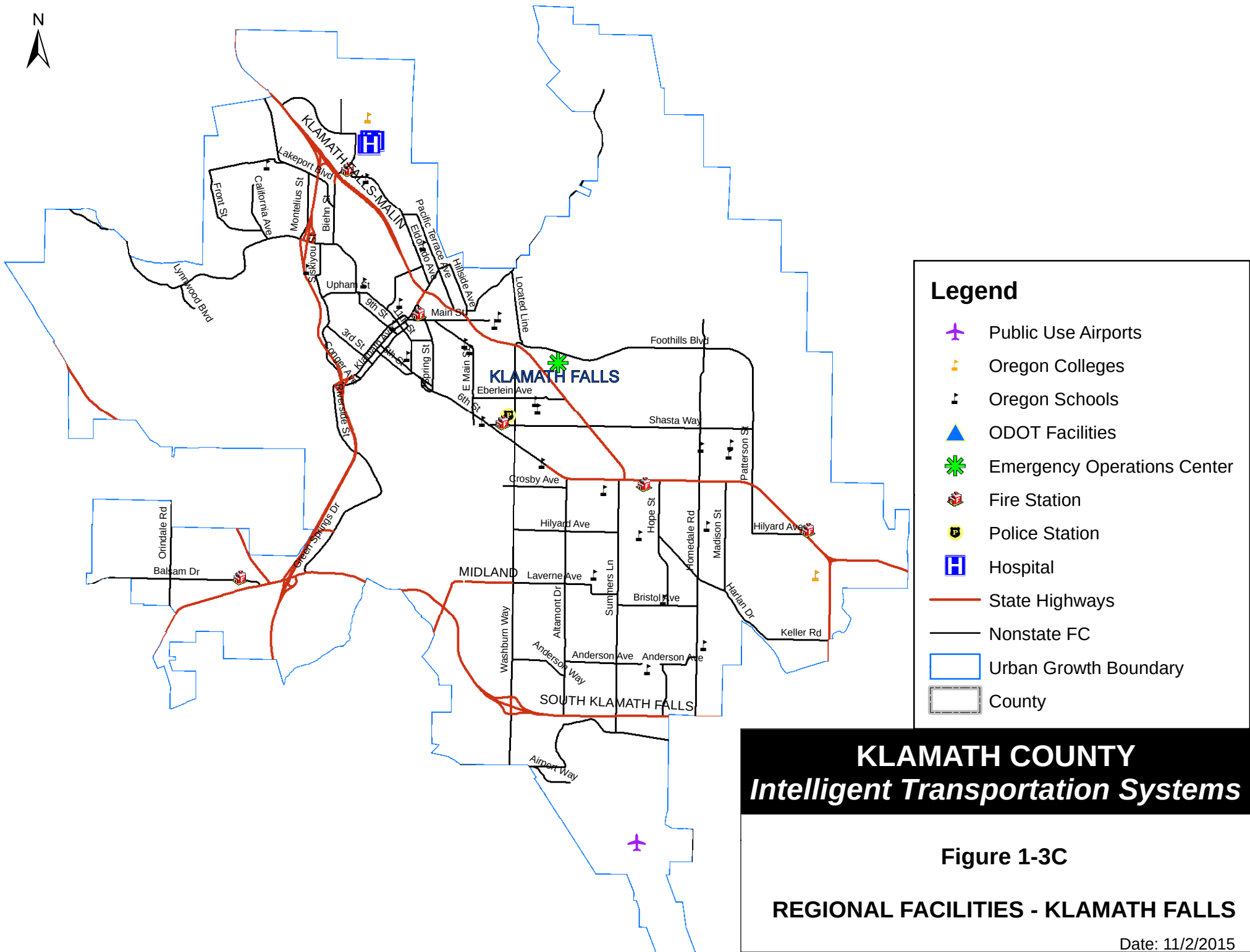


KLAMATH COUNTY
Intelligent Transportation Systems

Figure 1-3B

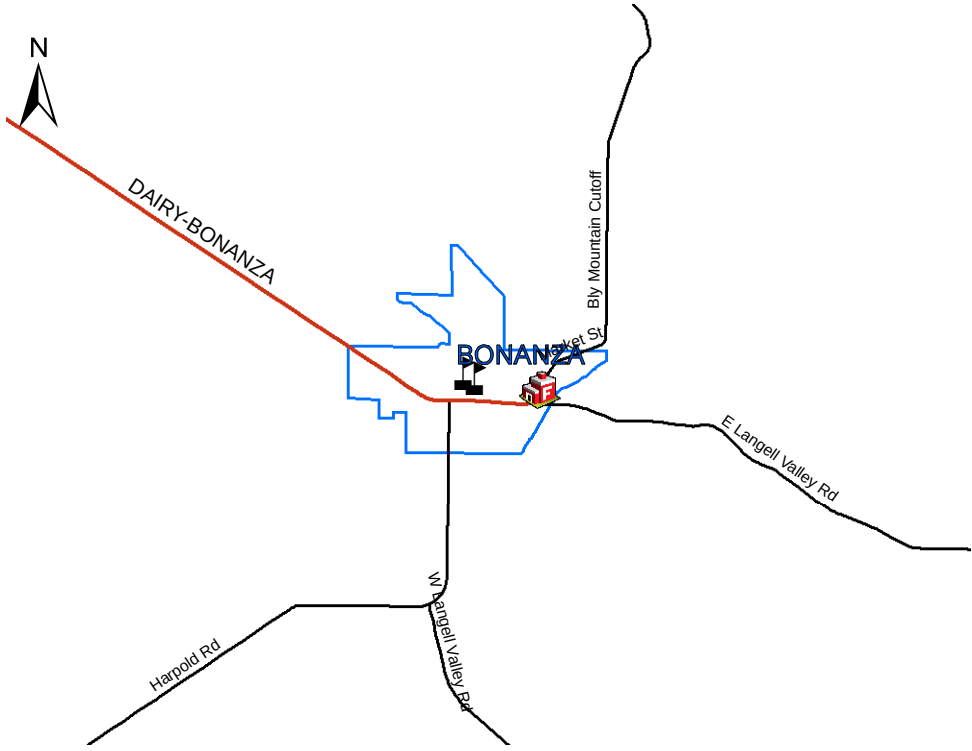
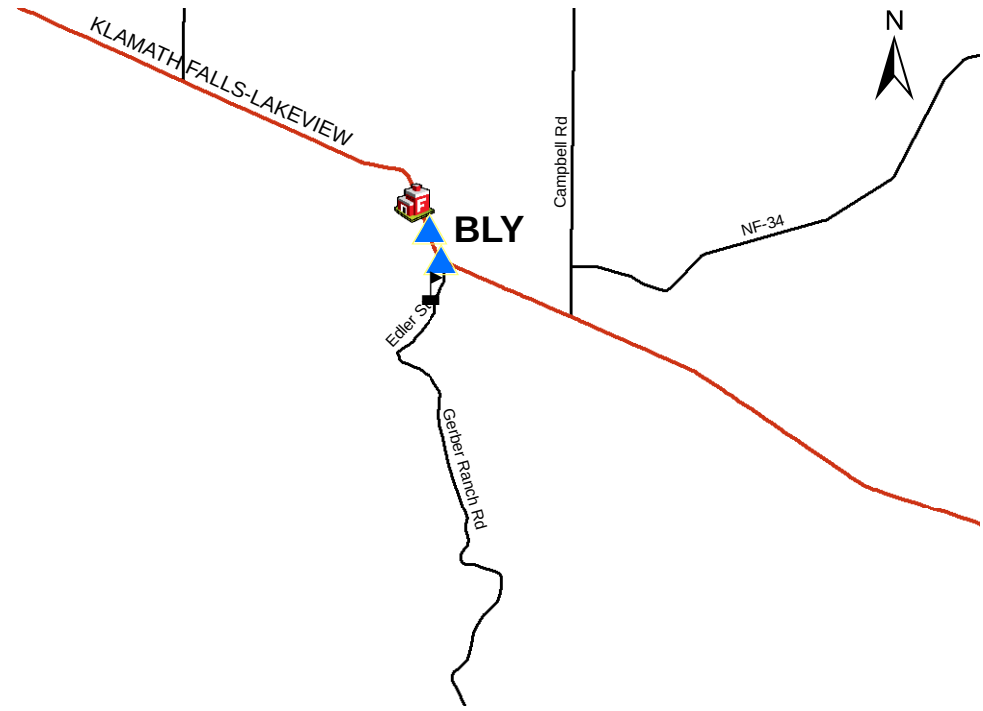
REGIONAL FACILITIES - CHILOQUIN

Date: 10/12/2015



Legend

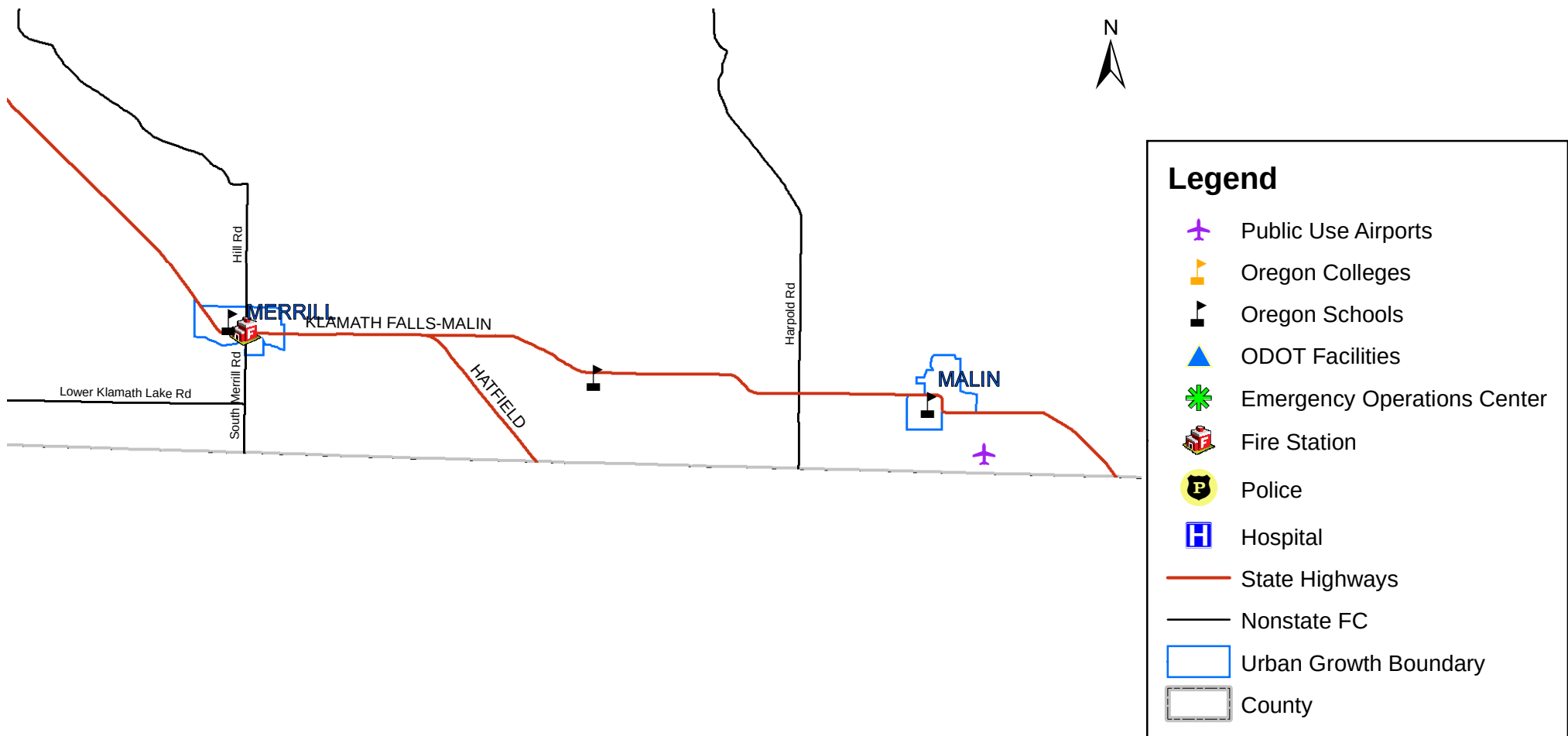
-  Public Use Airports
-  Oregon Colleges
-  Oregon Schools
-  ODOT Facilities
-  Emergency Operations Center
-  Fire Station
-  Police
-  Hospital
-  State Highways
-  Nonstate FC
-  Urban Growth Boundary
-  County



KLAMATH COUNTY
Intelligent Transportation Systems

Figure 1-3D
REGIONAL FACILITIES
BONANZA & BLY

Date: 10/12/2015



KLAMATH COUNTY

Intelligent Transportation Systems

Figure 1-3E

**REGIONAL FACILITIES
MERRILL AND MALIN**

Date: 10/12/2015

Traffic Conditions Summary

Congested corridor sections / bottlenecks and high collision areas are indicators of locations where ITS field elements have potential for a noticeable benefit. This section provides a summary of existing and future recurrent congestion and high collision locations.

Characteristics of Congestion

Congestion is typically categorized as either non-recurrent or recurrent. Non-recurrent congestion results from unexpected random events (crashes / debris in roadway / maintenance). Recurrent congestion occurs at the same location repeatedly at areas such as bottlenecks, merge points, or weaving sections during peak periods. Volume-to-capacity (v/c) ratios along roadways or at intersections can help determine locations where traffic flows are near, at or above capacity, indicating recurrent congestion. Travel demand forecast models provided v/c ratios by roadway link for current and future time periods. Congested v/c levels assigned in Klamath County models are listed in **Table 1-2**.

Table 1-2: Congestion Levels Based on V/C Ratios¹

Congestion Level	Volume-to-Capacity (v/c) Ratio
Low	< 0.65
Moderate	0.65 to 0.75
High	> 0.75

1 – From ODOT Transportation Planning & Analysis Unit

Existing Congestion

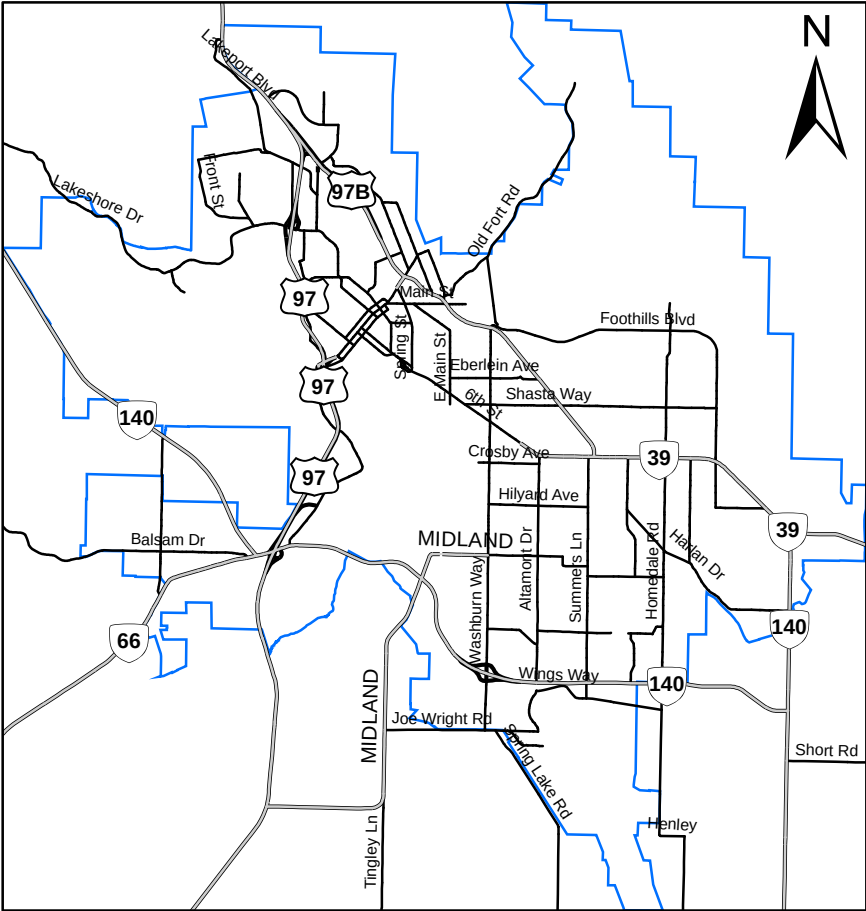
Current data indicates that there are low levels of recurrent congestion on State Highways in Klamath County. **Figure 1-4** details existing congestion on State Highways in Klamath County. The data presented in the figure is based on analysis from ODOT Transportation Planning and Analysis Unit's (TPAU) congestion management dataset for 2013 and represents segment v/c ratios.

Future Congestion

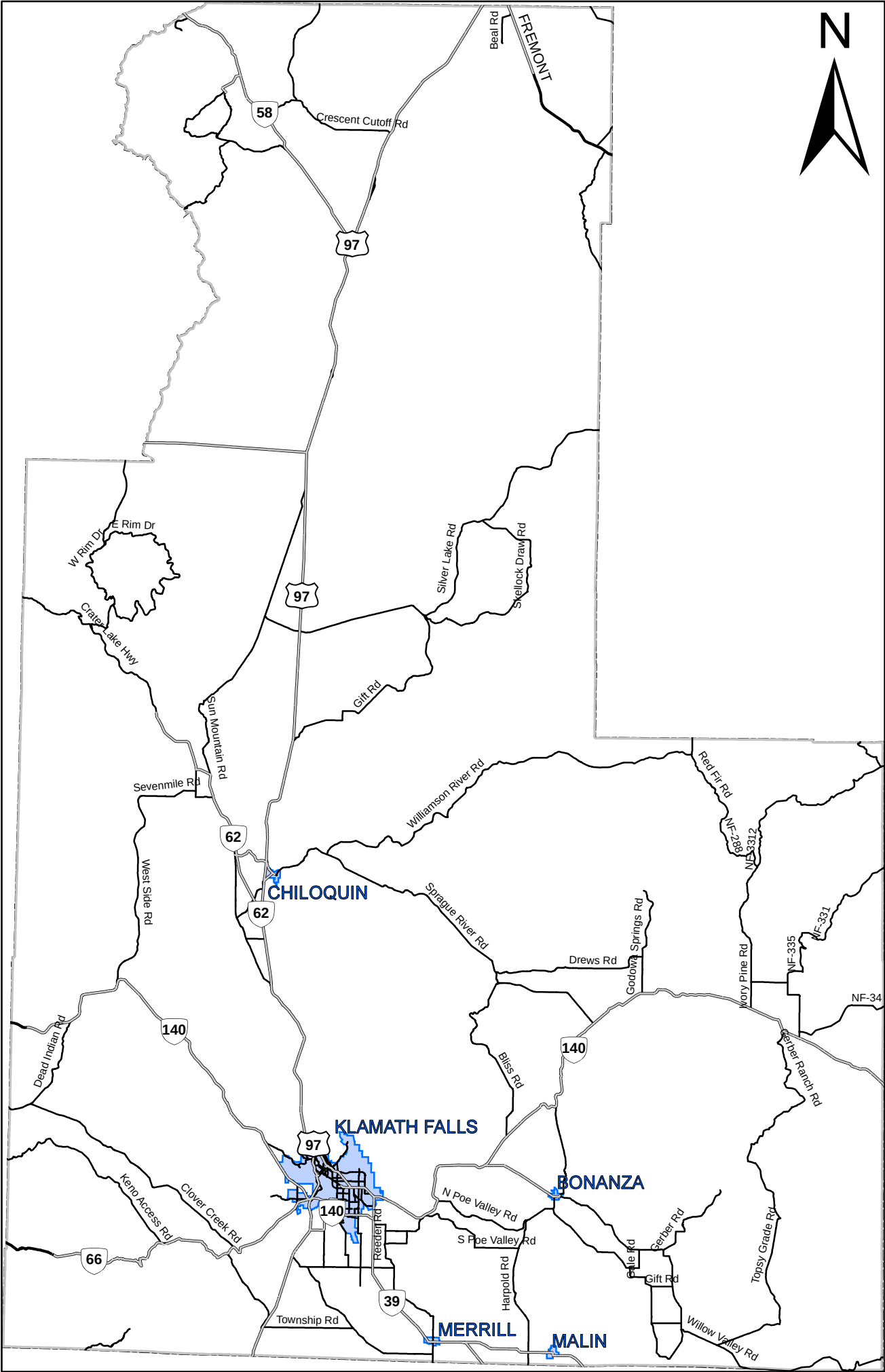
Portions of US97, US97 Business, and OR39 within the City of Klamath Falls Urban Growth Boundary are expected to experience moderate levels of congestion in 2033. **Figure 1-5** illustrates the future congestion levels anticipated in Klamath County based on TPAU's congestion management dataset for 2033 projected conditions and represents segment v/c ratios.

Note:
 The congested areas shown on this map are based on the Transportation Planning Analysis Unit's data for Klamath County Congestion Management System dataset for 2013.

Congested areas shown refere to segment v/c, not intersection v/c.



Klamath Falls Urban Area Inset



Legend

CMS_VMT_CD

Less Than 0.65 V/C Congestion

0.65 to 0.75 V/C Congestion

Greater Than 0.75 V/C Congestion

State Highways

Non-State Roadway

Urban Growth Boundary

County

KLAMATH COUNTY

Intelligent Transportation Systems

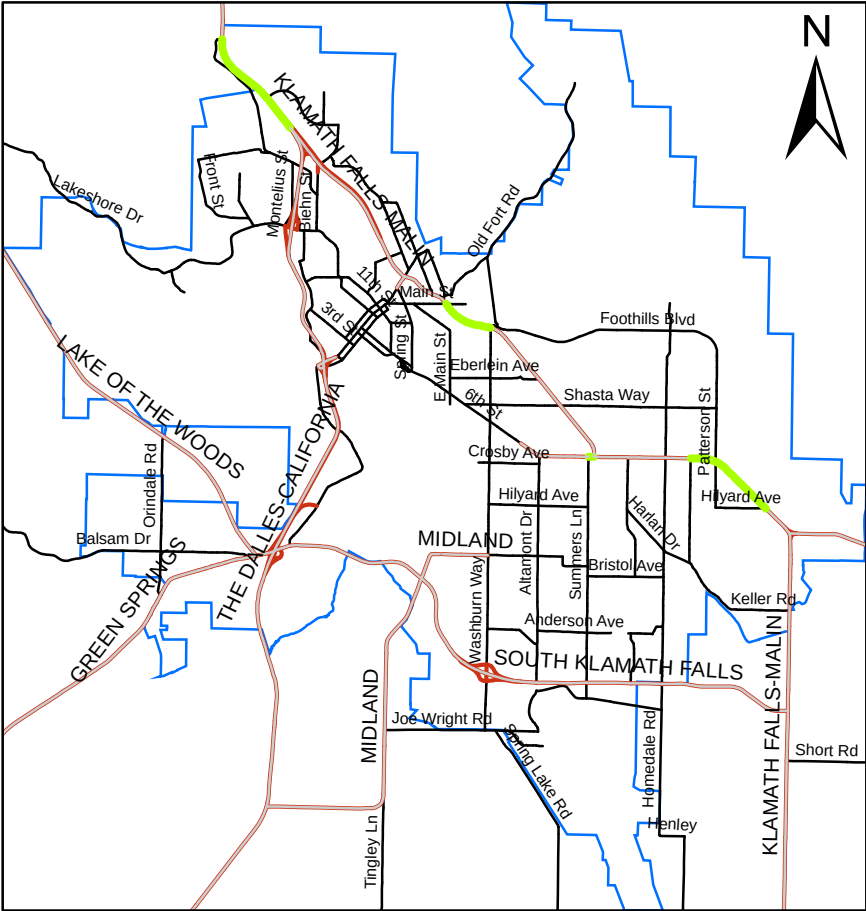
Figure 1-4

EXISTING PROBLEM AREAS

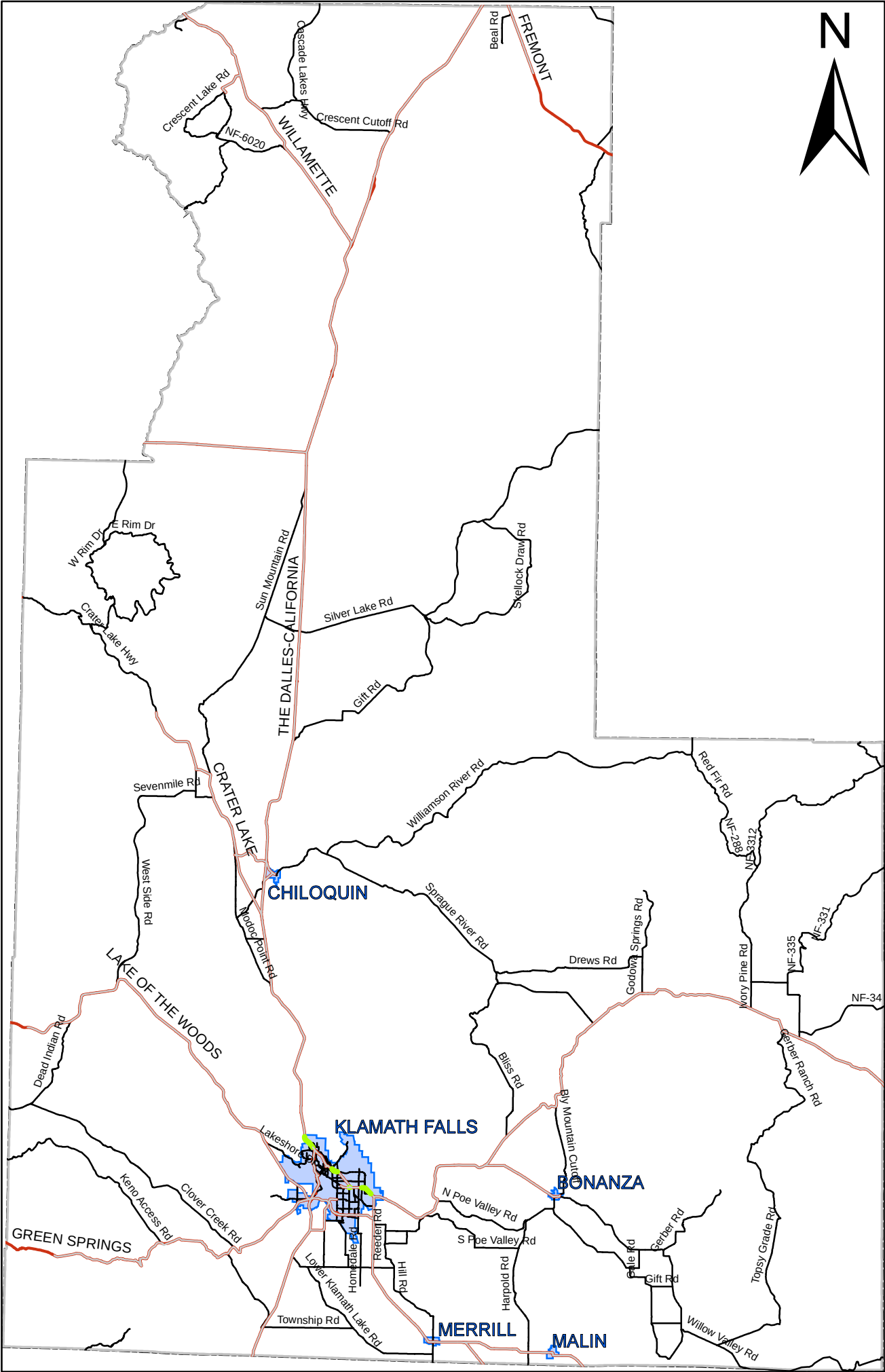
Date: 11/2/2015

Note:
 The congested areas shown on this map are based on the Transportation Planning Analysis Unit's data for Klamath County Congestion Management System for 2033 projections.

Congested areas shown refer to segment v/c, not intersection v/c.



Klamath Falls Urban Area Inset



Legend

- Less Than 0.65 V/C Congestion
- 0.65 to 0.75 V/C Congestion
- Greater Than 0.75 V/C Congestion
- State Highway
- Non-State Roadway
- Urban Growth Boundary
- County

KLAMATH COUNTY *Intelligent Transportation Systems*

Figure 1-5
 2033 FUTURE PROBLEM AREAS

Crash Summary

In the most recent five years of available crash data (2009-2013), there were 4,025 reported crashes in Klamath County resulting in 52 fatalities and 2,762 injuries. Of those crashes 55% occurred on State Highways, 24% occurred on City Streets, and 21% occurred on Klamath County Roadways.

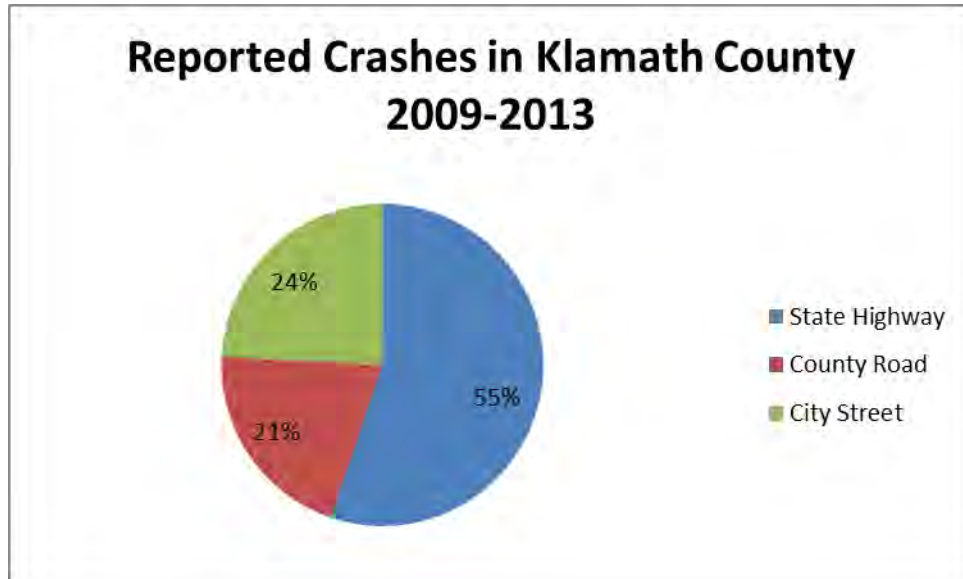


Chart 1: Reported Crashes in Klamath County by Jurisdiction

Chart 2 below shows the severity of reported crashes in Klamath County. Approximately half of the reported crashes result in some level of injury ranging from fatality to minor injuries.

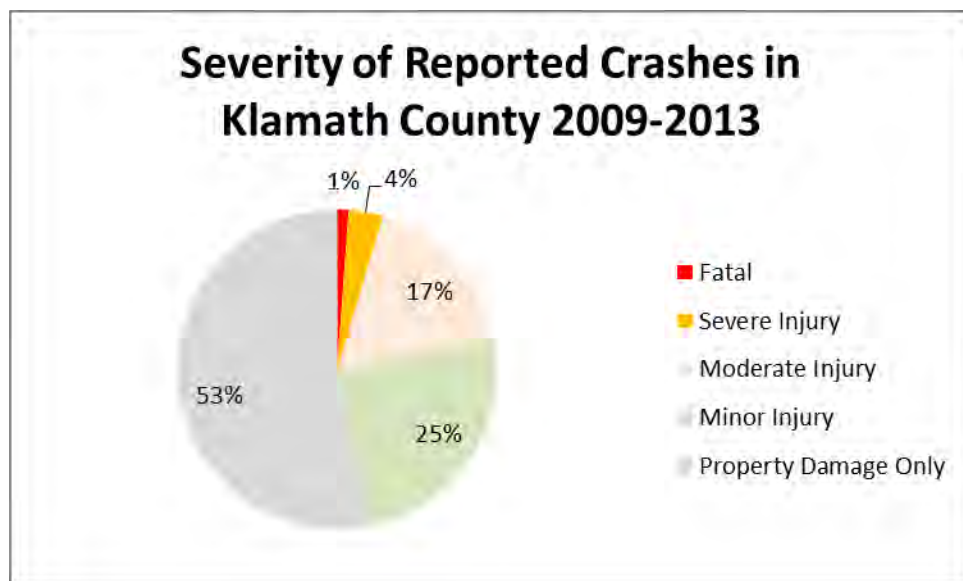


Chart 2: Severity of Reported Crashes in Klamath County

Chart 3 shows the proportion of fatal and severe injury crashes occurring on State Highways, County Roads, and City Streets. Approximately 61% of fatal and severe injury crashes in Klamath County occurred on State Highways, 29% occurred on County Roads and 10% occurred on City Streets.

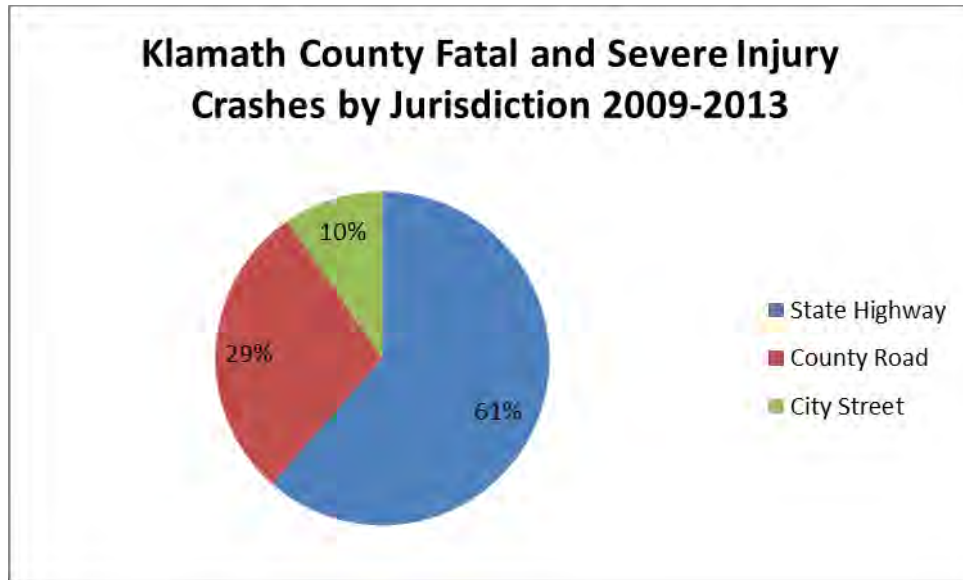


Chart 3: Fatal and Severe Injury Crashes by Jurisdiction

Charts 4 and 5 below show the predominant crash types and each crash type's proportion of fatal and severe injury crashes. Fixed object crashes are the predominant crash type reported in Klamath County, as well as the crash type responsible for the largest proportion of fatal and severe injury crashes. Turning or non-collision (overtake) crashes also represent a large proportion of reported crashes resulting in fatal or severe injury crashes.

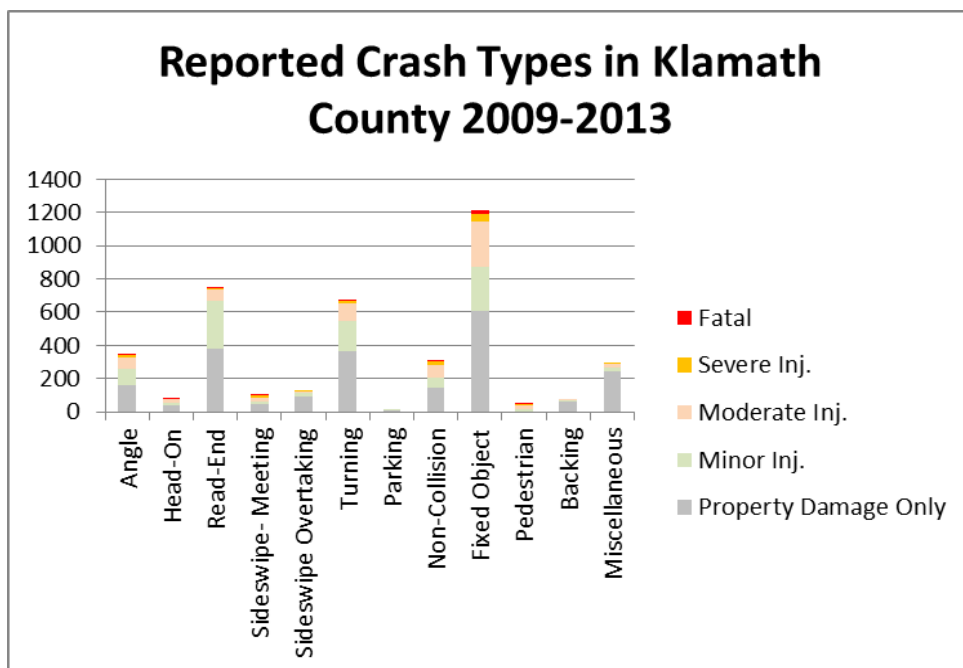


Chart 4: Crash Types in Klamath County

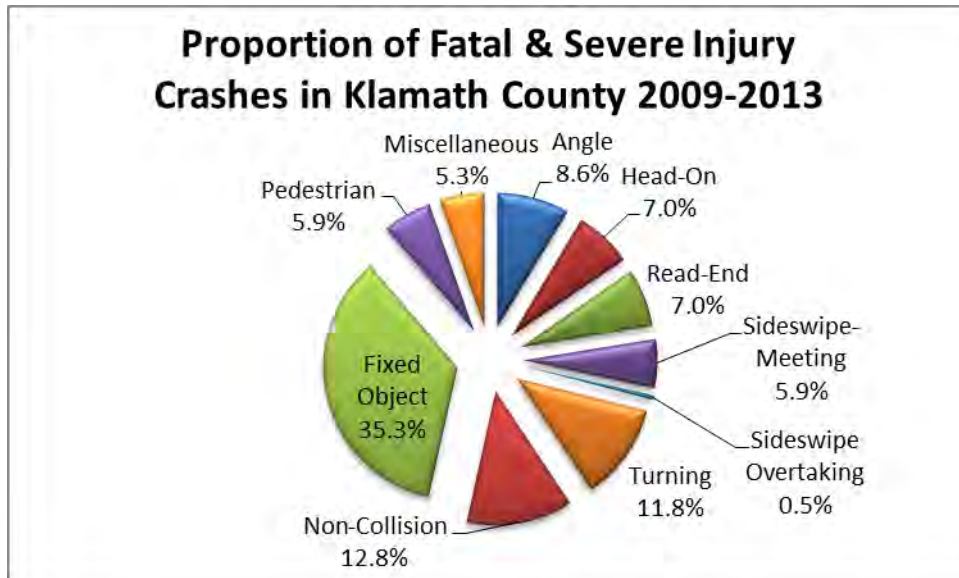


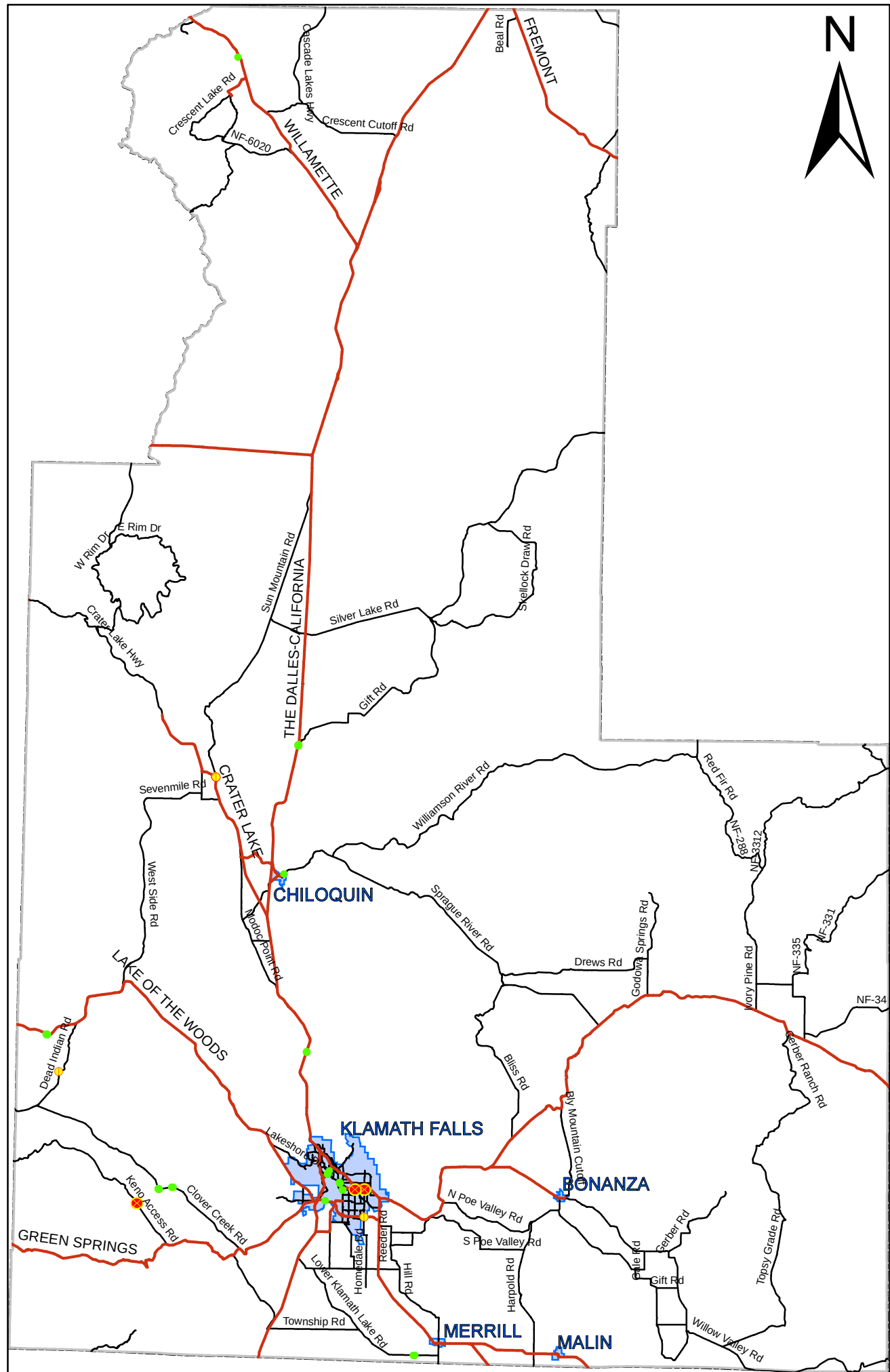
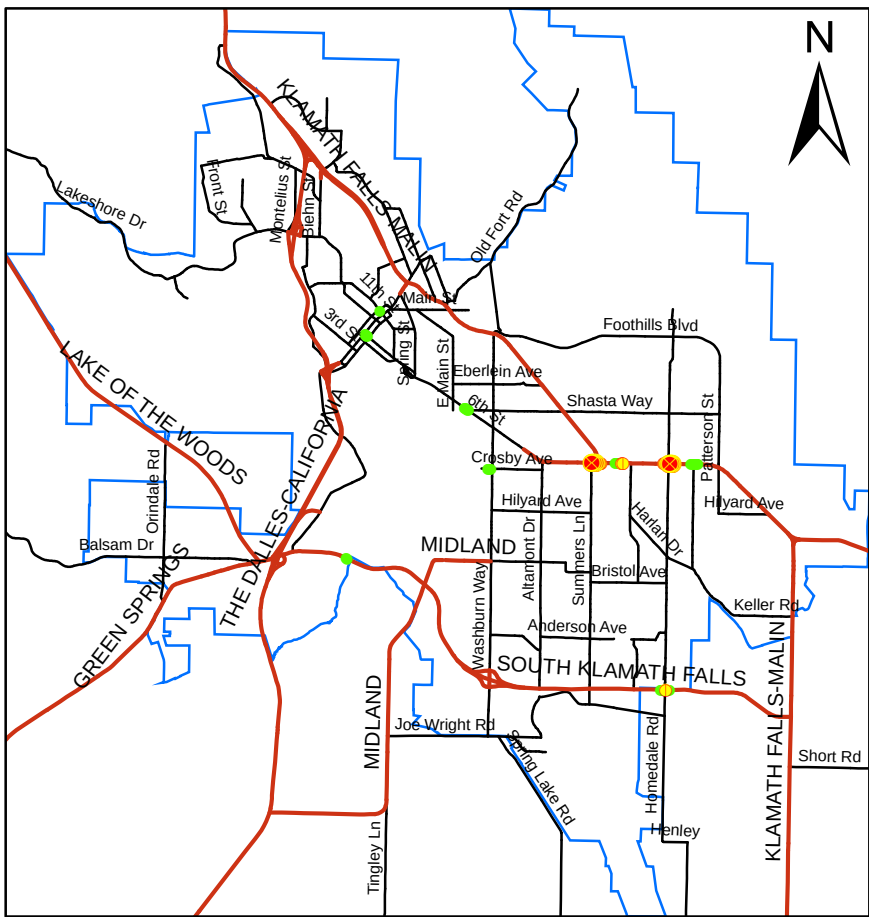
Chart 5: Proportion of Fatal & Severe Injury Crashes in Klamath County

Crash Location Identification

ODOT uses a Safety Priority Index System (SPIS) to identify and rank high crash locations. The system analyzes every 0.10-mile section of roadway based on three years of crash data. A weighted score is given to each section based on that sections crash frequency, rate and severity. A minimum of three crashes or a single fatal crash are required for a location to be considered a SPIS site. ODOT identifies and analyzes the top 10 percent SPIS sites every year and evaluates the locations for safety problems and potential solutions. **Figure 1-6** highlights current SPIS sites throughout Klamath County for the 2011-2013 reporting year (2014 SPIS Report), which are also shown in the following table.

Table 1-3: 2014 SPIS Locations in Klamath County (State Highway)

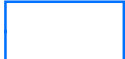
<u>Location</u>	<u>BMP</u>	<u>EMP</u>	<u>SPIS Score (%)</u>	<u>Problem Description</u>
US-97: The Dalles-California Hwy near Kirk Road	236.91	237.09	40.43 (85%)	4/7 road departure
US-97: The Dalles-California Hwy	263.94	264.09	39.79 (85%)	7/8 road departure 6/8 icy conditions
OR-62: Crater Lake Hwy @ Sun Mountain Road	91.24	91.40	48.86 (90%)	3/3 motorcycle road departure on curve
OR-140: Lake of the Woods	34.91	35.09	42.77 (85%)	
OR-39: Klamath Falls-Lakeview Hwy @ Summers Ln	3.18	3.36	66.74 (95%)	26/47 rear end 18/47 turning movement 2/47 sideswipe overtaking
OR-39: Klamath Falls-Lakeview Hwy @ Gettle Street	3.48	3.58	46.78 (90%)	See ARTS Projects
OR-39: Klamath Falls-Lakeview Hwy @ Homedale Road	3.91	4.09	60.08 (95%)	
OR-39: Klamath Falls-Lakeview Hwy	4.02	4.11	43.15 (85%)	
OR-39: Klamath Falls-Lakeview Hwy @ Madison St.	4.18	4.33	45.10 (85%)	
OR140: South Klamath Falls Hwy @ Homedale Road	4.59	4.69	45.52 (90%)	4/7 angle, 1/7 turning, 1/7 rear-end, 1/7 pedestrian
OR140: South Klamath Falls Hwy	0.66	0.76	45.02 (85%)	



Legend

2014 Safety Priority Index System

-  95% - 100%
-  90% - 94.99%
-  85% - 89.99%

-  State Highway
-  Non-State Roadway
-  Urban Growth Boundary
-  County

KLAMATH COUNTY
Intelligent Transportation Systems

Figure 1-6

HIGH CRASH LOCATIONS

Date: 11/2/2015

In 2010 ODOT partnered with the Federal Highway Administration (FHWA) to develop *The Roadway Departure Safety Implementation Plan*. This plan calls for the systematic deployment of relatively low cost, cost effective countermeasures on targeted roadway segments with a history of roadway departure crashes. While roadway departure crashes account for approximately 66% of all fatalities in Oregon, the data analysis estimates that implementation of the countermeasures identified for each of the roadway segments would achieve an approximate 20% reduction in roadway departure fatalities. The plan evaluated the following systematic countermeasures:

- Enhanced Sign and Markings to Reduce Roadway Departure on Curves
- Centerline Rumble Strips to Reduce Head-On and Opposing Flow Sideswipe Crashes
- Edgeline/Shoulder Rumble Strips to Reduce Roadway Departure Crashes
- Alignment Delineation
- Select Tree Removal in Rural Areas to Reduce Future Tree Crash Occurrences
- Guard Rail Upgrades

Figure 1-7 shows the most recent 5-years (2009-2013) of roadway departure crashes in Klamath County. Maps summarizing the roadway segments, on state highway, and applicable roadway departure countermeasures from the *Roadway Departure Safety Implementation Plan* are available in **Appendix A**.

Following the development of the *Roadway Departure Safety Implementation Plan*, ODOT and FHWA developed a plan to focus on reducing fatal and severe injury crashes at intersections. This plan, *The Intersection Safety Implementation Plan*, was developed in 2012 and focuses on using cost effective strategies to apply systemic (basic sign and signal improvements) and hot spot improvements (signal/roundabout installation) at intersections in order to reach an estimated 13% reduction in intersection fatalities. Maps summarizing the plan's identified intersections on state highways are available in **Appendix B**.

Historically, ODOT has used Highway Safety Improvement funds (HSIP) as a primary funding source for safety improvements on state highways. The *Moving Ahead for Progress in the 21st Century* legislation has provided more HSIP funding to address safety. In response, ODOT has developed a "jurisdictionally blind" process that addresses fatal and serious crashes on all public roads in Oregon. The *ODOT Federal Highway Safety Improvement Program Transition Process* identified and ranked projects for systemic improvements to be developed between 2014 and 2016. The fully jurisdictionally blind process, *All Roads Transportation Safety (ARTS)*, is intended to take effect starting in 2017. **Appendix C** provides a listing of projects identified in Klamath County for the HSIP Transition and ARTS program.



Legend

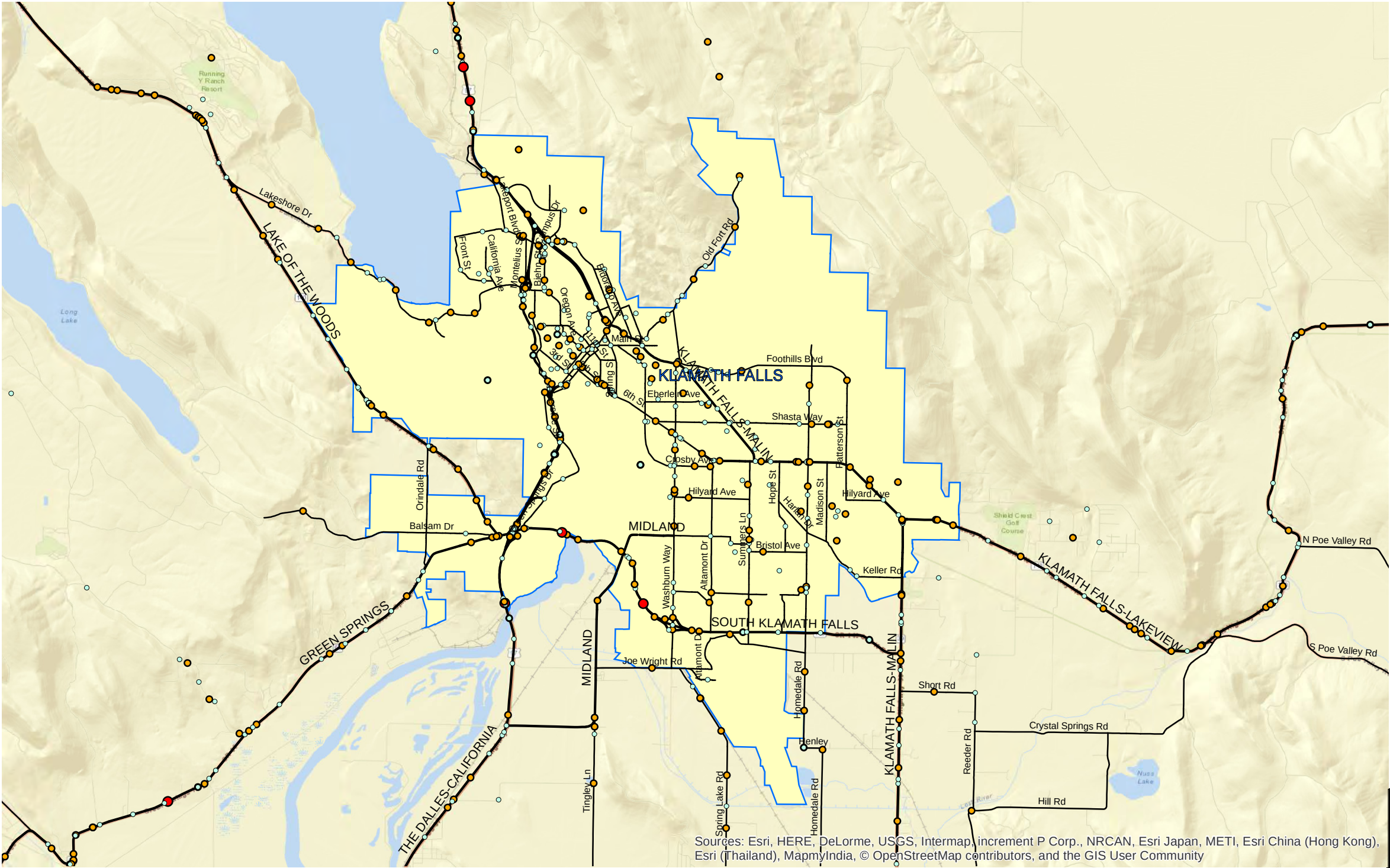
- Fatal
- Non-Fatal Injury
- Property Damage Only
- State Highways
- Nonstate FC
- Urban Growth Boundary
- County
- World Street Map

CRASH TYPES INCLUDED:
Fixed/Other Object, Head On,
Sideswipe Meeting, Overturn/Rollover

KLAMATH COUNTY
Intelligent Transportation Systems

Figure 1-7
ROAD DEPARTURE CRASHES
(2009-2013)

Date: 10/12/2015



Legend

- <all other values>
- Fatal
- Non-Fatal Injury
- Property Damage Only
- State Highways
- Nonstate FC
- Urban Growth Boundary
- County
- World Street Map

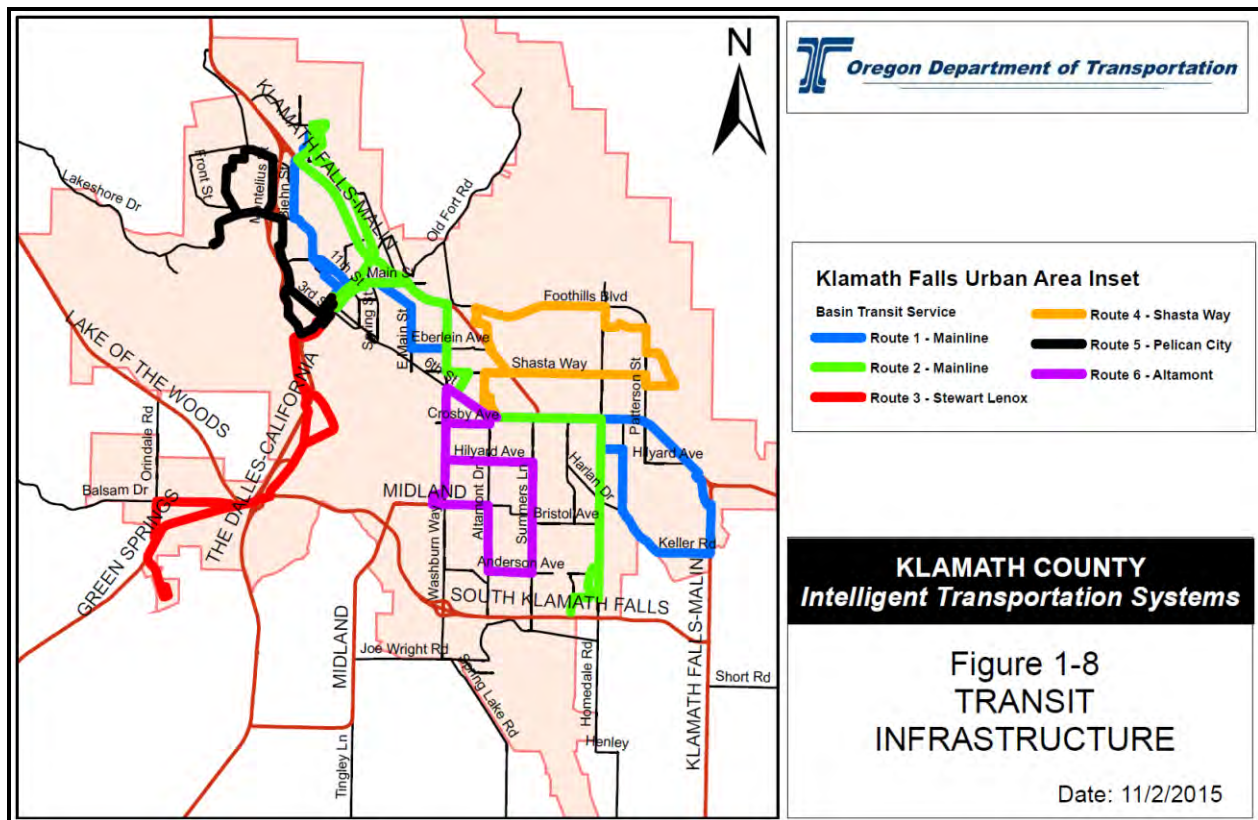
CRASH TYPES INCLUDED:
Fixed/Other Object, Head On,
Sideswipe Meeting, Overturn/Rollover

KLAMATH COUNTY
Intelligent Transportation Systems

Figure 1-7A
ROAD DEPARTURE CRASHES
(2009-2013)

Transit

Basin Transit Services provides six public transportation bus routes within the City of Klamath Falls. **Figure 1-8**, shown below, details the routes provided by Basin Transit Services. General operation hours include Monday through Friday from 6:00am to 7:00pm, and Saturdays from 10:00am to 5:00pm. Mainline routes (Route 1 and 2) run every 30 minutes, while the remaining routes run every 60 minutes. Typical ridership ranges from 1200-1400 on weekdays and 500-600 on Saturdays. All of the fixed route busses are equipped with Apollo video systems that include a GPS locator.



There are also a number of private transportation service providers that serve Klamath County providing longer route trips to and from the Klamath County Regions. Private transportation service providers in Klamath County are shown in the following table.

Table 1-4: Private Transportation Service Providers

Provider	Route	Transit Type
Amtrak	Coast Starlight – Los Angeles to Seattle	Passenger Train
Crater Lake Trolley	Klamath Falls – Crater Lake	Bus/Trolley
High Desert POINT	Chemult to Bend	Bus
Klamath Tribes	Quail Trail	Bus
Sage Stage	Alturas to Canby	Bus
Southwest POINT	Klamath falls to Medford/Ashland	Bus

Traffic Signals

This section describes the traffic signal equipment at the 50 signalized intersections in Klamath County. **Figure 1-9** details the existing and planned intersection traffic control (signal, roundabout, interchange, etc.) within the study area. The existing signals are color-coded to reflect jurisdiction of ownership.

Traffic Signal Operations

ODOT operates and maintains all of the traffic signals in Klamath County, with the exception of the City of Klamath Falls downtown core, through agreements with local agencies. For remote access to the traffic signal controllers, ODOT uses Translink, NWS Signal and TranSuite closed loop signal control software. For Central Signal System Management ODOT uses TransSuite. Not all signals are accessible remotely. **Table 1-5** details the existing traffic signals in Klamath County.

Table 1-5: Klamath County Existing Traffic Signal Locations

#	Intersection	Jurisdiction	Controller	Software	CSS
1	US97B at Campus Dr. / Biehn St.	ODOT	170*	Wapiti W4IKS	
2	US97B at Portland St. (Pedestrian Hybrid Beacon)	ODOT	2070	Voyage	✓
3	US97B at Esplanade Ave.	ODOT	2070	Voyage	✓
4	US97B at Main Street	ODOT	2070	Voyage	✓
5	US97B at Washburn / Foothills Blvd	ODOT	2070	Voyage	
6	US97B at Shasta Way	ODOT	2070	Voyage	✓
7	S. 6 th Street (OR39) at Altamont	ODOT	2070	Voyage	✓
8	S. 6 th Street (OR39) at Crest Street	ODOT	2070	Voyage	✓
9	S. 6 th Street (OR39) at Summers Lane	ODOT	2070	Voyage	✓
10	S. 6 th Street (OR39) at US97B	ODOT	2070	Voyage	✓
11	S. 6 th Street (OR39) at Hope Street	ODOT	2070	Voyage	✓
12	S. 6 th Street (OR39) at Homedale Road	ODOT	2070	Voyage	✓
13	S. 6 th Street (OR39) at Madison Street	ODOT	2070	Voyage	✓
14	S. 6 th Street (OR39) at Patterson Street	ODOT	2070	Voyage	✓
15	S. 6 th Street (OR39) at Galpin Lane (Home Depot)	ODOT	2070	Voyage	✓
16	OR140/OR39 @ Malin Jct.	ODOT	2070	Voyage	✓
17	OR140 at OR66	ODOT	2070	Voyage	
18	Washburn Way at OR140 Ramps	ODOT	2070	Voyage	✓
19	Campus Way at Dahlia Street	City of K-Falls	170*	Wapiti W4IKS	
20	Klamath Avenue at S. 9 th Street	City of K-Falls	170	Wapiti W4IKS	
21	Klamath Avenue at S. 7 th Street	City of K-Falls	170	Wapiti W4IKS	
22	Klamath Avenue at S. 6 th Street	City of K-Falls	170	Wapiti W4IKS	

23	Klamath Avenue at S. 5 th Street	City of K-Falls	170	Wapiti W4IKS	
24	Main Street at Esplanade	City of K-Falls	170	Wapiti W4IKS	
25	Main Street at S. 11 th Street	City of K-Falls	170	Wapiti W4IKS	
26	Main Street at S. 9 th Street	City of K-Falls	170	Wapiti W4IKS	
27	Main Street at S. 8 th Street	City of K-Falls	170	Wapiti W4IKS	
28	Main Street at S. 7 th Street	City of K-Falls	170	Wapiti W4IKS	
29	Main Street at S. 6 th Street	City of K-Falls	170	Wapiti W4IKS	
30	Main Street at S. 5 th Street	City of K-Falls	170	Wapiti W4IKS	
31	Main Street at S. 4 th Street	City of K-Falls	170	Wapiti W4IKS	
32	Pine Street at S. 9 th Street	City of K-Falls	170	Wapiti W4IKS	
33	Pine Street at S. 11 th Street	City of K-Falls	170	Wapiti W4IKS	
34	Main Street at Michigan Ave. / E Main Street	City of K-Falls	170	Wapiti W4IKS	
35	Main Street at Spring Street	City of K-Falls	170	Wapiti W4IKS	
36	S. 6 th Street at Avalon Street	City of K-Falls	170	Wapiti W4IKS	
37	S. 6 th Street at Shasta Way	City of K-Falls	170*	Wapiti W4IKS	
38	S. 6 th Street at Washburn Way	City of K-Falls	170**	Wapiti W4IKS	
39	S. 6 th Street at E. Main Street	City of K-Falls	170	Wapiti W4IKS	
40	S. 6 th Street at Austin Street	City of K-Falls	170	Wapiti W4IKS	
41	Shasta Way at Avalon Street	City of K-Falls	170	Wapiti W4IKS	
42	Washburn Way at Shasta Way	City of K-Falls	170**	Wapiti W4IKS	
43	Washburn Way at Crosby Way	City of K-Falls	2070	Voyage	
44	Washburn Way at Hilyard Ave.	City of K-Falls	2070	Voyage	
45	Washburn Way at Onyx Ave.	City of K-Falls	2070	Voyage	
46	Washburn Way at OC&E Trail	City of K-Falls	170**	Wapiti W4IKS	
47	Washburn Way at Laverne Ave.	City of K-Falls	2070	Voyage	
48	Altamont Drive at Crosby Ave.	Klamath County	2070	Voyage	✓
49	Altamont Drive at Hilyard Ave.	Klamath County	2070	Voyage	Future
50	Altamont Drive at Laverne Ave.	Klamath County	2070	Voyage	Future
51	Summers Lane at Hilyard Ave.	Klamath County	2070	Voyage	✓
CSS = traffic signal is remotely accessible through the Central Signal System (Transuite)					
* - to be replaced with 2070 controller in Summer/Fall 2015.					
** - to be replaced with 2070 controller as part of Region 4 HSIP Transition Urban project (Key #19166)					

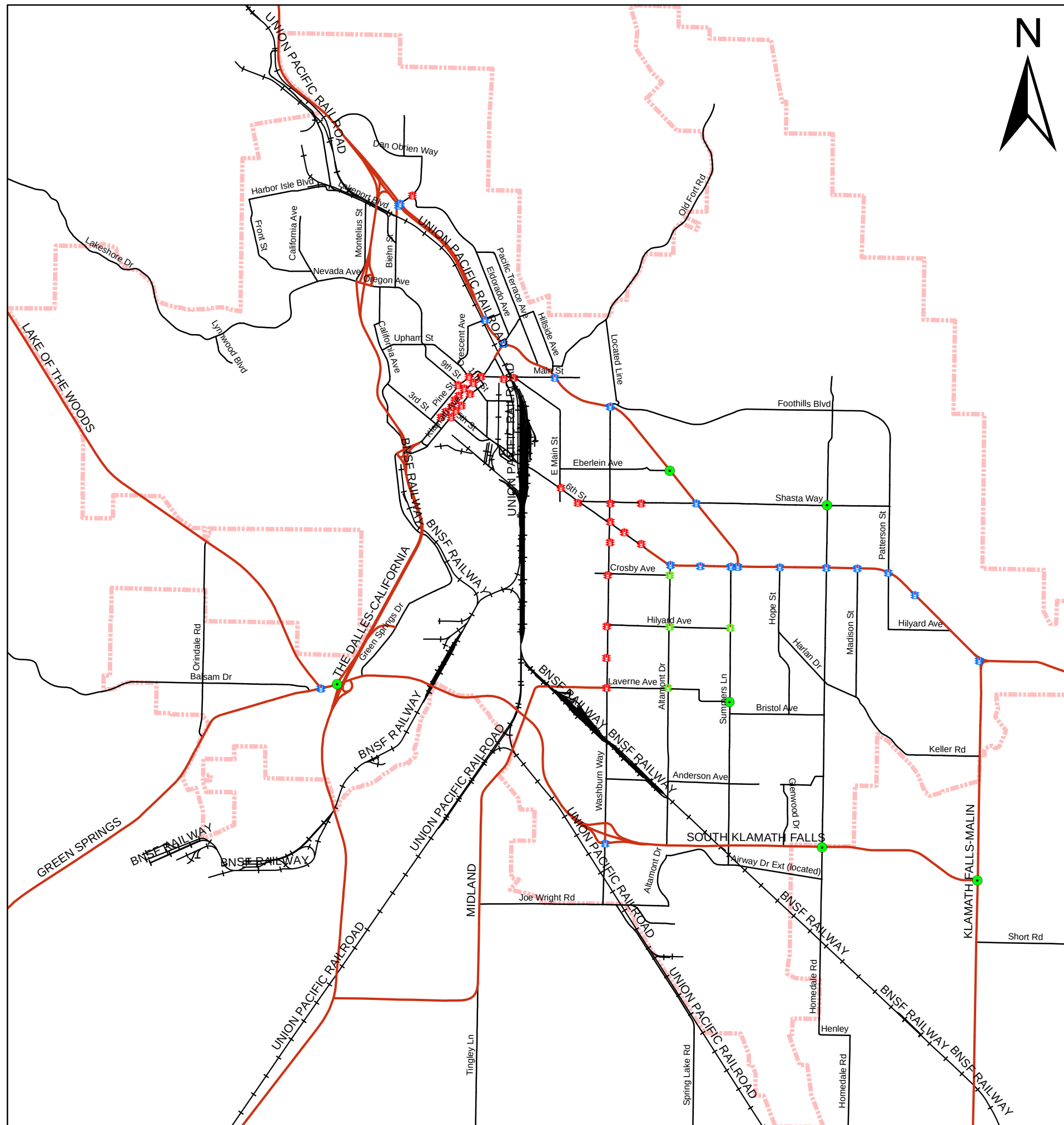
Detection

The majority of traffic signals in Klamath County use inductive loops or video detection equipment. The video used for vehicle detection is not transmitted to a central location for monitoring, but some video detectors can be accessed remotely, where communication is available, to monitor performance and adjust the layout. Each video detection system requires proprietary software to access the video and create/edit the detection zones.

Emergency Vehicle Preemption

The majority of traffic signals in Klamath County have full emergency vehicle preemption capability using OpticomTM. Fire and Ambulance services utilize the preemption by permit. Police vehicles do not have the capability preempt traffic signals. Most of the existing

preemption equipment in the traffic signal cabinets does not have the ability to recognize vehicle identification codes.



Legend

-  Traffic Signals - ODOT
-  Traffic Signals - City of Klamath Falls
-  Traffic Signals - Klamath County
-  Planned Traffic Control Improvement
-  State Highways
-  Nonstate FC
-  Railroads
-  Urban Growth Boundary
-  County

KLAMATH COUNTY Intelligent Transportation Systems

Figure 1-9

EXISTING AND PLANNED TRAFFIC
SIGNAL LOCATIONS

Date: 11/2/2015

ITS Systems and Equipment

There are numerous existing intelligent transportation systems (ITS) and devices within the boundaries of Klamath County. The following sections describe the existing and planned ITS systems and devices including the Traffic Operations Center (TOC), existing closed-circuit television (CCTV) cameras, variable message signs (VMS), traffic count stations (ATR), and remote weather information stations (RWIS). **Figure 1-10** shows the locations of the existing field devices.

ITS Systems

Klamath County currently uses a variety of software systems to access and control ITS field devices, and to dispatch response vehicles. **Table 1-6** provides a summary of the existing software systems and their primary function. Many of the software systems used today are redundant because they are proprietary to the specific vendor for the field device.

Table 1-6: Existing Systems in Klamath County

System	Vendor/Software	Operating Agency	Purpose	Notes
Signal System	Wapiti / Voyage / TransSuite / TransLink	ODOT	Signal Control	TOC Operators do not have access to this system.
Video Detection	TrafiCon / FLIR Iteris	ODOT	Intersection Detection	
Variable Message Signs	Skyline/Daktronics	ODOT	Message Sign Control	
Portable Variable Message Signs	Skyline Others DOS Programs	ODOT	Message Sign Control	
Highway Advisory Radio	Highway Information Systems	ODOT	Radio Messaging	
OSP Computer Aided Dispatch	Public Safety Systems Inc. (PSSI) CAD	OSP/ODOT	Manage incidents	Provides link to OSP dispatch in Salem.
Highway Traffic Conditions Reporting System	ODOT Visual Basic Application	ODOT	Feeds Info to TripCheck	
Road Weather Information System	SSI ScanWeb Software	ODOT Visual Basic Application	Weather Information	Server in Salem
Emergency Computer Aided Dispatch	HiTech Systems	Klamath County 911	Computer Aided Dispatch	
Dynamic Ice Warning System	Flashing beacons tied to Butte Creek RWIS	ODOT	Warning of Icy Roadway Cond.	Lake of the Woods Hwy

Transportation Operations Center (TOC)

Transportation operations are monitored via a Transportation Operations Center (TOC) located at the ODOT Region 3 office Medford (Station 3). A summary of the primary functions performed by the operators is provided below.

- Incident Management – Incident detection, response planning, resource tracking and coordination and output to the traveler information systems.
- Emergency Management – Includes incident management functions and the implementation of Emergency Operations Plans.
- Dispatch – dispatching emergency service providers as needed.
- Traffic Management – Control dynamic message signs, highway advisory radio, and dispatch incident responders.
- Traveler Information – Place and update incident alerts and road restriction messages on dynamic message signs and highway advisory radio and output to media and TripCheck.
- Winter Operations – Monitor roadway conditions with CCTV and environmental sensors. Coordinate crew assignments and notifications. Place outputs to traveler information systems (HAR and DMS).
- Maintenance Operations – Assist maintenance manager with crew availability and location information and place call-outs.

Operators in the center currently manage driver feedback field devices using a variety of software packages. ODOT is currently conducting a Transportation Operations Center System (TOCS) project intending to integrate the functions of the advanced transportation management systems and the computer aided dispatch system. The ultimate intent is to provide an integrated system interface for the management of ODOT assets.

Closed-Circuit Television (CCTV) Cameras

ODOT currently uses 11 closed-circuit television (CCTV) to monitor traffic throughout Klamath County. ODOT posts images from the existing cameras on the TripCheck website. **Table 1-7** details the existing CCTV camera locations.

Table 1-7: CCTV Locations in Klamath County

Highway Location	Milepoint	Manufacturer - Model #
US97 SB @ Crescent Cutoff	MP 185.38	Panasonic WV-CP474
OR58 EB @ Willamette Pass	MP 62.3	Surface Systems Inc. - DOS
US97 NB @ Chemult	MP 203.8	Panasonic WV-CP474
US97 near Diamond Lake Jct.	MP 214	Panasonic WV-CP454
US97 @ Sand Creek	MP 230.93	Panasonic WV-CP500
US97 NB @ Spring Creek	MP 240.9	Panasonic WV-CP500
US97 SB @ Modoc Pt	MP 257.9	Panasonic WV-CP484
OR140 WB @ Bly Mountain	MP 31	Panasonic WV-GP464
US97 @ Green Springs Int.	MP 277	Rockhouse LCL187 Watec
OR140 @ Doak Mt.	MP 53.8	Panasonic WV-CP500
OR140 WB @ Lake of the Woods	MP 37	Panasonic WV-CP474

Variable Message Signs (VMS)

ODOT operates and maintains 4 variable message signs in Klamath County. **Table 1-8** details the existing DMS sign locations.

Table 1-8: VMS Sign Locations in Klamath County

Highway Location	Milepoint	Manufacturer - Model #
US97 NB @ Diamond Lake Jct.	MP 214.11	LedStar
US97 SB @ Chiloquin	MP 245.42	LedStar VMS-091-3x-18-LB
US97 NB @ Klamath Falls	MP 278.83	Ledstar VMS-091R3-3x18-RB
OR140 WB @ Lake of the Woods	MP 62.4	Daktronics VF3000-3-7x15-12-F

Variable Speed Limit Signs (VSL)

Through a consultant contract procured in 2013, ODOT developed a US97 variable speed study. The study recommends installation of a weather responsive variable speed system on US97: The Dalles-California Highway between milepoint 143-164 and 204-244 to improve safety and mobility throughout the corridor. A memorandum summarizing the US97 variable speed study is available in **Appendix D**.

ODOT currently has a variable speed limit project in development (*US97: Bend to Spring Creek Hill VSL, Key Number 19260*). This project will develop shelf ready plans until funding is secured.

Automatic Traffic Recorders (ATR)

ODOT currently operates 8 automatic traffic recorders (ATR), independent of traffic signals, within Klamath County. ATRs provide hourly count summaries 24-hours a day, 365 days a year. **Table 1-9** details the existing ATR station locations.

Table 1-9: ATR Station Locations in Klamath County

ATR #	Highway, Milepoint	Location
18-006 Chemult	US97, MP 204.65	0.40 miles south of Chemult Dump Rd
18-017 Beatty	OR140, MP 44.92	4.20 miles east of Yellow Jacket Springs Rd
18-018 Klamath Falls	US97, MP -4.08	0.46 miles south of Main Street
18-019 Midland	US97, MP 291.73	At the Oregon-California State Line
18-020 Merrill	OR39, MP 16.15	0.36 miles west of Hatfield Hwy No. 426
18-021 Fort Klamath	OR62, MP 91.1	0.28 miles northwest of Sun Mountain Rd
18-023 Chiloquin	US97, MP 243.22	4.32 miles north of Chiloquin Hwy
18-022 Modoc Point	US97, MP 254.3	3.53 miles north of Modoc Point Rd

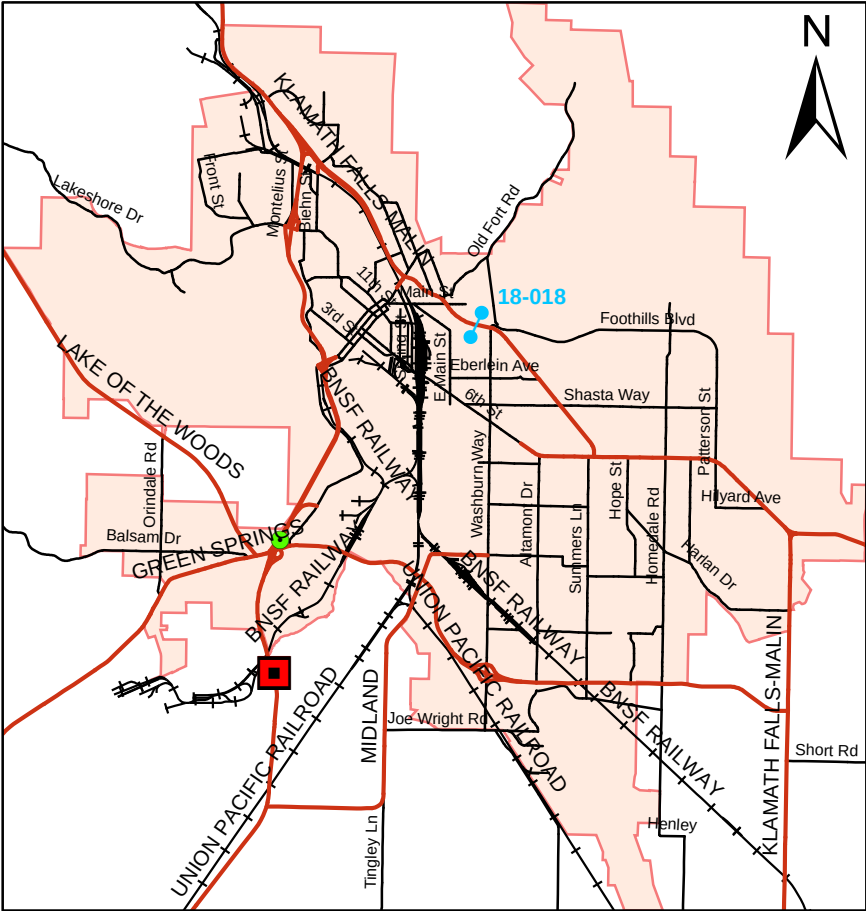
Road Weather Information Systems (RWIS)

ODOT operates and maintains 10 weather stations in Klamath County. These devices are connected with the RWIS server located in Salem. 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, a real-time traveler information website, and can be used to identify icy conditions.

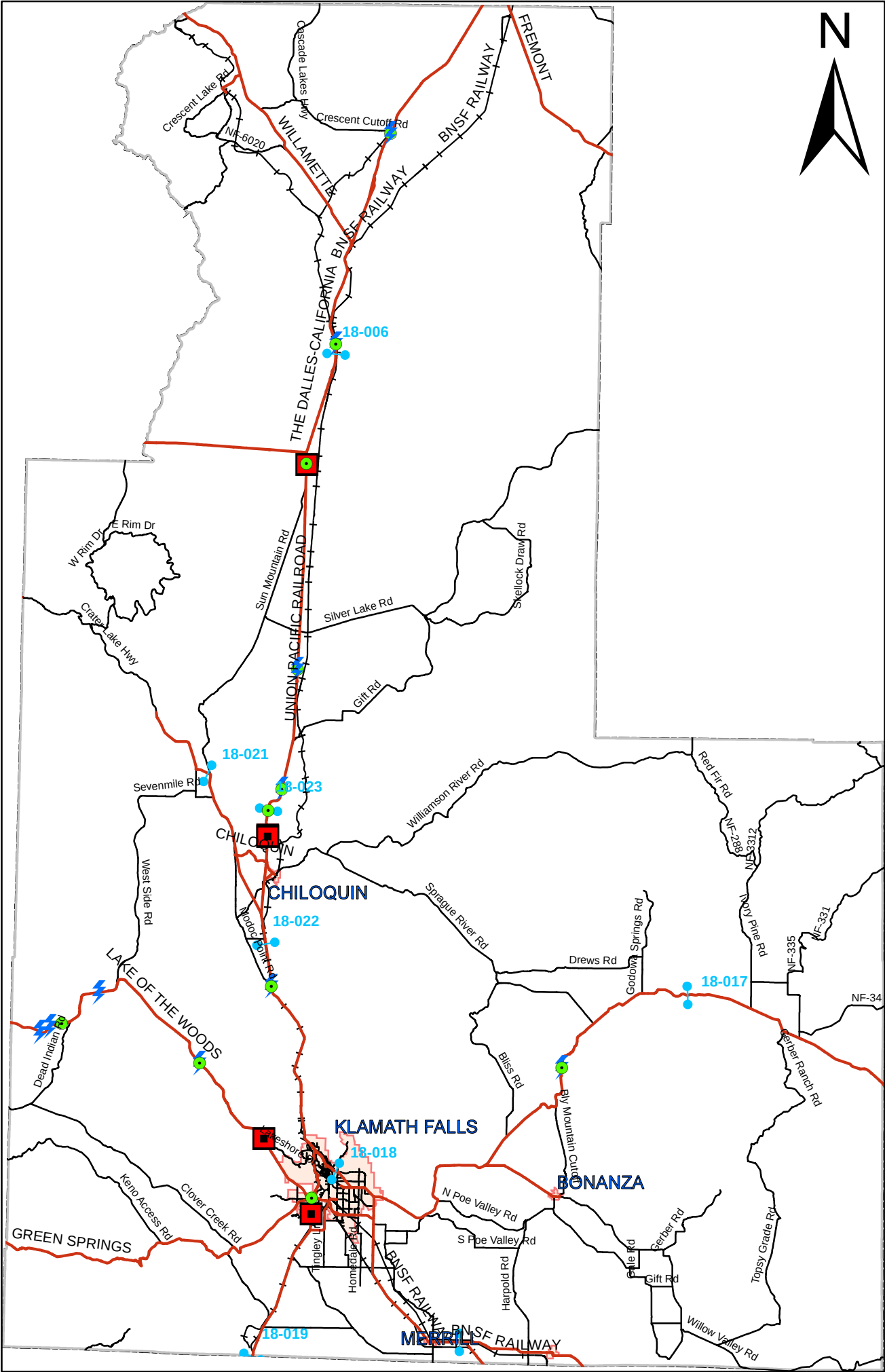
The Butte Creek RWIS, located on Lake of the Woods Highway at milepoint 34.9 is the controlling unit for the Butte Creek Ice Warning System. When this RWIS detects environmental conditions associated with ice on the roadway, it is linked to two static signs with flashing beacons to warn travelers of potentially icy conditions.

Table 1-10: RWIS Locations in Klamath County

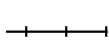
Highway Location	Milepoint	Manufacturer - Model #
US97 SB @ Crescent	MP 185.39	Linux RPU by Viasala
US97 NB @ Chemult	MP 203.8	Linux RPU by Viasala
US97 NB @ Sand Creek*	MP 230.93	Linux RPU by Viasala
US97 NB @ Spring Creek*	MP 240.9	Linux RPU by Viasala
US97 SB @ Modoc Point	MP 257.90	Linux RPU by Viasala
OR140 WB @ Bly Mountain	MP 31.12	Linux RPU by Viasala
OR140 WB @ Doak Mt	MP 53.8	Linux RPU by Viasala
OR140 WB @ Butte Creek	MP 41.68	Ice Warning Sign w/ Flashing Beacons
OR140 WB @ Lake of the Woods	MP 36	Linux RPU by Viasala
OR140 @ Butte Creek	MP 34.9	Ice Detection System Device
OR140 EB @ Butte Creek	MP 21.4	Ice Warning Sign w/ Flashing Beacons
* = RWIS powered using solar energy		



Klamath Falls Urban Area Inset



Legend

-  Road Weather Information Systems
-  Variable Message Signs
-  Closed Circuit Television Camera
-  Automatic Traffic Recorders (ATR)
-  State Highways
-  Nonstate FC
-  Railroads
-  Urban Growth Boundary
-  County

KLAMATH COUNTY

Intelligent Transportation Systems

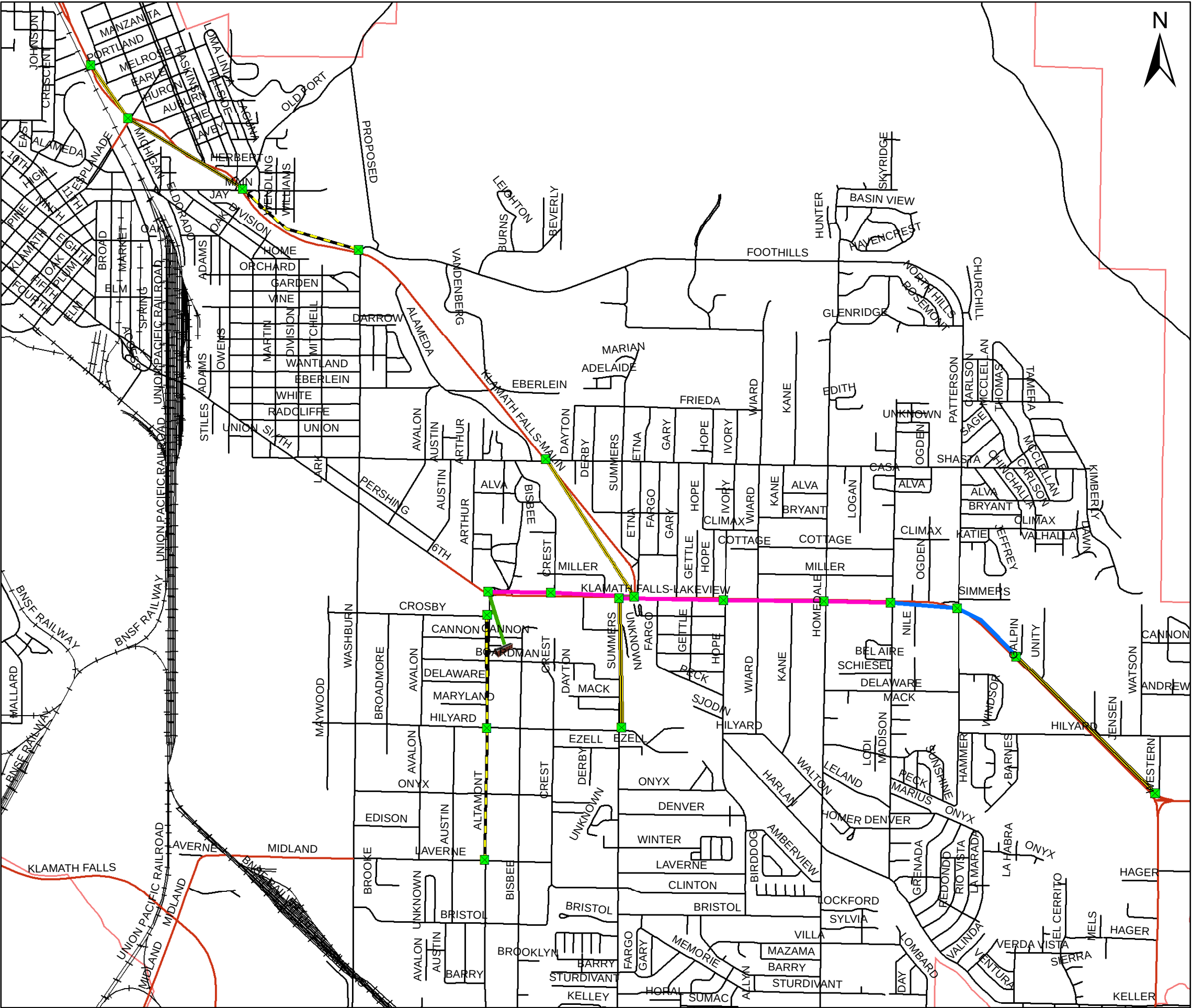
Figure 1-10

EXISTING ITS EQUIPMENT

Communications Equipment

The communications system is one of the most critical components in the deployment of ITS infrastructure since agencies must be able to monitor, control, and operate traffic management devices from remote locations. To effectively manage mobility and respond to incidents, operation centers need to be able to share information in real time. The existing transportation related communications network in Klamath County consists of a variety of infrastructures such as fiber optic cable, twisted-pair copper and wireless networks.

ODOT's existing communications infrastructure in the City of Klamath Falls is illustrated in **Figure 1-11**; which includes a portion of the communications system utilizing "Hunter Fiber" which is a private service provider in the area. Many of the traffic signals in Klamath Falls have a single dedicated fiber backhaul to ODOT's network. Outside of Klamath Falls, communication with ITS devices is available primarily through cellular router with some dedicated point to point circuits.



Legend

- Future Communications
- ODOT Wireless
- ODOT Copper
- ODOT Fiber
- Hunter Fiber
- Cabinet
- Office Building
- State Highways
- Urban Growth Boundary

KLAMATH COUNTY
Intelligent Transportation Systems

Figure 1-11

**EXISTING COMMUNICATIONS
 INFRASTRUCTURE**

Date: 11/2/2015

Emergency Management

This section describes the emergency management agencies in Klamath County as well as the strategies used for routine services typically handled by 911, police, fire, and medical providers and strategies for major emergencies and disasters.

911 Center

The **Klamath 9-1-1 Emergency Communications District (KECD 911)** is the single answering and dispatch point for all public safety agencies in Klamath County, including Klamath Falls, Merrill and Malin Police Departments, Klamath County Sheriff's Office, and all fire and ambulance districts within the County.

Police, Fire, and Medical Agencies

Emergency management facilities and hospitals are illustrated in a previous report section on Figure 1-2. The police, fire and medical agencies that serve Klamath County are listed below.

Police

Oregon State Police
Klamath County Sheriff's Office
Klamath Falls Police Department
Merrill Police Department
Malin Police Department
Klamath County Parole & Probation
OIT Security
Bureau of Land Management
Amtrak Police
UPRR Police
U.S. Nation Forest Law Enforcement

Ambulance

Basin Ambulance
Bly Ambulance
Chiloquin Ambulance
Bonanza Ambulance

Fire

Bly Fire Dept.
Bonanza Rural Fire Dept.
Central Cascade Fire & EMS
Chemult Rural Fire Dept.
Chiloquin-Agency Lake Fire
Crescent Rural Fire Dept.
Keno Fire Dept.
Kingsley Field Fire Dept.
Keno Fire Dept.
Klamath County Fire Dist. (1, 3, 4, 5)
Malin Rural Fire Dept.
Merrill Rural Fire Dept.
Oregon Outback Rural Fire & Protection Dist.
Rocky Point Fire & EMS

Management of Major Emergencies & Disasters

The **Klamath County Emergency Operations Plan**, dated March 2011, provides framework for coordinated emergency response activities during an event. The plan is intended to be utilized when responding to an unforeseen incident or planned event with complexity beyond that normally handled by routine operations.

Incident Management

ODOT currently staffs one incident responder full time in Region 4. Due to the Region's needs, this position primarily covers the US97 corridor between Madras and La Pine (outside of Klamath County). ODOT District 11 maintains one positions largely focused on incident management. This position typically provides coverage Monday through Friday from 7:00am to

3:30pm. During an incident in Klamath County, ODOT District personnel work closely with emergency management agencies to maintain accessible transportation routes and to re-route traffic.

Special Events

Klamath County primarily supports substantial agricultural and ranching industries. It is also home to a diverse local economy consisting of wood product industry, manufacturing, service, and technology. Additionally, tourism is an emerging industry due to the natural beauty and proximity to attraction such as the Crater Lake National Park, Lava Beds National Monument, wildlife refuges and area resorts. The agricultural/ranching industry and summer tourism are responsible for seasonal traffic changes. Outside of seasonal traffic, the Klamath County Fair and the Air National Guard Air Show have generated significant traffic flows.

Freight

Freight arrives, departs, or passes through Klamath County via truck and train. Most commercial vehicle traffic utilizes state highways, however, a number of county roadways (listed below) have greater than 10 percent truck traffic.

- Westside Road – 20% truck traffic south of Rocky Point Road
- Sprague River Road – 12% near Sprague River Road Bridge #4
- Keno-Worden Road – 19% eastbound, east of Overland
- Bly Mountain Cutoff – 73% south of Teal Drive (Bonanza)

The Klamath area is also served by the Union Pacific (UP) and Burlington Northern (BN) railroads. Both rail systems maintain parallel main lines between the Pacific Northwest and California. General freight rail issues, identified in the *Klamath County Transportation System Plan*, include the following:

- Lack of railcars to meet local needs.
- At-grade crossing on South Side Expressway near Summers Lane; trains can cause significant back-ups on the Expressway.
- Two problem intersection along Hill Road – where there are two at-grade crossings within ¼ mile of each other.

Traveler Information

ODOT provides real-time traveler information through the TripCheck website, 511, and Cable Channel 48. ODOT's TripCheck website (www.tripcheck.com) includes camera images, road conditions, weather information, incident maps, and construction activity for state highways. ODOT continues to add information to TripCheck as new equipment is deployed.

ODOT implemented 511, a traveler information phone number, in 2003 to provide various types of real-time traveler information throughout the state. The system is accessible over the phone through touch-tone dialing or voice activation.

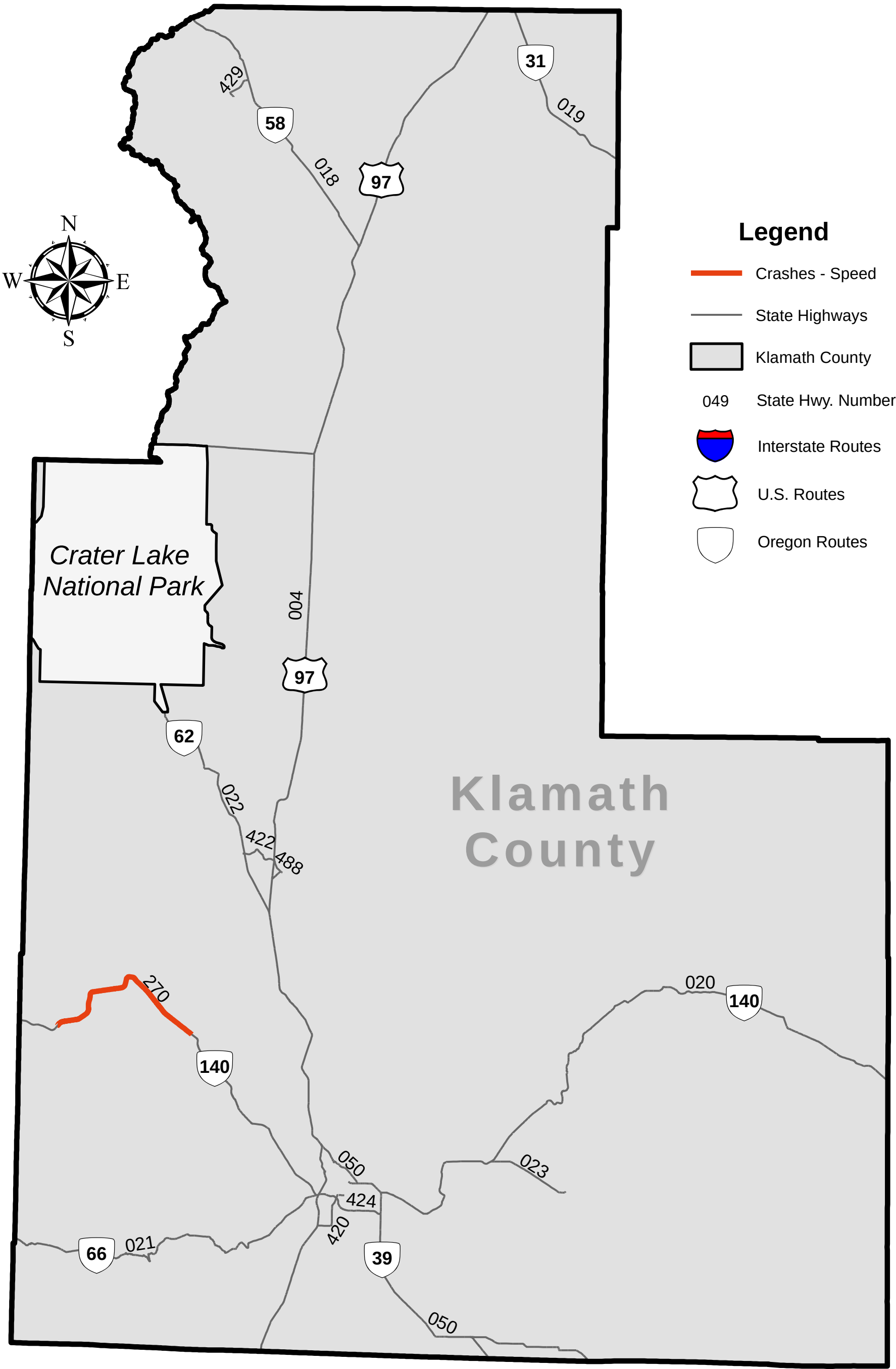
Traveler information is also provide to the public on Cable Channel 48, which shows video images from ODOT's many Closed Caption Television stations. Temperature and wind updates are provided with the footage.

APPENDIX A

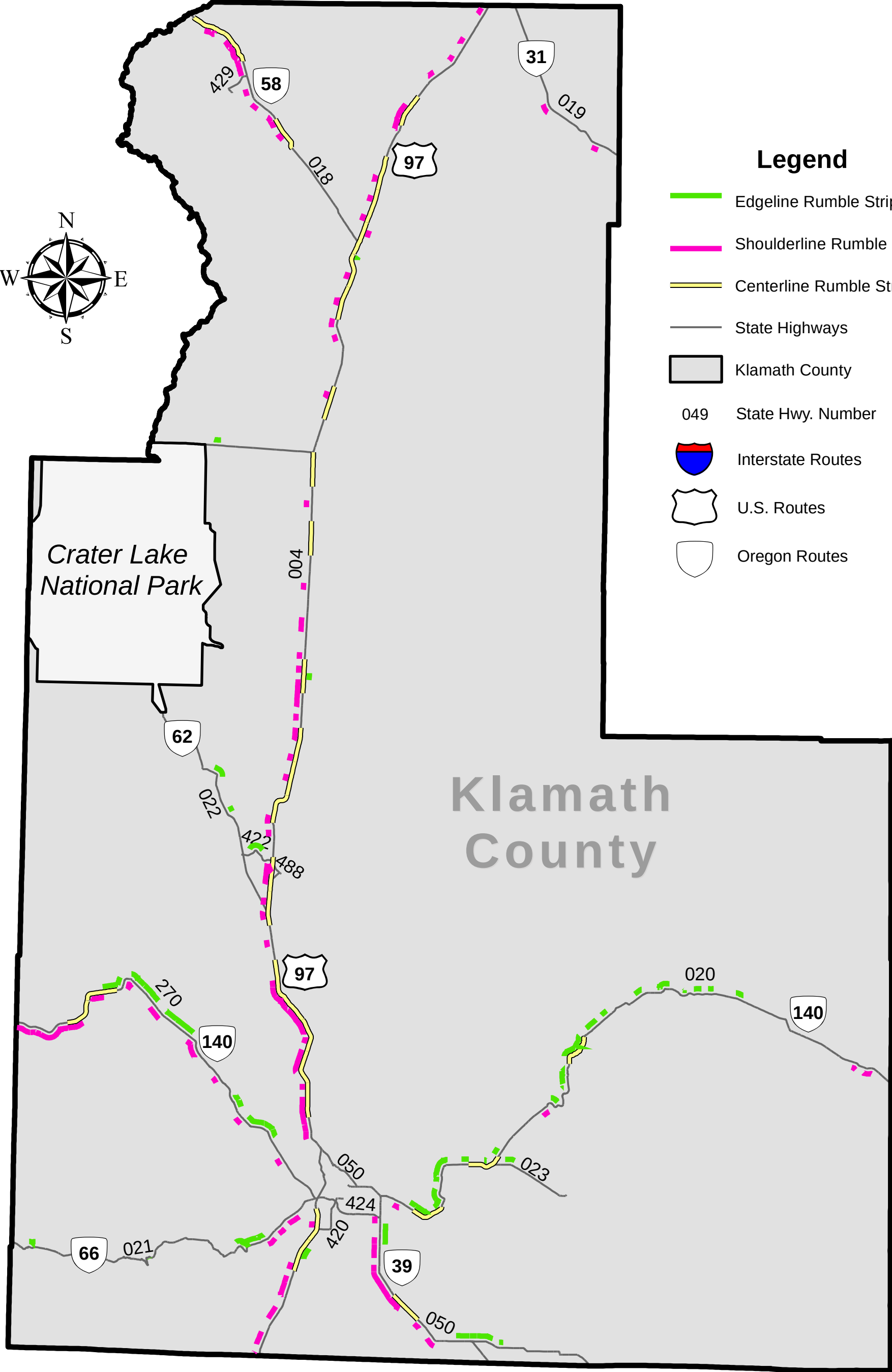
ROADWAY DEPARTURE SAFETY IMPLEMENTATION PLAN REGION 4 MAPS

http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/pages/roadway_departure.aspx

KLAMATH COUNTY - CRASHES DUE TO SPEED, ALCOHOL & NO SEATBELT
Roadway Departure Safety Implementation Plan (6/2010)



KLAMATH COUNTY - RUMBLE STRIPS
Roadway Departure Safety Implementation Plan (6/2010)



Legend

- Edgeline Rumble Strips
- Shoulderline Rumble Strips
- Centerline Rumble Strips
- State Highways
- Klamath County
- 049 State Hwy. Number
- Interstate Routes
- U.S. Routes
- Oregon Routes

Crater Lake
National Park

Klamath
County

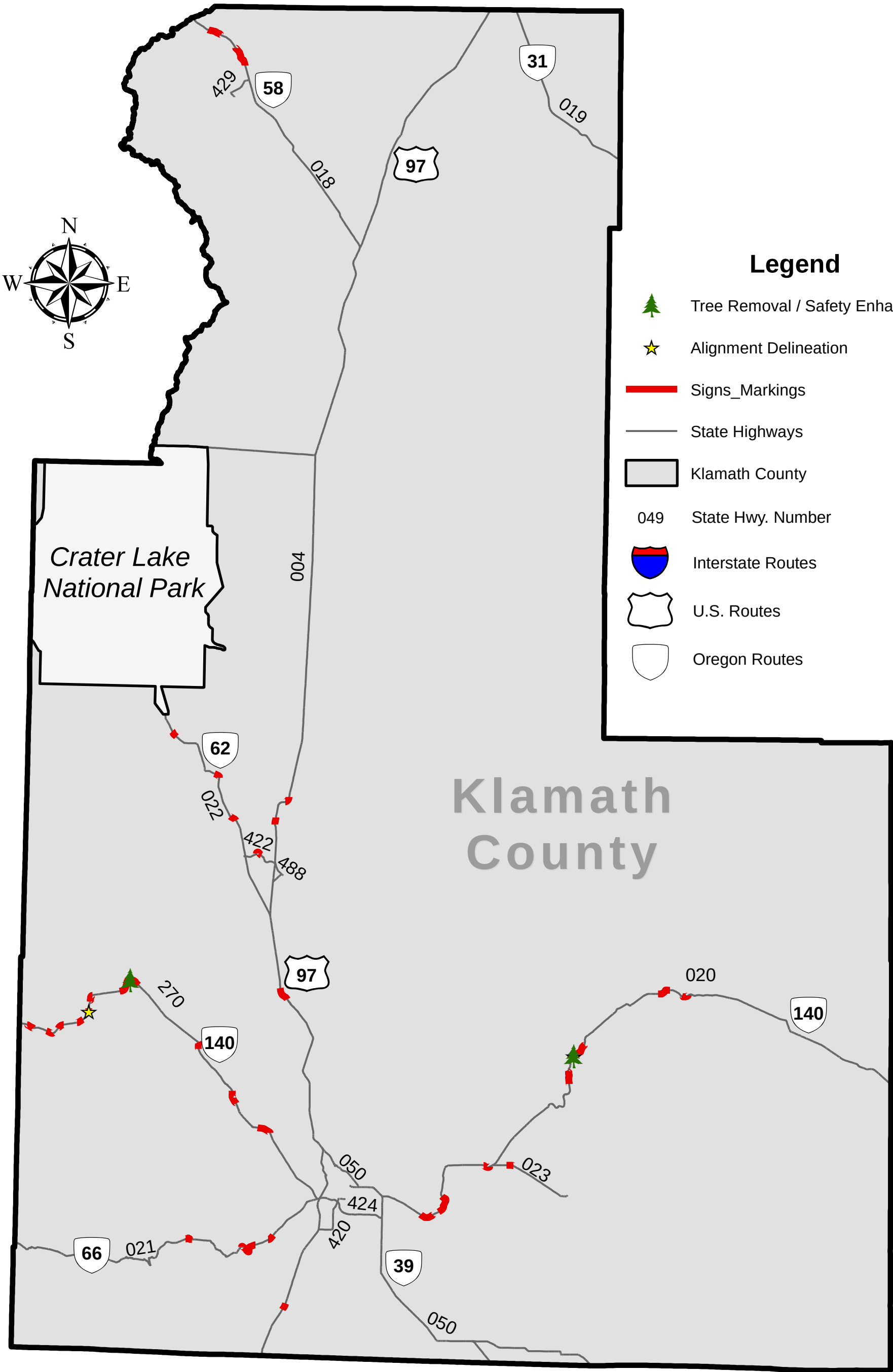


PRODUCED BY ODOT - GIS UNIT
(503) 986-3154 - OCTOBER 2015
GIS No. 23-70

0 5 10 15 20
Miles

DISCLAIMER:
This product is for informational purposes only and may not have been prepared for or be suitable for legal, engineering or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

KLAMATH COUNTY - SIGNS, MARKINGS, BEACONS,
TREE REMOVAL & ALIGNMENT DELINEATION
Roadway Departure Safety Implementation Plan (6/2010)



PRODUCED BY ODOT - GIS UNIT
(503) 986-3154 - OCTOBER 2015
GIS No. 23-70

0 5 10 15 20
Miles

DISCLAIMER:
This product is for informational purposes only and may not have been prepared for or be suitable for legal, engineering or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

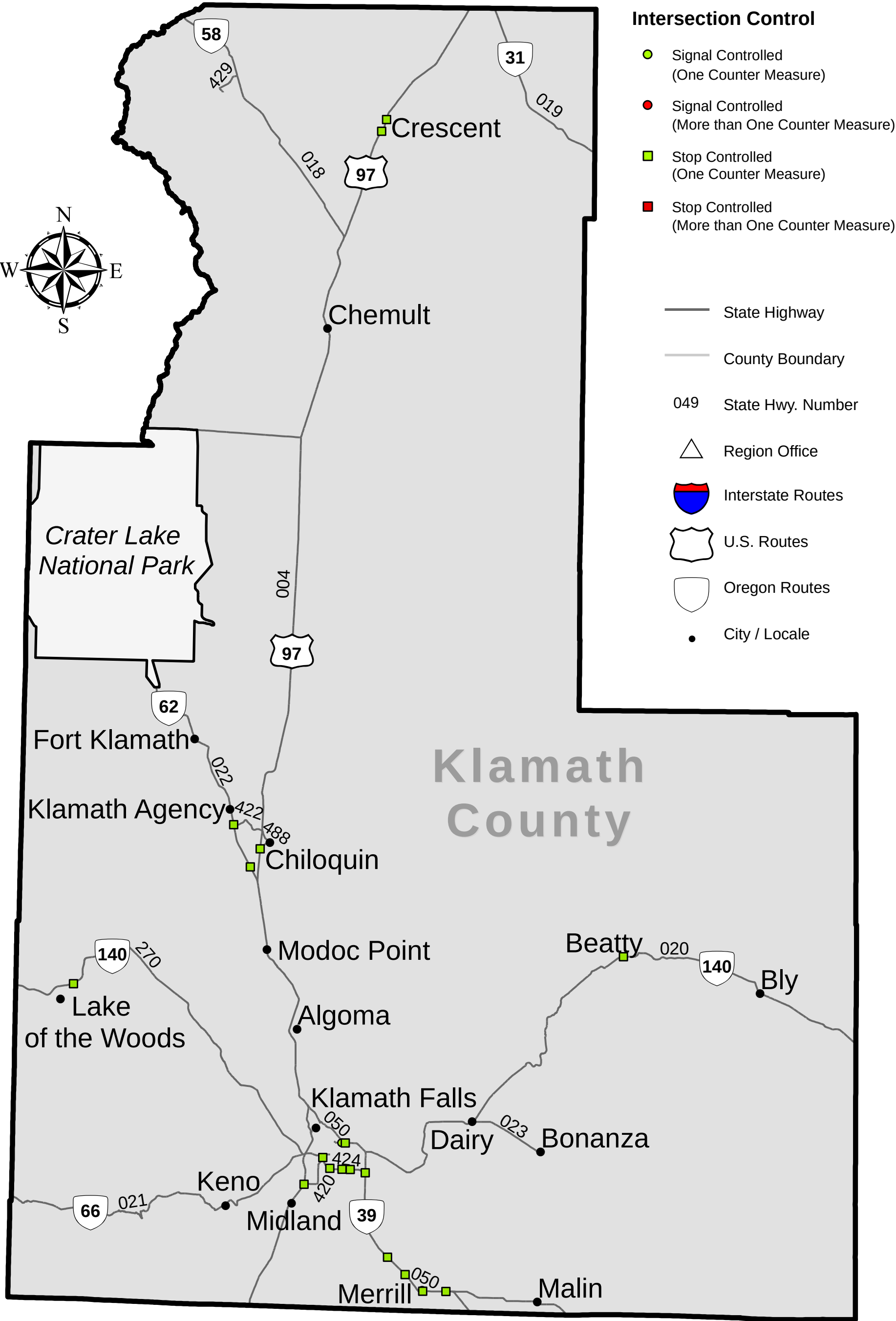
APPENDIX B

INTERSECTION SAFETY IMPLEMENTATION PLAN REGION 4 MAPS

<http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/Pages/intersections.aspx>

OREGON DEPARTMENT OF TRANSPORTATION

Klamath County



PRODUCED BY ODOT - GIS UNIT
(503) 986-3154 - OCTOBER 2015
GIS No. 23-70

DISCLAIMER:
This product is for informational purposes only and may not have been prepared for or be suitable for legal, engineering or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

APPENDIX C

ODOT HSIP TRANSITION & ALL ROADS TRANSPORTATION SAFETY PROJECTS

http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/pages/highway_safety.aspx

ODOT Highway Safety Improvement Program Transition Process Project*					
Jurisdiction	Roadway	To	From	Estimated Cost	Notes
Klamath County	Dead Indian Memorial Road	Clover Creek Road	OR140: Lake of the Woods Hwy	\$24,700	Enhanced Curve Signing
Klamath County	Harpold Road	City of Bonanza	OR39:Klamath Falls- Malin Hwy	\$13,600	Enhanced Curve Signing
Klamath County	Sprague River Road	City of Chiloquin	OR140: Klamath Falls- Lakeview Hwy	\$4,000	Enhanced Curve Signing
City of Klamath Falls	Washburn Way	Laverne Ave.	Shasta Way	\$83,300	Basic signalized intersection improvements

** only projects within Klamath County shown.*

Systemic Intersection Improvements*				
All Roads Transportation Safety Project List (2017-2021)				
Jurisdiction	Project Location	Estimated Cost	Notes	Rank
ODOT	OR39: @ Gettle Street	\$45,500	Un-signalized intersection sign upgrades	100%
City of Klamath Falls	Main St./Klamath Ave: 4 th to Wall St.	\$523,250	Signalized intersection improvements	100%
Klamath County	US97 @ Sawmill Rd US97 @ Miller Island Rd	\$30,000	Un-signalized intersection sign upgrades	100%
ODOT	OR39 @ Chin Rd OR39 @ Merrill Pit Rd OR39 @ Malone Rd OR39 at Southside Bypass	\$221,000	Un-signalized intersection sign upgrades	150%

** only projects within Klamath County shown.*

Bike and Pedestrian Improvements*				
All Roads Transportation Safety Project List (2017-2021)				
Jurisdiction	Project Location	Estimated Cost	Notes	Rank
ODOT	OR39: Summers Lane to Madison Street	\$134,000	2 RRFB Crossings w/ illumination	100%

** only projects within Klamath County shown.*

<u>Systemic Roadway Departure Improvements*</u> <u>All Roads Transportation Safety Project List (2017-2021)</u>				
Jurisdiction	Project Location	Estimated Cost	Notes	Rank
ODOT	Region 4 Centerline Rumble Strip Project #2	\$1,000,000	Various highways	100%
Klamath County	Clover Creek Road	\$143,000	Enhanced curve signing	100%
Klamath County	Keno-Worden Road	\$153,400	Delineation and curve signing	100%
Klamath County	Lower Klamath Lake Road	\$93,700	Centerline Rumble Strips	100%
ODOT	OR39 @ Chin Rd OR39 @ Merrill Pit Rd OR39 @ Malone Rd OR39 at Southside Bypass	\$221,000	Un-signalized intersection sign upgrades	150%
Klamath County	Old Fort Road	\$143,000	Enhanced curve signing	150%

** only projects within Klamath County shown.*

<u>Hot Spot Improvements*</u> <u>All Roads Transportation Safety Project List (2017-2021)</u>			
Jurisdiction	Project Location	Estimated Cost	Countermeasure(s)
ODOT	OR140 @ MP 46.9	\$56,000	Increase distance to rural roadside obstacle.
ODOT	OR140 @ MP 21.1	\$206,000	Increase distance to rural roadside obstacle.
ODOT	OR140 @ MP 27.1	\$256,000	Increase distance to rural roadside obstacle.
City of Klamath Falls	Washburn Way @ 6 th Street	\$124,000	Install bike lanes.
ODOT	OR140 @ Homedale Rd (MP 4.6)	\$953,000	Install Rural Traffic Signal
ODOT	OR66 @ Delap Pit Rd (MP 59)	\$1,245,000	Install Rural Traffic Signal Install Lighting at Intersection Install Lighting on Roadway Segment
ODOT	OR39 @ Madison St (MP 4.3)	\$500,000	Improve Signal Hardware (lenses, reflectorized backplates, size and number)
ODOT	OR140 @ Homedale Rd (MP 4.6)	\$374,000	Install lighting at intersection Provide actuated flashing beacons

** only projects within Klamath County shown.*

APPENDIX D

ODOT REGION 4 US97 VARIABLE SPEED STUDY



720 SW Washington St.
Suite 500
Portland, OR 97205
503.243.3500
www.dksassociates.com

MEMORANDUM

DATE: June 27, 2013

TO: Joel McCarroll, P.E., PTOE (ODOT Region 4)

FROM: Jim Peters, P.E., PTOE, Carl Olson, Rudy Garcia, and Renee Hurtado, P.E., PTOE

SUBJECT: **ODOT Region 4 US 97 Variable Speed Study**

P#12016-008-003

We recommend the installation of a weather responsive variable speed system on US 97 (The Dalles-California Highway) in ODOT Region 4 from mile point (MP) 143 to 164 (Bend to La Pine) and MP 204 to 244 (Chemult to Spring Creek Hill) to improve safety and mobility throughout the corridor. Travel speeds vary greatly during adverse weather, particularly winter ice and snow events in Region 4, and determining a safe operating speed for the roadway conditions is not always apparent. The crash data for both US 97 study segments indicate that most crashes occur during the months of November through April, approximately half of crashes occur when there is ice on the roadway, and approximately half of crashes are attributed to drivers traveling too fast for the conditions. These conditions are well-suited for a weather responsive variable speed system¹. A variable speed system installed on a 52-mile section of Interstate 80 in Wyoming experienced a 55 percent crash reduction in its first full year of operation compared to the year prior to installation².

The use of a weather responsive variable speed system on US 97 is consistent with needs identified in the Deschutes County Intelligent Transportation System (ITS) Plan and the Oregon Statewide ITS Architecture and Operational Concept Plan. The Deschutes County Transportation System Plan (TSP) and Klamath County TSP both support the use of ITS solutions to improve safety and operations.

In addition to the safety benefits, a variable speed system will also provide secondary benefits:

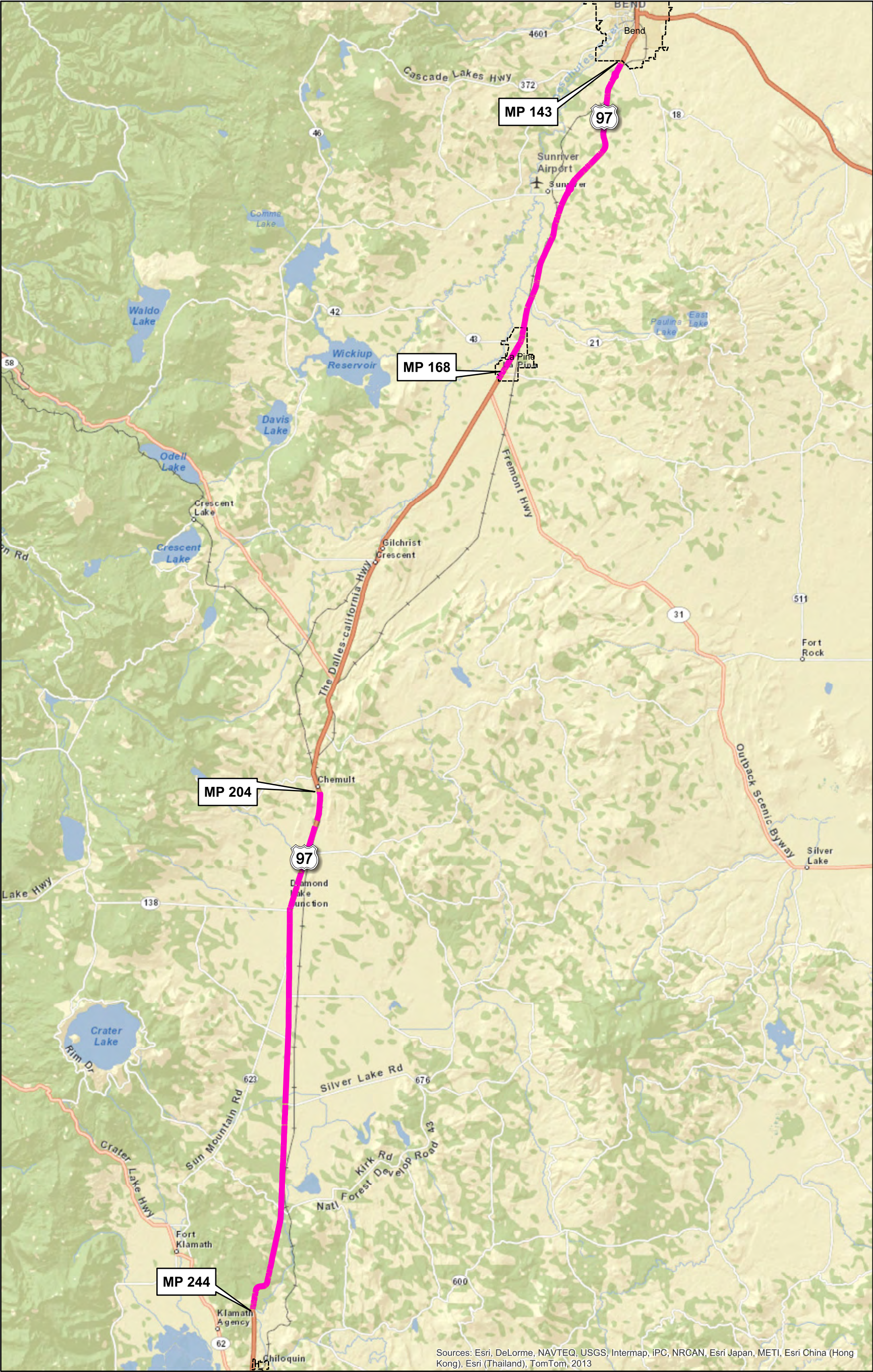
- Real-time data from additional road weather sensors will support maintenance crew decisions regarding snow and ice control measures, which will improve resource allocation efficiency.
- Speed sensors will collect traffic count and speed data throughout the corridor that will support performance measurement outlined in Trip 97.
- Additional traveler information will be provided to ODOT's existing TripCheck system to support informed traveler decisions.

¹ *Guidelines for the Use of Variable Speed Limit Systems in Weather*. Federal Highway Administration, Safety Program, Aug. 2012.

² *Variable Speed Limit System for Elk Mountain Corridor*, Final Report FHWA-WY-10/04F. Prepared by University of Wyoming, Department of Civil and Architectural Engineering, for the Wyoming Department of Transportation and the Federal Highway Administration, Oct. 2010.



This memorandum provides an overview of the existing traffic conditions, including a spot speed study and crash analysis, as well as the proposed variable speed system component locations. This variable speed study and the complementary Oregon Statewide Variable Speed System Concept of Operations conform to the engineering study requirements of OAR 734-020-0018 (Establishment of Variable Speed Zones). Figure 1 provides an overview map of the US 97 study segments.



LEGEND

- Study Segments
- City Limits

US 97 Study Segment Overview

June 12, 2013

ODOT Region 4 US 97 Variable Speed Study



EXISTING TRAFFIC CONDITIONS

US 97 is generally a rural principal arterial with two lanes (one lane each direction), a posted basic rule speed of 55 mph, no major geometric issues, a larger variation of travel speeds during adverse weather, and a large occurrence of crashes in the winter involving icy road conditions and drivers traveling too fast for the conditions. Table 1 provides an overview of the traffic characteristics for both US 97 study segments. The segments are fairly similar except the MP 143 to 168 segment has a higher average daily traffic volume (approximately 14,900 vehicles) and a lower percentage of heavy vehicles (11 percent) than the MP 204 to 244 segment, which has an average daily traffic volume of 5,400 vehicles with 38 percent heavy vehicles. Additionally, the following subsections provide the results of a spot speed study at MP 156 and a crash analysis for both study segments.



Table 1: US 97 Traffic Characteristics

Characteristic	MP 143 to 168 (Bend to La Pine)	MP 204 to 244 (Chemult to Spring Creek Hill)
Functional classification	Rural Principal Arterial, except: Urban Principal Arterial in La Pine	Rural Principal Arterial
Part of National Highway System	Yes	
Freight Route (federal and state)	Yes	
Location	Deschutes County, including incorporated City of La Pine	Klamath County
Culture	Rural	
Cross-section	2 lanes (1 lane per direction) with intermittent 3- and 4-lane passing segments	
Elevation change	338 ft gain from north to south, which includes a 625 ft gain from Baker Rd to Lava Butte Pass	531 ft gain from south to north
Curvature (horizontal and vertical)	No reported issues	
Sight distance	No reported issues	
Annual average daily traffic (AADT) volume for 2011	14,900 vehicles	5,400 vehicles
Seasonal volume variation	Largest volumes in summer	
Vehicle classification for 2011	Autos = 89% Heavy Vehicles = 11%	Autos = 62% Heavy Vehicles = 38%
Posted speed	55 mph (basic rule), except: MP 164.37 to 165.27: 50 mph MP 167.27 to 167.46: 45 mph MP 167.46 to 168.35: 35 mph	55 mph (basic rule), except: MP 209.05 to 209.41: 50 mph
Annual modeled precipitation	Lava Butte (4,557 ft)	Chemult (4,879 ft)
Rainfall	13.7 in	21.4 in
Snowfall	7.8 in	21.6 in

Data from ODOT (www.oregon.gov/odot) and the National Oceanic and Atmospheric Administration (www.nohrsc.nws.gov).



Spot Speed Study

ODOT conducted a spot speed study on US 97 at approximately MP 156, near the US 97/Vandervert Rd/Lambertiana Rd intersection, to compare travel speeds during normal road conditions and adverse road weather conditions. The posted speed is 55 mph following the basic rule. The basic speed rule essentially means that drivers are expected to use good judgment to select a speed based on traffic, road, and weather conditions. The 85th percentile travel speed did drop from 63 to 49 mph during adverse weather. Compared to normal road conditions, the percent of vehicles in the 10 mph pace dropped from 89 to 71 and the travel speed spread increased from 20 to 29 mph during adverse road weather conditions. This indicates an inconsistent selection of travel speed by drivers during adverse road weather conditions. A wide range of travel speeds on the same roadway has been linked to higher crash rates^{3,4}. The use of a variable speed zone that identifies the appropriate travel speed during adverse weather conditions would likely help improve the consistency of travel speeds.

Table 2: US 97 Spot Speed Study at MP 156 near Vandervert Rd/Lambertiana Rd

Measurement	Normal Road Conditions	Adverse Road Weather Conditions
Road Conditions	Dry surface, snow off roadway	Packed snow and ice, snow flurries
Date	10/26/2010	11/22/2010
85 th Percentile Speed	63 mph	49 mph
Percent in 10 mph Pace	89% (55 – 64 mph)	71% (40 – 49 mph)
Speed Range	50 – 70 mph	30 – 59 mph
Percent Exceeding Posted Speed	90%	1%

³ *The Attitude and Behaviour of European Car Drivers to Road Safety*. SARTRE 2 Reports, Part 3. The SARTRE Group, Institute for Road Safety Research (SWOV), Leidschendam, Netherlands, 1998, pp. 1-38.

⁴ Garber, N.J. and R. Gadiraju. Factors Affecting Speed Variance and its Influence on Accidents. In *Transportation Research Record No. 1213*, Transportation Research Board of the National Academies, Washington D.C., 1989, pp 64 – 71.



Crash Analysis

The crash data for both US 97 study segments indicate that most crashes occur during the months of November through April, approximately half of crashes occur when there is ice on the roadway, and approximately half of crashes are attributed to drivers traveling too fast for the conditions. Variable speed zones on the US 97 corridor will likely reduce the frequency and severity of crashes related to icy road conditions and high travel speeds. This section provides an overview of crash analysis terminology followed by a detailed crash analysis for both US 97 study segments.

Crash Analysis Terminology

The following terminology is used in the crash analysis^{5,6,7}:

- Safety Priority Index System (SPIS): A scoring system based on crash rate, frequency, and severity over the prior three calendar years; generally, the higher a SPIS score the higher a potential safety solution is needed
- Fatality: A crash that results in fatal injuries to one or more persons within 30 days of the crash
- Injury A: A crash that results in any incapacitating injury that prevents a person from walking, driving, or continuing activities the person was capable of doing before the injury
- Injury B: A crash that results in any non-incapacitating injury that is not severe but is evident to observers at the scene of the crash such as bruises, abrasions, and minor bleeding
- Injury C: A crash that results in any injury that is reported but not apparent such as complaint of pain or momentary lapse of consciousness
- Property Damage Only (PDO): a crash in which there is no injury to any person, but only damage to a motor vehicle or other property
- Careless Driving: a traffic violation for a person who unintentionally drives a vehicle in a manner that endangers or may endanger any person or property (ORS 811.135)
- Reckless Driving: a misdemeanor for a person who consciously drives a vehicle in a manner that endangers or may endanger any person or property (ORS 811.140)

⁵ *Safety Priority Index System (SPIS)*. Oregon Department of Transportation, Traffic-Roadway Section.

<http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/Pages/spis.aspx>

⁶ *Statewide Crash Data System Motor Vehicle Traffic Crash Analysis and Code Manual*. Oregon Department of Transportation, Transportation Development Division, Transportation Data Section, Crash Analysis and Reporting Unit, May 2007.

⁷ *Oregon Revised Statutes*, Chapter 811- Rules of the Road for Drivers, 2011 ed. <http://www.leg.state.or.us/ors/811.html>

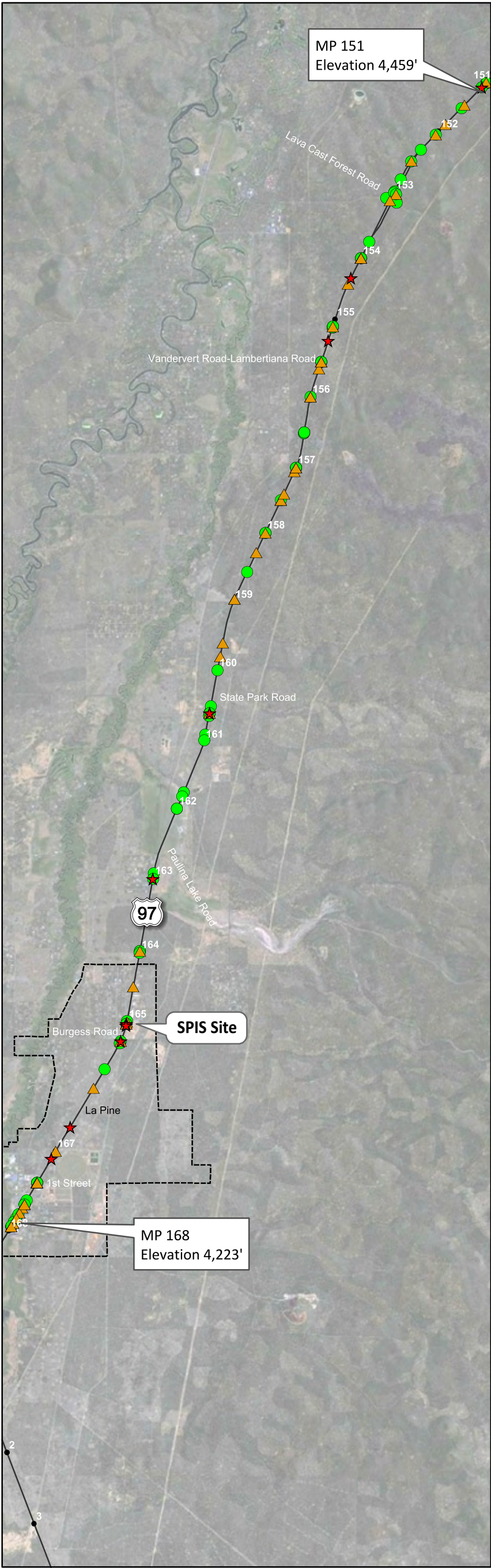


US 97 Crash Analysis for MP 143 to 168

The US 97 study segment from MP 143 to 168 (Bend to La Pine) includes two SPIS locations (year 2009 through 2011) falling within the 85 – 89.99 percentile and the segment experienced 240 crashes from January 1, 2009 to July 31, 2012. The posted speed is generally 55 mph in this study segment with a range of posted speeds from 35 to 55 mph within the City of La Pine.

Key findings include:

- SPIS locations are shown in Figure 2. The SPIS location at MP 145.92 to 146.00 is near the Bend weigh station and the one at MP 164.94 to 165.00 is near Burgess Rd in La Pine. **Both SPIS sites include at least one fatality** and fall within the 85 to 89.99 percentiles for SPIS locations, which mean they have a higher crash rate, frequency, or severity than 85 percent of the crash sites in Oregon.
- Figure 2 illustrates the crash severity for the 240 crashes that occurred:
 - ❖ **5% fatality/injury A crashes (includes 8 fatalities)**
 - ❖ 36% injury B/C crashes
 - ❖ 59% property damage only crashesAlthough some locations experience higher crash frequencies, **crash locations are located throughout the entire study segment.**
- **Most crashes (46%) were caused by drivers traveling at speeds that were too fast for the conditions** as shown in Figure 3. Other speed-related crashes were caused by careless driving (2%) and reckless driving (2%). The remaining 50% of crashes were caused by a variety of improper driving activities such as following too closely or failure to yield right-of-way.
- **Most crashes occurred when there was ice on the road surface** as shown in Figure 4:
 - ❖ 43% ice
 - ❖ 40% dry
 - ❖ 10% snow
 - ❖ 6% wet
 - ❖ 1% unknown
- Despite higher ADT volumes in the summer, **crashes occur most frequently in the winter** during the months of November through April when ice or snow is on the road as shown in Figure 5.
- Crashes by time of day and day of week are generally proportionate to the volume profiles for those same time periods.



LEGEND

Crash Type (Total Qty = 240)

- ★ Fatality/Injury A (Qty = 12)
- ▲ Injury B/C (Qty = 87)
- Property Damage Only (Qty = 141)
- Mile Point

US 97 Crash Severity for MP 143 to 168
(Jan. 1, 2009 to July 31, 2012)

June 12, 2013

ODOT Region 4 US 97 Variable Speed Study

Figure
2

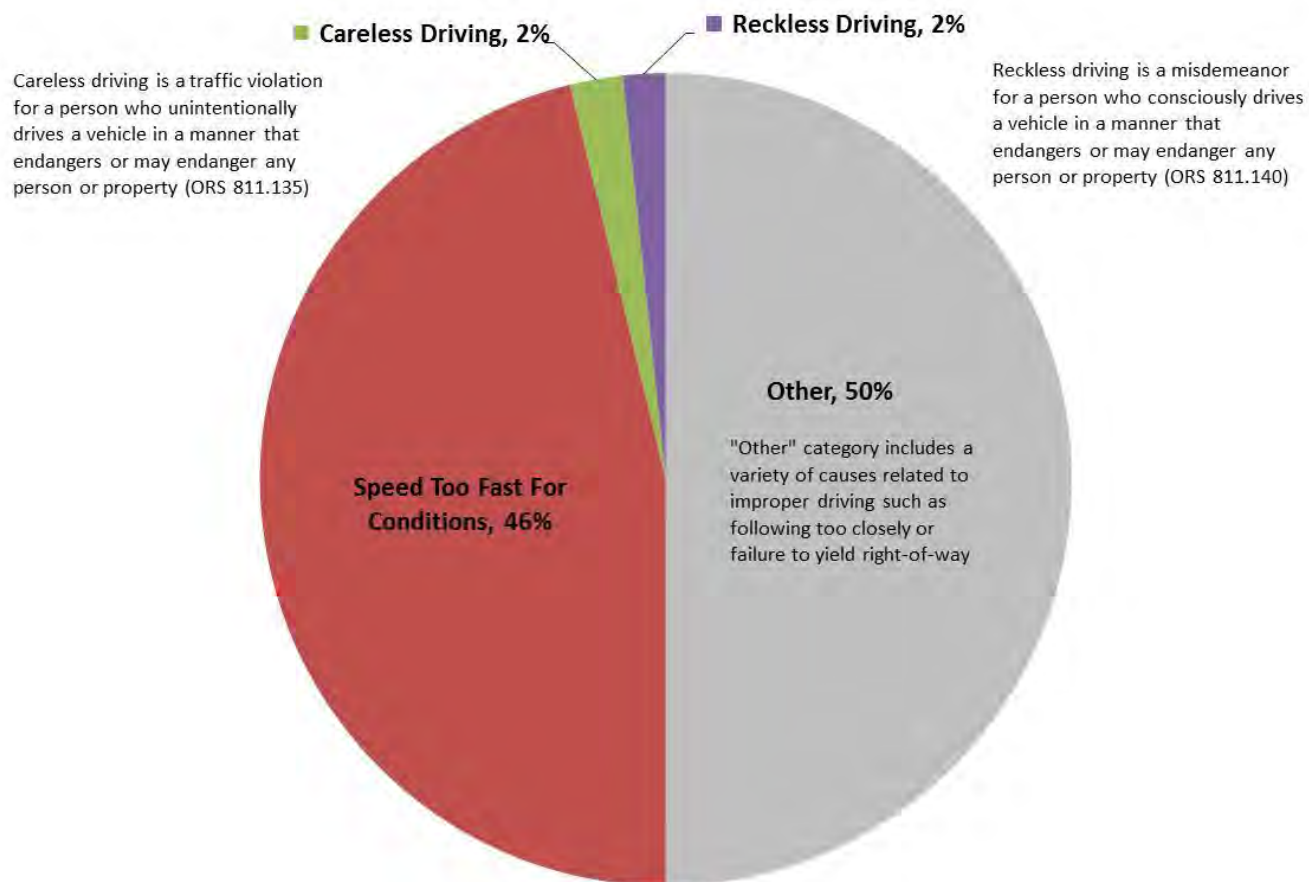
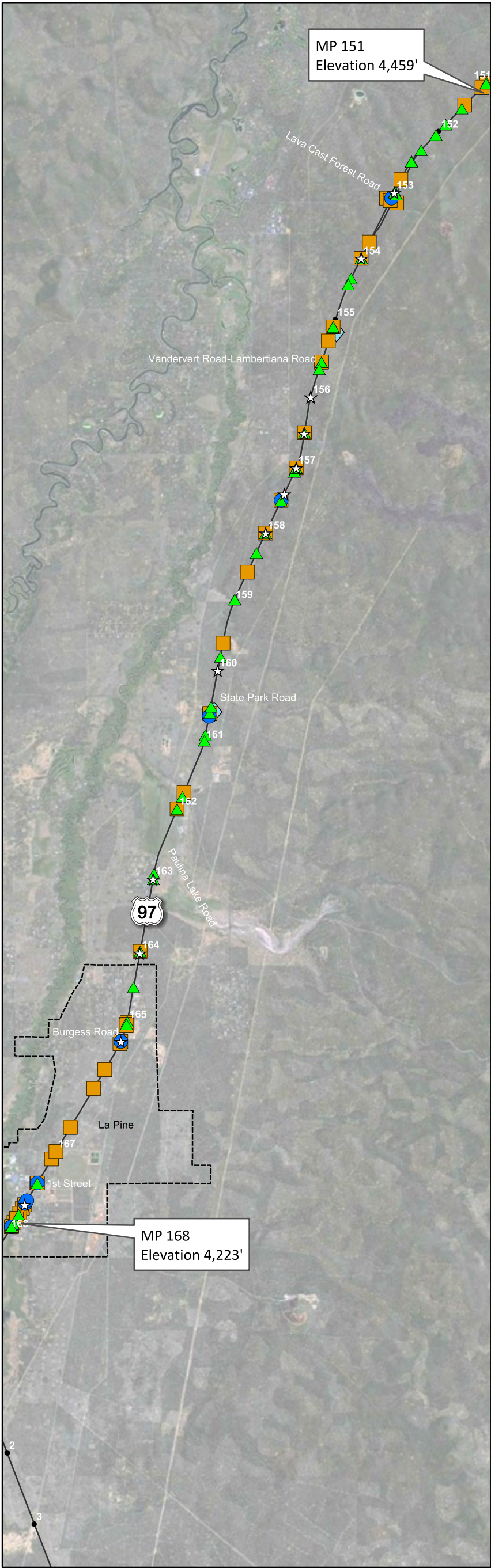


Figure 3: US 97 Crash Causes for MP 143 to 168 (Jan. 1, 2009 to July 31, 2012)



LEGEND

- Road Conditions at Crash Site (Total Qty = 240)**
- | | |
|-------------------|-------------------|
| ☆ SNOW (Qty = 24) | ◆ Unknown (Qty=3) |
| ▲ ICE (Qty = 103) | ● Mile Point |
| ● WET (Qty = 14) | |
| ■ DRY (Qty = 96) | |

US 97 Crashes by Road Conditions for MP 143 to 168
(Jan. 1, 2009 to July 31, 2012)

June 19, 2013

ODOT Region 4 US 97 Variable Speed Study

Figure
4

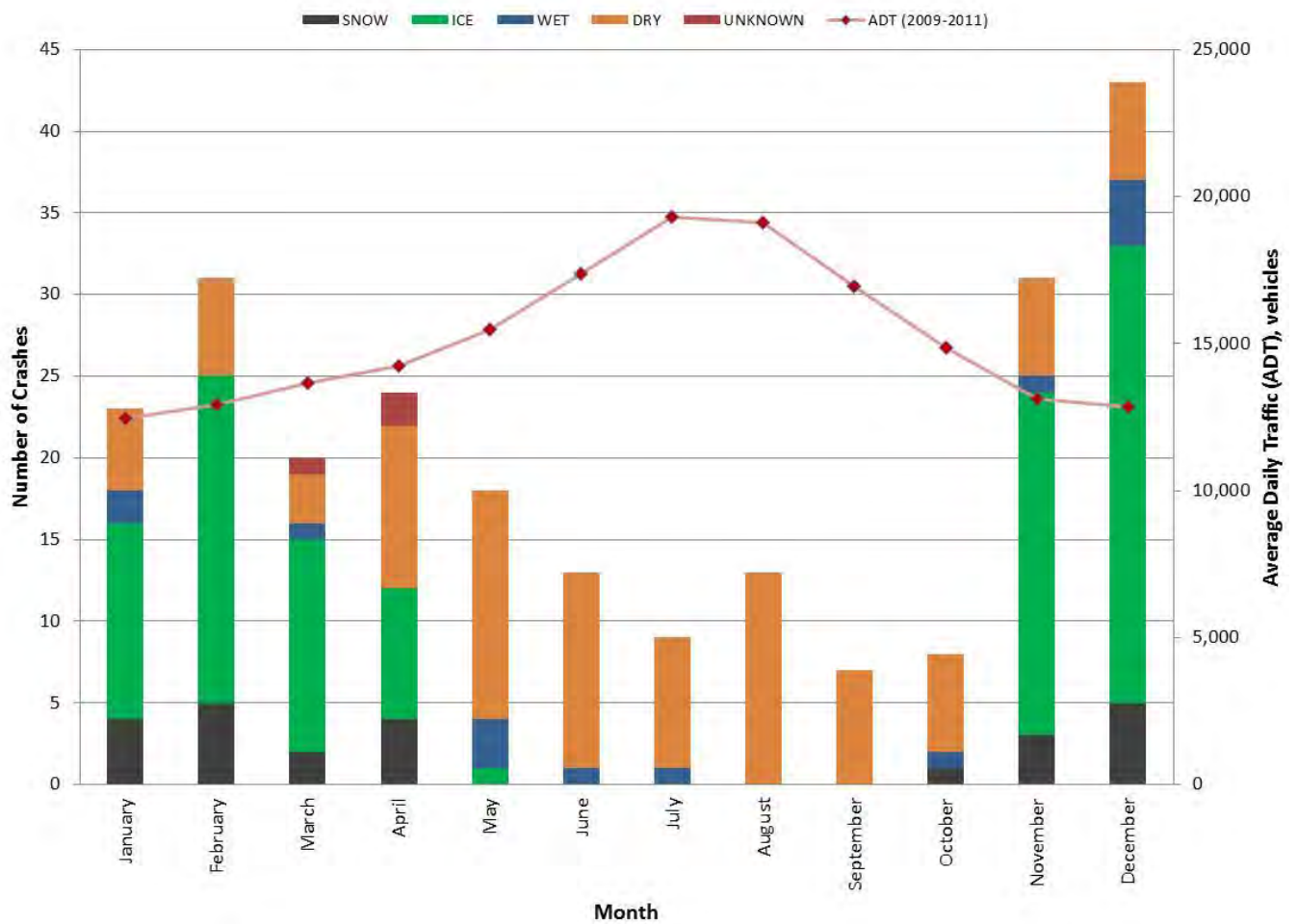


Figure 5: US 97 Crashes by Road Conditions and Month for MP 143 to 168 (Jan. 1, 2009 to July 31, 2012)



US 97 Crash Analysis for MP 204 to 244

The US 97 study segment from MP 204 to 244 (Chemult to Spring Creek Hill) experienced 153 crashes from January 1, 2009 to July 31, 2012. The posted speed is generally 55 mph in this study segment except for a 2,000-foot section that is posted 50 mph in the unincorporated area of Beaver Marsh.

Key findings include:

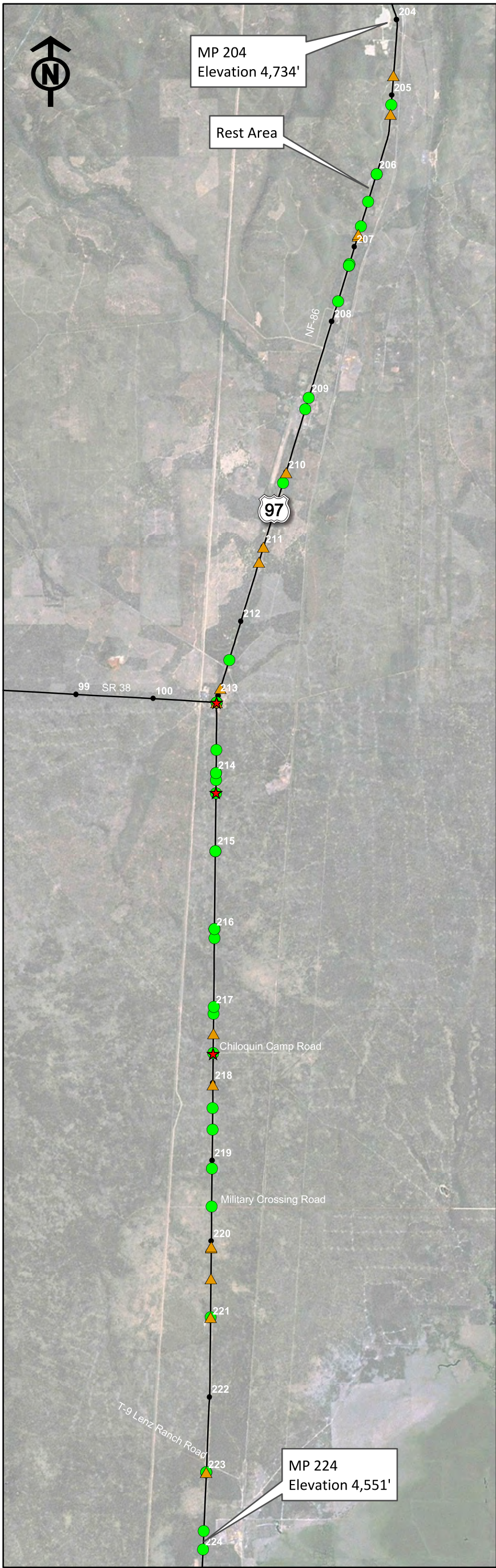
- **This segment does not include any SPIS locations in the 85 to 100 percentiles.**

- Figure 6 illustrates the crash severity for the 153 crashes that occurred:

- ❖ **5% fatality/injury A crashes (includes 3 fatalities)**
- ❖ 29% injury B/C crashes
- ❖ 66% property damage only crashes

Although some locations experience higher crash frequencies, **crash locations are located throughout the entire study segment.**

- **Most crashes (54%) were caused by drivers traveling at speeds that were too fast for the conditions** as shown in Figure 7. Other speed-related crashes were caused by careless driving (8%) and driving in excess of posted speed (1%). The remaining 37% of crashes were caused by a variety of improper driving activities such as following too closely or failure to yield right-of-way.
- **Most crashes occurred when there was ice on the road surface** as shown in Figure 8:
 - ❖ 66% ice
 - ❖ 23% dry
 - ❖ 7% snow
 - ❖ 3% wet
 - ❖ 1% unknown
- Despite higher ADT volumes in the summer, **crashes occur most frequently in the winter** during the months of November through April when ice or snow is on the road as shown in Figure 9.
- Crashes by time of day and day of week are generally proportionate to the volume profiles for those same time periods.



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

LEGEND

Crash Type (Total Qty = 153)

- ★ Fatality/Injury A (Qty = 7)
- ▲ Injury B/C (Qty = 45)
- Property Damage Only (Qty = 101)
- Mile Point

US 97 Crash Severity for MP 204 to 244
(Jan. 1, 2009 to July 31, 2012)

June 12, 2013

ODOT Region 4 US 97 Variable Speed Study

Figure
6

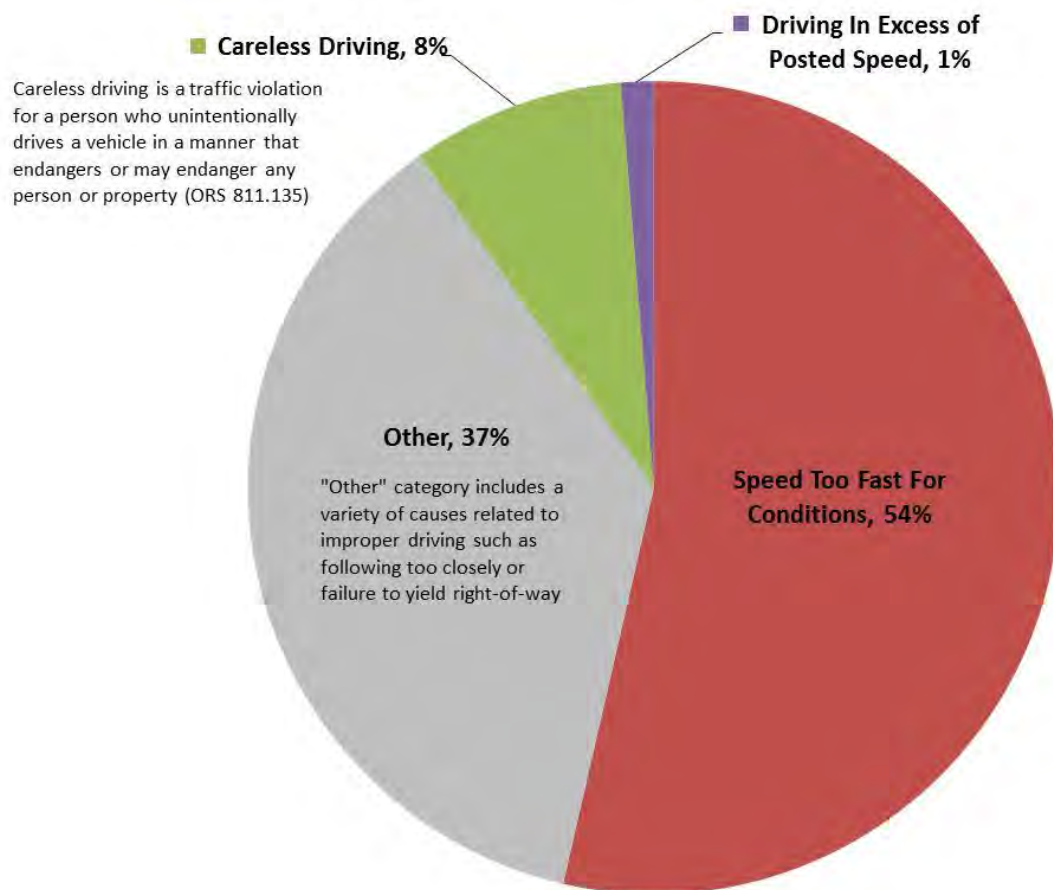
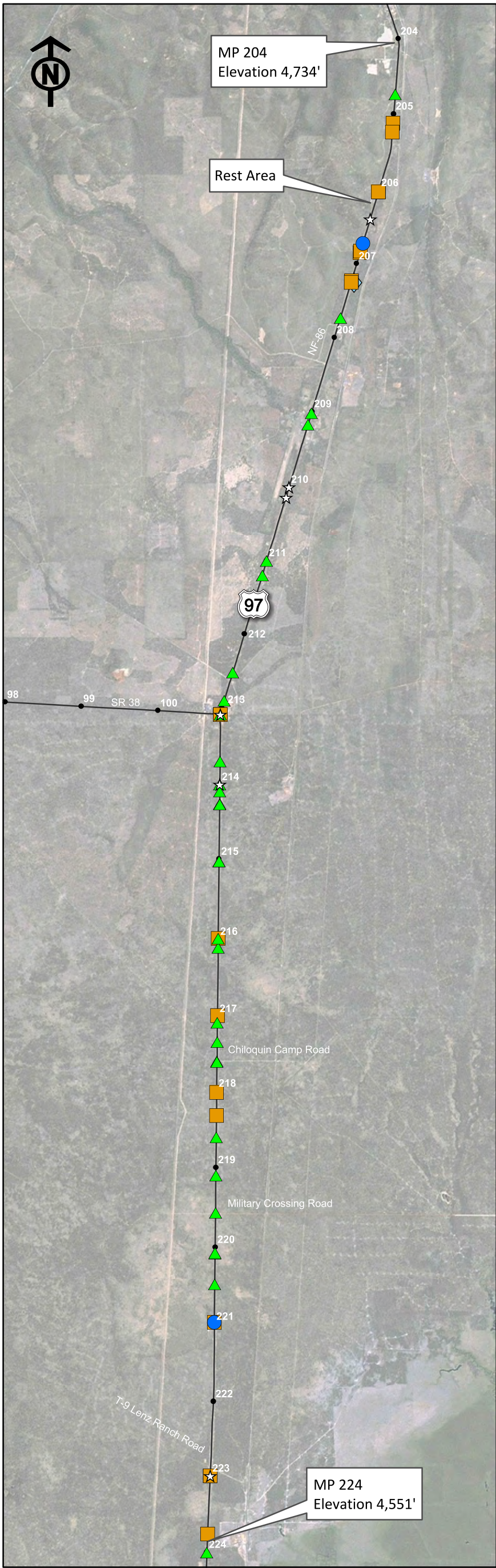


Figure 7: US 97 Crash Causes for MP 204 to 244 (Jan. 1, 2009 to July 31, 2012)



LEGEND

Road Conditions at Crash Site (Total Qty = 153)

- | | |
|-------------------|-------------------|
| ☆ SNOW (Qty = 11) | ◆ Unknown (Qty=1) |
| ▲ ICE (Qty = 101) | • Mile Point |
| ● WET (Qty = 4) | |
| ■ DRY (Qty = 36) | |

US 97 Crashes by Road Conditions for MP 204 to 244
(Jan. 1, 2009 to July 31, 2012)

June 19, 2013

ODOT Region 4 US 97 Variable Speed Study

Figure
8

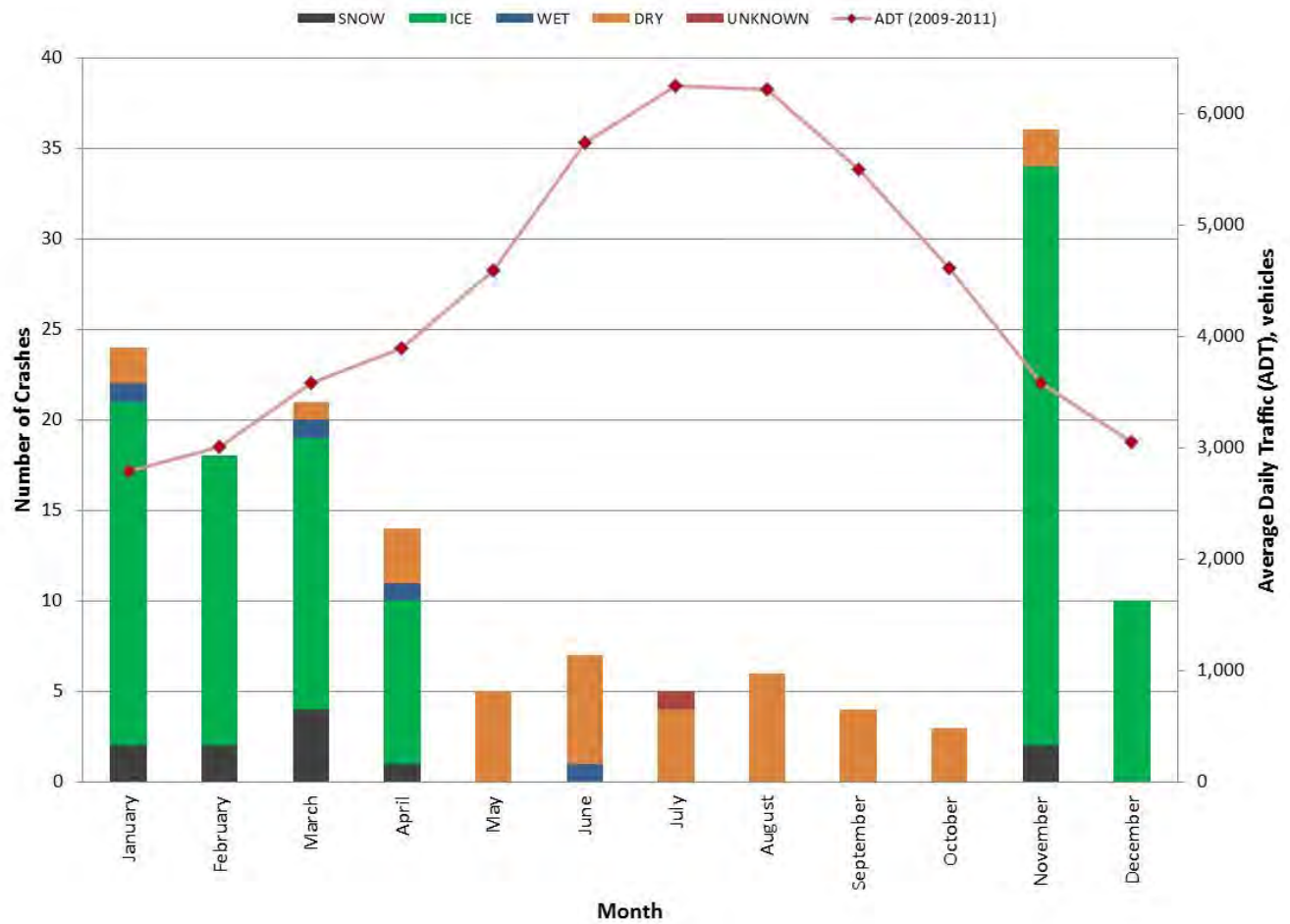


Figure 9: US 97 Crashes by Road Conditions and Month for MP 204 to 244 (Jan. 1, 2009 to July 31, 2012)



PROPOSED VARIABLE SPEED SYSTEM

We propose the installation of a weather responsive variable speed system for the two US 97 study segments to address the high percentage of crashes caused by travel speeds too fast for ice and snow road conditions. ODOT Region 4 may possibly consider using congestion responsive variable speeds in the summer. This section provides an overview of the concept of operations and proposed variable system components and locations.

Concept of Operations

A concept of operations for statewide variable speed systems in Oregon is currently being developed by DKS Associates for ODOT. A number of variable speed systems are being developed or investigated by ODOT throughout the state. The US 97 variable speed system will be operated by the ODOT Region 4 Traffic Operations Center in accordance with the statewide concept of operations. Staff members from ODOT Region 4 are involved in the development and review of this document along with other statewide stakeholders.

The concept of operations will document the stakeholders and their shared understanding of how variable speed systems will be operated and maintained. Key items that will be included are algorithms for determining posted speed, speed change intervals, procedures for changing posted speed, procedures for keeping speed change records, and a law enforcement concept. The law enforcement concept for US 97 will primarily address notification procedures of posted speed changes. Limited resources are available for speed enforcement during adverse weather conditions due to the increased demand for other response activities.

Variable Speed System Components and Locations

This section describes the components needed for a comprehensive variable speed system and the proposed equipment locations for both US 97 study segments. The components for a variable speed system are generally categorized as either signing or monitoring equipment.

The variable speed system for US 97 includes various **signing components**:

- **Variable speed (VS) signs:** VS signs will be used at the entry point of each speed zone, at regular intervals, downstream of major entry points, and at locations where the maximum posted speed changes based on speed zone orders. The sign legend will be the black on white regulatory basic rule speed sign (OR2-1). We recommend the use of a full matrix LED sign, approximately five feet by five feet in size, to allow for flexibility in the future to use a sign legend consistent with statewide policy or to make adjustments based on an evaluation of system performance.
- **Variable message signs (VMSs):** These will primarily be used to notify drivers of adverse weather conditions and the use of variable speeds on the corridor. We recommend the installation of a VMS at the entry point to each speed zone. The entry point VMS will be used in place of a stand-alone VS sign because the VS sign legend will be displayed on the VMS in conjunction with additional information as applicable (e.g. WATCH FOR ICE). Because the US 97 variable speed zones are long, we recommend the



use of a supplemental VMS approximately near the mid-point of the speed zone. When not used for the variable speed system, the VMSs may also be used to post traveler information per ODOT's standard operating procedures.

- **Supplementary signs:** Similar to standard speed zone notification signs, advance signs are needed to alert drivers they are entering a variable speed zone corridor. Static signs will most likely be used to provide this information.

The variable speed system for US 97 includes various **monitoring components**:

- **Grip factor sensors:** These remote pavement sensors measure a variety of conditions using optics and a spectroscopic analysis of infrared light reflected back from the roadway surface. A key feature is the measurement of the pavement grip factor, which is the level of friction between the pavement and vehicle tires. This factor is greatly impacted by rain, snow, slush, frost, and ice. These sensors can also determine the surface classification (e.g. dry, wet, snow, ice) and the amount of depth of those conditions. Visibility can also be measured directly at the roadway. Grip factor sensors are proposed for installation at every other variable speed sign location to get a comprehensive assessment of road surface conditions throughout each speed zone corridor.
- **Road weather information systems (RWISs):** Existing RWIS stations support detection of adverse weather through measurement of conditions such as air temperature, humidity, wind speed and direction, and rainfall occurrence and intensity. The conditions measured at each RWIS station varies by installation. RWIS data may also be used for evaluation and fine-tuning of the variable speed systems.
- **Speed and volume sensors:** Point-based sensors will measure real-time speed and traffic volumes across all lanes to support the procedures outlined in the concept of operations for determining variable speeds. Speed and volume sensors are proposed for installation in conjunction with every variable speed sign since real-time speed data is a key factor in the algorithms for setting the posted speed. We recommend the use of radar traffic sensors to measure speed and volume since they are non-intrusive and typically mounted on the side of the highway away from the travel lanes.
- **Automatic Traffic Recorders (ATRs):** Existing ATRs on US 97 will collect volume and vehicle classification data to support performance measurement of the variable speed system.
- **Closed-circuit television (CCTV) cameras:** Existing CCTV cameras will be used to monitor system operations and support decisions related to manual system overrides. Additional CCTV cameras may be considered in the future, as funding allows, to provide more comprehensive coverage of US 97.

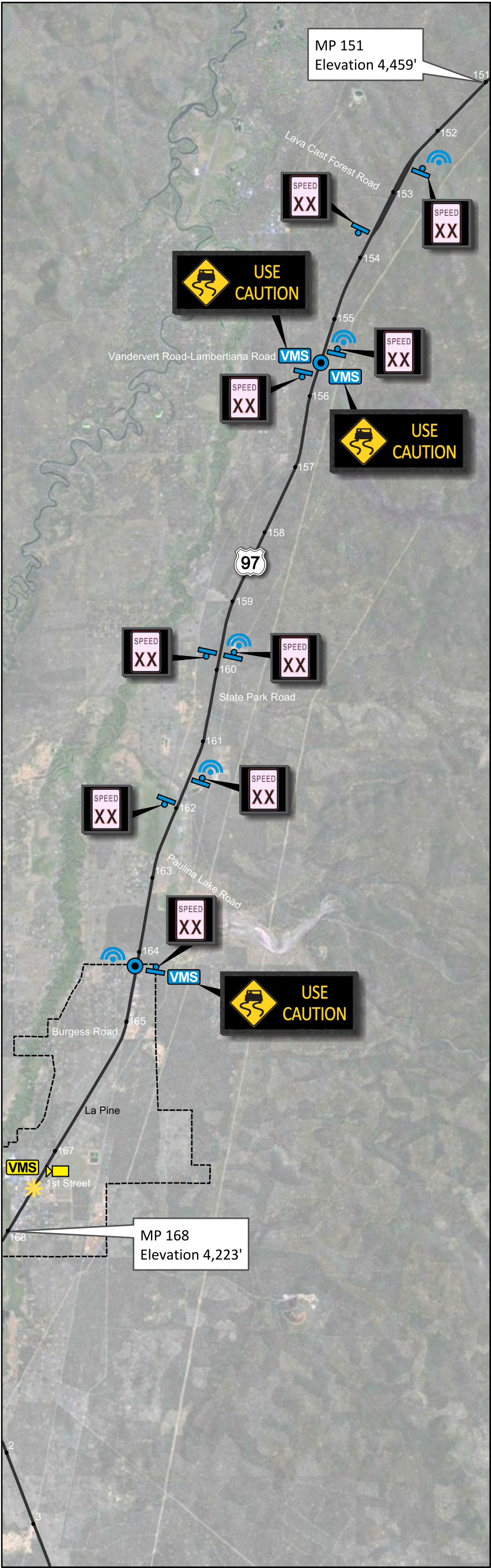
The posted speed from the variable speed system will likely be provided in real-time to ODOT's existing TripCheck system, which provides traveler information through a variety of means (e.g. website, smart phone applications, 511, social media, public access message broker). This effort will be addressed at the statewide level by the ODOT ITS Unit.

The existing and proposed variable speed equipment locations for US 97 are shown in Figure 10 for MP 143 to 168 (Bend to La Pine) and in Figure 11 for MP 204 to 244 (Chemult to Spring Creek Hill). For the MP 143 to 168 study segment, we propose ending the variable speed zone at MP 164 to avoid the complexity of operating the



variable speeds within La Pine where the speed zones range from 35 to 55 mph over a four-mile segment. Preliminary ten-percent plans are being developed for both study segments to identify power supply sources and communications connections. Initial analysis shows that power locations are available within 1,000 feet of all proposed devices. Communications will be evaluated on a site-by-site basis. Hardwire communications is preferred but cellular communications will also be considered.

The two US 97 study segments will operate independently of one another and may be implemented at different times based on funding availability.



LEGEND

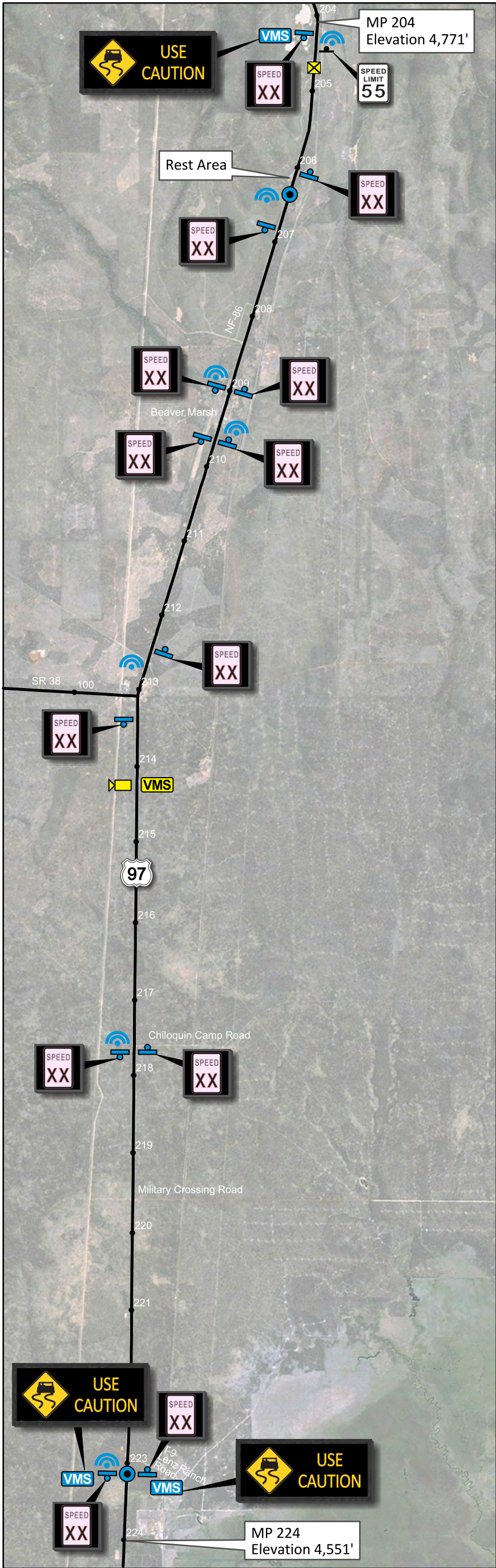
- Proposed Grip Factor Sensor
- Proposed VS Sign
- Proposed VMS
- Proposed Speed & Volume Sensor
- Existing Grip Factor Sensor
- Existing RWIS
- Existing CCTV Camera
- Existing VMS
- Sign
- Mile Point

US 97 Proposed Equipment Locations for MP 143 to 168

June 19, 2013

ODOT Region 4 US 97 Variable Speed Study

Figure **10**



LEGEND	
Proposed Grip Factor Sensor	Existing Grip Factor Sensor
Proposed VS Sign	Existing RWIS
Proposed VMS	Existing CCTV Camera
Proposed Speed & Volume Sensor	Existing VMS
	Existing ATR
	Sign
	Mile Point

June 19, 2013

**US 97 Proposed Equipment Locations
for MP 204 to 244**

ODOT Region 4 US 97 Variable Speed Study

Figure
11

Appendix C: Needs Assessment Memorandum



720 SW Washington St.
Suite 500
Portland, OR 97205
503.243.3500
www.dksassociates.com

MEMORANDUM

DATE: February 9, 2016

TO: Rick Williams (ODOT)

FROM: Deena Platman (DKS), Project Manager
Jennifer Bachman (DKS), PE

SUBJECT: User Needs Assessment Memorandum P12016-016

This memorandum provides a summary of user needs captured through stakeholder interviews and the project Technical Advisory Committee (TAC). The user needs are organized into to one of eight categories. Within each category the TAC prioritized the needs into “high”, “medium”, or “low” priority groupings. The project team will use the prioritized list of user needs to develop preliminary strategies for the deployment plan. In March 2016 a stakeholder workshop will further refine the proposed strategies and priorities, leading to a final set of strategies that will be documented in the Deployment Plan memorandum.

The assessment of current and future transportation user needs in Klamath County provides the foundation for developing potential ITS projects for the Deployment and Communication Plans.

STAKEHOLDER INTERVIEWS

The stakeholder interviews were conducted by phone and lasted approximately an hour each. Staff from the following six organizations were interviewed: Basin Transit, City of Klamath Falls (street and maintenance divisions), ODOT Maintenance, ODOT Incident Response Patrol, ODOT Klamath Falls Port of Entry, and Keno Fire Department. A summary of the interviews is included in Appendix “A” to this memorandum, and the needs identified through the interviews served as a starting point for documenting and organizing Klamath County’s ITS needs.

USER NEEDS

The needs are organized in eight categories:

- Traffic Operations and Management
- Weather Event Management
- Traveler Information
- Maintenance and Construction Management
- Emergency and Incident Management

- Data Management and Performance Measurement
- Public Transportation Management
- Freight Management

Needs can either apply system wide, or to a specific location. An example of a system-wide need is “improve real-time traveler information throughout Klamath County”; whereas an example of a location specific need is “improved ice detection on Highway 140”.

The following sections document the user needs and priorities as determined by the TAC members and discussed at the TAC meeting held on January 21, 2016.

To summarize, the highest priority and system-wide needs include:

- The need to connect field devices to a communication system that allows operators to remotely access and monitor the system
- The need to provide more accurate real time traveler information on a larger portion of the county’s roadways, including road conditions during weather events
- The need to connect the county’s 9-1-1 dispatch system to ODOT and Oregon State Policy (OSP)
- The need to address run off the road crashes and weather related crashes
- The need to establish a method for automatically sharing data and performance measures between agencies
- The need to automate maintenance logs

Traffic Operations and Management Needs

The overarching system wide need for traffic operations is connecting field devices to a central system so that operators can manage the devices and the system for efficiently. In Klamath County the majority of field devices communicate via cellular routers or point to point circuits due to the county’s rural traits. In the city of Klamath Falls there is a fiber line along a portion of 6th Street, and some twisted copper communication lines.¹

Other high priority needs in this category include improving multi-modal crossings, adding surveillance capabilities at specific locations, and addressing safety elements including run-off-the road crashes and speed disparity issues.

Table 1 describes the traffic operation and management needs for Klamath County.

¹ Klamath County ITS Project – Existing Conditions Memorandum. November 16, 2015.

Table 1: Traffic Operations and Management Needs

Need	Notes
HIGH Priority Needs	
Provide remote access to traffic signals in the county through ODOT's central system	• This allows a big improvement in efficiency of staff as well as operational improvements • Key for overall coordination. • Fiber or other communication line necessary
Ability to interconnect to field equipment and access video detection	Key locations: • 6th Street • Crater Lake Parkway
Ability to continue updating traffic signal controllers from 170s to 2070s	
Improve pedestrian and bicycle crossings and data collection	• On 6th street three fatal crashes occurred over the last five years at midblock crossings • Mid-block transit stops lead to pedestrians more likely crossing at mid-block locations
Address run-off-the road crashes	Key locations: • US 97 • OR 140
Address speed disparity for travel conditions <i>Note: Variable Speed Study completed</i>	• Key issue during weather events
Ability to view local agency cameras on TripCheck	• Note that video detection cameras cannot be used for TripCheck, but other cameras can easily be added to the system • System to add cameras is currently available
MEDIUM Priority Needs	
Access real-time images at key locations	Key locations: • Silver Lake Road MP 27 • Dead Indian Memorial MP 30.6 • Williamson River Road MP 17 • Hwy 140 to Medford near MP 20-24 • Hwy 39 – need one near Merrill • Hwy 66 – mile post 43 • Hwy 62 – mile post 83.6
Obtain more real-time information including road conditions, construction activity, video, incident information, and weather	• Consider TripCheck local entry tool • Connected vehicle readiness
Ability to update systems and malfunctioning equipment	
Ability to upgrade to Advanced Traffic Signal Controllers (ATCs) as ODOT shifts	
LOW Priority Needs	
none	

Weather and Event Management

Weather events in Klamath County, especially during the winter can pose significant safety hazards for travelers. The key needs identified in this category include system-wide elements such as addressing weather related crashes and providing better real-time road weather conditions to travelers. Some location specific needs involve better ice detection systems and automated changeable snow signs at specific locations. Needs such as automated de-icing and automated rock fall warning fell to lower priorities due to the lower frequency those needs arise and the likelihood that strategies addressing those needs have a high cost relative to other projects.

Table 2 describes the weather event management needs for Klamath County.

Table 2: Weather Event Management Needs

Need	Comments
HIGH Priority Needs	
Address weather-related crashes.	• High percentage of weather related crashes
Provide better real-time road weather conditions across the county.	Key RWIS locations (same as some camera locations in Table 1): • Hwy 140 to Medford near MP 20-24 • Hwy 39 – need one near Merrill • Hwy 66 – mile post 43 • Hwy 62 – mile post 83.6
Improve ice detection system	Location: • Hwy 140 and other locations
Ability to change snow signs remotely	Locations: • US 97 near mile post 240-243 (high volumes) • OR 140 W mile post 41 (possibly the worst conditions)
MEDIUM Priority Needs	
Ability to change snow signs remotely	Locations: • OR 140 near Bly Mountain Pass mile post 53-57 • OR 140E mile post 25-35
Ability for maintenance operations to be automatically notified when rock fall occurs	• Low frequency events • US 97 North of Klamath Falls would be a good location, due to blind corners when traveling next to the lake and single lane conditions.
LOW Priority Needs	
Ability to automatically de-ice at key locations	Key Locations: • Bridges • Spring Creek Hill near Chiloquin • Lake of the Woods – three mile hill
Provide heating elements in the pavement at key locations	• Maintenance concerns. • <i>Note – there may already be heating elements at Esplanade Ave/Crater Lake Parkway and Beihn St/Crater Lake Parkway</i>

Traveler Information Needs

Klamath County is largely rural with areas that lack cellular coverage and long stretches of roadways with no alternate routes. These characteristics lend themselves to improved traveler information, especially at key junction points, that do not rely on mobile devices that need a cellular connection. Additionally, travelers in Klamath County experience a significant number of conflicts with wildlife on roadways, specifically mule deer during migration season. That conflict leads to needing active warning devices to alert drivers when wildlife is on the roadway.

The need for a rock fall warning system moved to a lower priority due to lower event frequency and cost to implement a system.

Table 3 describes the traveler information needs for Klamath County.

Table 3: Traveler Information Needs

Need	Comments
HIGH Priority Needs	
Provide drivers with real-time road weather conditions.	• Large travel distances, changing weather
Provide drivers with route information prior to key junctions (such as detours or closures)	• Limited cell coverage to get info out other ways.
Provide drivers with active warnings when wildlife is present in or near the roadway	• Key areas: near Klamath Falls, and US 97 especially at the north end of the county.
MEDIUM Priority Needs	
Provide drivers with active warnings when rock fall occurs.	Key areas: • US 97 mile posts 257-267 (Modoc Point to Hagelstein Park) • US 97 mile posts 240-243 (lower frequency)
LOW Priority Needs	
none	

Maintenance and Construction Needs

The key needs identified in this category revolve around automated maintenance logs, both for vehicles and infrastructure. Ultimately the information from the automated logs, especially the vehicle logs, could be used to provide real-time traveler information such as plowed roadways, and pesticide spray locations. As fleets become equipped with automated logging capabilities, it also provides an opportunity to test fleet vehicles with connected and automated elements or pilot projects.

The County currently provides pesticide spray location information via an 800 phone number and a prerecorded message updated daily (during spraying season). With automated vehicle logs, that information could provide travelers with real-time location without requiring staff time to manually update the message and also allows for flexibility. If the maintenance vehicle needs to change course, travelers can still get accurate information.

Table 4 describes the maintenance and construction needs for Klamath County.

Table 4: Maintenance and Construction Needs

Need	Comments
HIGH Priority Needs	
Ability to automate vehicle maintenance logs	- Provides information for operational decisions and traveler information. - Automate logging the location and actions of maintenance vehicles such as snow plow vehicles, and pesticide sprayers. - Example logging may include vehicle location, amount of de-icer or sand used, whether plow was up or down, where pesticide was sprayed and amount, etc. - Tracking and archiving data for improving safety, efficiency. - Review the Region 5 pilot project. - Currently pesticide spray information is available through an 800 number. Could link this info to TripCheck through TTIP local entry tool
Ability to automate infrastructure maintenance logs (traffic signal controllers, street lights, cameras, VMS, etc)	- For traffic signals TransSuite can track logs if connected to the central system - ODOT uses Micromain for ITS equipment
MEDIUM Priority Needs	
Ability to automate the process for the public to document a signal timing complaint.	
Ability to automate the process for the agency to document the traffic signal mitigation in response to a public complaint.	
Ability to automate measurements for de-icing storage tanks.	
Ability to use software to optimize plow routes and resources.	
LOW Priority Needs	
Use predictive software to optimize maintenance during weather events	Predictive software works best in the mid-west where terrain is flat and weather is more predictable.

Emergency and Incident Management

Fast and reliable communication between incident responder agencies is essential to optimizing emergency and incident response. The highest priority need in this category is to connect the Klamath 9-1-1 facility with ODOT and OSP. Providing that connection will allow information about an incident and the real-time response to push

to ODOT and OSP. Deschutes County implemented a similar system and over the first two years they realized significant benefits: reduced incident response time by 30%, reduced incident duration by 38%, reduced dispatch response by 25%, and improved dispatch efficiency by 60%.² There is a funded project to complete the 9-1-1 CAD interconnect project.

Table 5 describes the emergency and incident management needs for Klamath County.

Table 5: Emergency and Incident Management Needs

Need	Comments
HIGH Priority Needs	
Ability to connect the 9-1-1 dispatch center with ODOT and OSP <i>Note – project is funded, but the Klamath 911 center needs to engage in the project</i>	• Successful prototype in Deschutes Co – lower incident response times, shortened duration of incidents, clearance reduction, shortened dispatch time, improved dispatch efficiency, reduced center-center phone calls by 60%. Other counties added. • Automatic calls to ODOT without dispatch having to do anything – CAD systems talk to each other and automatically pushes out the call.
Provide traveler information via portable VMS during events.	
Improve radio communications interoperability	
Ability to send and receive photos and video from an incident scene	
MEDIUM Priority Needs	
Ability to automate notification to responsible agency if infrastructure is damaged.	
Ability to automate notifications to responsible agency if a bridge is out or structurally unsound (key information for implementing detours).	
Ability to automate resource sharing and resource availability during emergencies and incident management.	
Improve communications during incident response efforts	• Note that Keno Fire Department currently uses Intterra Situational Awareness software
LOW Priority Needs	
none	

² Draft Technical Memorandum 9-1-1 CAD Interconnect Project Evaluation. Prepared by Kittelson and Associates. July 16, 2014

Data Management and Performance Measurement Needs

The needs in this area focus on automating the data sharing between agencies so that multiple agencies can benefit from the information. In Klamath County, data sharing between agencies is currently limited to methods such as phone calls or emails.

Table 6 describes the data management and performance measurement needs for Klamath County.

Table 6: Data Management and Performance Measurement Needs

Need	Comments
HIGH Priority Needs	
Ability to monitor the transportation system and data and share data with participating agencies (counts, video, etc.).	• Relates to data sharing and communications • May be CAV components
MEDIUM Priority Needs	
Ability for Klamath Falls and Klamath County to access to ODOT's central signal system (could be viewing rights only).	• This connection can currently be accomplished, no additional infrastructure is necessary
LOW Priority Needs	
none	

Public Transportation Management Needs

The majority of public transportation routes in Klamath County are in Klamath Falls, run by Basin Transit Services. The highest priority needs related to public transit involve better real-time information to transit riders about arrival times and route changes. The Basin Transit fleet is small enough that there is limited interest in investing in things like an electronic fare service or transit signal priority.

Table 7 describes the public transportation management needs for Klamath County.

Table 7: Public Transportation Management Needs

Need	Comments
HIGH Priority Needs	
Provide transit riders with real-time bus arrival information	
Provide transit riders with automated notifications if weather or other events affect transit routes	
Improve pedestrian crossings to reach bus stops	• See Table 1
Provide an updated website for Basin Transit	

MEDIUM Priority Needs	
Ability to create a statewide price agreement for transit related equipment (buses, fare systems, tracking software, GPS units, security cameras, etc.).	
Ability to automate a tracking system for data such as transit boardings.	• Helpful in prioritizing pedestrian improvements.
LOW Priority Needs	
Provide an electronic fare system	• High cost to benefit ratio
Ability to update transit equipment	
Improve transit progression through traffic signals	

Freight Management Needs

The roads throughout Klamath County are used heavily by freight vehicles. On several roadways, the percent of heavy vehicles is over 25%.³ The large amount of freight traffic can create parking shortages, especially when weather conditions close alternate routes. The needs for freight focus on needing to provide real-time parking availability information to freight drivers and route restrictions. In the City of Klamath Falls the need to reduce red light running for heavy vehicles was also identified as a high priority.

Table 8 describes the freight management needs for Klamath County.

Table 8: Freight Management Needs

Need	Comments
HIGH Priority Needs	
Reduce the likelihood of trucks running red lights through the Klamath Falls area (truck signal dilemma zone protection)	• At specific locations such as higher speed signals (Crater Lake Parkway)
Provide an automated method to alert truck drivers about restrictions along routes (width, height, weight, etc.).	
Provide real-time available parking information to truck drivers	
MEDIUM Priority Needs	
Ability to communicate Truck Route through town	
LOW Priority Needs	
Provide better loading/unloading coordination through downtown Klamath Falls.	• Trucks generally block a full lane or use the center turn lane for loading/unloading through downtown Klamath Falls. <i>Note that Main and Klamath being considered for one way traffic.</i>
Additional Weigh-In-Motion stations	

³ Klamath County ITS Project – Existing Conditions Memorandum. November 16, 2015.

STRENGTHS AND CHALLENGES

During the interviews and project meetings, the project team identified strengths and challenges that may affect ITS opportunities for Klamath County. The following two sections highlight key strengths and challenges.

Strengths

- Staff longevity and strong working relationships between agencies.
- Funding available for the 9-1-1 dispatch interconnect project.
- Low to moderate levels of congestion expected through 2033 projections.
- Completed Variable Speed Study for US 97 with recommendation for a weather responsive variable speed system.
- Several traffic signals already upgraded to 2070's.
- Some video detection is already in place.
- Current use of advanced situational software by Keno fire department.

Challenges

- Lack of existing communication infrastructure.
- Lack of reliable cellular coverage throughout the County.
- Lack of power connection options to remote equipment locations.
- Outdated and malfunctioning field equipment.
- Severe winter weather and mountainous terrain.
- Long stretches of roadway with no alternate route options.
- Funding challenges, particularly for on-going maintenance.

Appendix D: Signal Maintenance Agreement

TRAFFIC SIGNAL MAINTENANCE AGREEMENT
City of Klamath Falls

THIS AGREEMENT is made and entered into by and between the STATE OF OREGON, acting by and through its Department of Transportation, hereinafter referred to as "State;" and the CITY OF KLAMATH FALLS, acting by and through its elected officials, hereinafter referred to as "City," both herein referred to individually or collectively as "Party" or "Parties".

RECITALS

1. The Streets identified in Exhibit A are under the jurisdiction and control of the City. The roads identified on Exhibit B are part of the state highway system and under the jurisdiction and control of the Oregon Transportation Commission (OTC).
2. By the authority granted in Oregon Revised Statute (ORS) 190.110, 366.572 and 366.576, State may enter into cooperative agreements with counties, cities and units of local governments for the performance of work on certain types of improvement projects with the allocation of costs on terms and conditions mutually agreeable to the contracting parties.
3. By the authority granted in ORS 810.210, State is authorized to determine the character or type of traffic control devices to be used, and to place or erect them upon state highways at places where State deems necessary for the safe and expeditious control of traffic. No traffic control devices shall be erected, maintained, or operated upon any state highway by any authority other than State, except with its written approval. Traffic signal work on this Project will conform to the current State standards and specifications.
4. State and City have determined that it is both to their mutual benefit and to the general public's benefit if they jointly utilize State and City maintenance resources.
5. This Agreement will allow the city of Klamath Falls to utilize traffic timing software procured under ODOT contract.

NOW THEREFORE, the premises being in general as stated in the foregoing Recitals, it is agreed by and between the Parties hereto as follows:

TERMS OF AGREEMENT

1. This agreement supersedes all signal maintenance agreements previously entered into, if any there be, for the signals listed in Exhibits A and B. Said agreements shall terminate upon execution of this new agreement. Power costs for traffic signals not identified in Exhibits A and B of this Agreement shall survive the termination of any preceding Agreements.
2. Parties agree to enter into this Agreement for the purpose of the maintenance and

annual inspections of City and State owned traffic signals, hereinafter referred to as "Project". The approximate locations and the ownership or maintenance of the signals associated with the Project are approximate, as shown on the lists attached hereto, marked Exhibits A and B, and by this reference made a part hereof.

3. Parties agree that State shall provide maintenance and annual inspections as requested by City for the traffic signals listed on Exhibit A. Costs for the maintenance of these signals shall be the responsibility of the City.
4. Parties agree that City shall provide maintenance requested by State for the traffic signals listed in Exhibit B. Costs for the maintenance of these signals shall be the responsibility of the State.
5. The Parties hereto mutually agree to the maintenance response terms and conditions set forth in Exhibit C, attached hereto and by this reference made a part hereof
6. The project will be financed at an estimated total cost of \$150,000 in City and State funds. The estimate of the total Project cost is subject to change.
7. This Agreement shall become effective on the date all required signatures are obtained and shall remain in effect for the purpose of ongoing requested maintenance for the facilities listed in Exhibits A and B for a period of time not to exceed ten (10) years, unless extended by a fully executed amendment prior to termination of this Agreement. The City's responsibility to pay for power, for the facilities as specifically identified in Exhibit A, shall be ongoing throughout the term of this agreement.
8. Parties agree to meet every (5) years or as-needed for the duration of this Agreement to review the Project for re-negotiation and cost adjustments, as additional traffic signals are added to the local system, or if available funding is exhausted prior to termination date of this Agreement. Any changes to the terms or costs shall be added via a fully executed amendment to this Agreement.

CITY OBLIGATIONS

1. City shall be responsible for 100 percent of all power costs for the signals listed in Exhibit A.
2. City shall, upon receipt of an invoice from State, reimburse State for 100 percent of all costs attributable to requested maintenance and annual inspections performed on traffic signals identified in Exhibit A within 45 days of receipt of invoice. Materials shall be replaced by the benefited party with identical replacement parts within 30 days of a parts replacement request from the party performing the maintenance. City's obligation shall not exceed a total of \$75,000 for the duration of this agreement unless revised via a fully executed amendment to this agreement. Typical yearly maintenance charges are expected to be approximately \$15,000.

City of Klamath Falls/ODOT
Agreement No. 31165

3. City shall invoice State on a monthly basis for 100 percent of the costs associated with all requested maintenance performed on the traffic signals identified in Exhibit B and performed by City. All invoices shall be sent to the attention of the ODOT contact identified in this Agreement.
4. City shall be responsible for all utility locating information for signals listed in Exhibit A as requested by any third party and shall not hold State liable for failure to locate said facilities. All such utility location responsibilities shall be as per the Utility Notification Laws of the State of Oregon, ORS 757.551.
5. City hereby grants State the right to enter into and occupy City right of way for the performance of requested maintenance and annual inspections of the traffic signal equipment identified in Exhibit A, including vehicle detector loops.
6. City shall, at State's expense, perform all requested maintenance of the traffic signals listed in Exhibit B including, but not limited to:
 - a. Vehicle detector systems
 - b. Signal heads and lamps
 - c. Pedestrian heads and lamps
 - d. Signal control equipment.
7. City shall respond to State signal maintenance issues based on the priority of the signal. These categories are assigned to each signal and recorded in Exhibits A and B.
8. City may not modify signal timing without prior written approval of the State Region Traffic Engineer.
9. All employers, including City, that employ subject workers who work under this Agreement in the State of Oregon shall comply with ORS 656.017 and provide the required Workers' Compensation coverage unless such employers are exempt under ORS 656.126. Employers Liability insurance with coverage limits of not less than \$500,000 must be included. City shall ensure that each of its contractors complies with these requirements.
10. City certifies, at the time this Agreement is executed, that sufficient funds are available and authorized for expenditure to finance costs of this Agreement within City's current appropriations or limitation of the current annual budget.
11. City's Project Manager for this Project is Kelly Brennan, Maintenance Manager, 1190 S Spring St., Klamath Falls, OR 97601 or assigned designee upon individual's absence. City may replace the person acting as project manager upon written notice to State.

STATE OBLIGATIONS

1. State shall be responsible for 100 percent of all power costs for the signals listed in

City of Klamath Falls/ODOT
Agreement No. 31165

Exhibit B

2. State shall, upon receipt of an invoice from City, reimburse City for 100 percent of all costs attributable to requested maintenance performed on traffic signals identified in Exhibit B within 45 days of receipt of invoice. Materials shall be replaced by the benefited party with identical replacement parts within 30 days of a parts replacement request from the party performing the maintenance. States' obligation shall not exceed a total of \$75,000 for the duration of this agreement unless revised via a fully executed amendment to this agreement.
3. State shall invoice City on a monthly basis for 100 percent of all maintenance provided in the traffic signals identified in Exhibit A and performed by ODOT. All invoices shall be sent to the attention of the City contact identified in this Agreement.
4. State shall be responsible for a utility locating information for signals listed in Exhibit B as requested by any third party and shall not hold City liable for failure to locate said facilities. All such utility location responsibilities shall be as per the Utility Notification Laws of the State of Oregon, ORS 757.551.
5. State grants City the right to enter onto State right of way for the performance of duties as set forth in this Agreement.
6. State shall, at City's expense, perform all requested maintenance of the traffic signals listed in Exhibit A including, but not limited to:
 - a. Vehicle detector systems
 - b. Signal heads and lamps
 - c. Pedestrian heads and lamps
 - d. Signal control equipment
 - e. Communications and Intelligent Traffic Systems (ITS) infrastructure
 - f. Timing established for the operation of the traffic signals
7. State shall retain the right to review the traffic signal timing and to require City to make timing adjustments when needed.
8. State shall respond to City signal maintenance issues based on the priority of the signal. These categories are assigned to each signal and recorded in Exhibits A and B.
9. State shall perform and invoice City for the annual inspection of all signals listed in Exhibit A. This inspection shall be to department standards established by Traffic Signal Services Unit. A copy of the results of this inspection will be provided to City.
10. State certifies, at the time this Agreement is executed, that sufficient funds are available and authorized for expenditure to finance costs of this Agreement within State's current appropriations or limitation of the current biennial budget.
11. State's Project Manager for this Project is David Hirsch, Region 4 Traffic Signals Coordinator, 53066 N. Hwy 97, Bend, OR 97701, 541-3886472

City of Klamath Falls/ODOT
Agreement No. 31165

david.hirsch@odot.state.or.us or assigned designee upon individual's absence.
State may replace the person acting as project manager upon written notice to the City.

GENERAL PROVISIONS

1. State may terminate this Agreement effective upon delivery of written notice to City, or at such later date as may be established by State, under any of the following conditions:
 - a. If City fails to provide services called for by this Agreement within the time specified herein or any extension thereof.
 - b. If City fails to perform any of the other provisions of this Agreement, or so fails to pursue the work as to endanger performance of this Agreement in accordance with its terms, and after receipt of written notice from State fails to correct such failures within ten (10) days or such longer period as State may authorize.
 - c. If City fails to provide payment of its share of the cost of the Agreement.
 - d. If State fails to receive funding, appropriations, limitations or other expenditure authority sufficient to allow State, in the exercise of its reasonable administrative discretion, to continue to make payments for performance of this Agreement.
 - e. If federal or state laws, regulations or guidelines are modified or interpreted in such a way that either the work under this Agreement is prohibited or State is prohibited from paying for such work from the planned funding source.
2. City may terminate this Agreement effective upon delivery of written notice to State, or at such later date as may be established by City, under any of the following conditions:
 - a. If State fails to provide services called for by this Agreement within the time specified herein or any extension thereof.
 - b. If State fails to provide payment of its share of the cost of the Agreement.
 - c. If City fails to receive funding, appropriations, limitations or other expenditure authority sufficient to allow City, in the exercise of its reasonable administrative discretion, to continue to make payments for performance of this Agreement.
 - d. If federal or state laws, regulations or guidelines are modified or interpreted in such a way that either the work under this Agreement is prohibited or City is prohibited from paying for such work from the

planned funding source.

3. Any termination of this Agreement shall not prejudice any rights or obligations accrued to the parties prior to termination.
4. Both Parties shall comply with all federal, state, and local laws, regulations, executive orders and ordinances applicable to the work under this Agreement, including, without limitation, the provisions of ORS 279B.220, 279B.225, 279B.230, 279B.235 and 279B.270 incorporated herein by reference and made a part hereof. Without limiting the generality of the foregoing, Both Parties expressly agrees to comply with (i) Title VI of Civil Rights Act of 1964; (ii) Title V and Section 504 of the Rehabilitation Act of 1973; (iii) the Americans with Disabilities Act of 1990 and ORS 659A.142; (iv) all regulations and administrative rules established pursuant to the foregoing laws; and (v) all other applicable requirements of federal and state civil rights and rehabilitation statutes, rules and regulations.
5. If any third party makes any claim or brings any action, suit or proceeding alleging a tort as now or hereafter defined in ORS 30.260 ("Third Party Claim") against State or City with respect to which the other Party may have liability, the notified Party must promptly notify the other Party in writing of the Third Party Claim and deliver to the other Party a copy of the claim, process, and all legal pleadings with respect to the Third Party Claim. Each Party is entitled to participate in the defense of a Third Party Claim, and to defend a Third Party Claim with counsel of its own choosing. Receipt by a Party of the notice and copies required in this paragraph and meaningful opportunity for the Party to participate in the investigation, defense and settlement of the Third Party Claim with counsel of its own choosing are conditions precedent to that Party's liability with respect to the Third Party Claim.
6. With respect to a Third Party Claim for which the State is jointly liable with City (or would be if joined in the Third Party Claim), State shall contribute to the amount of expenses (including attorneys' fees), judgments, fines and amounts paid in settlement actually and reasonably incurred and paid or payable by City in such proportion as is appropriate to reflect the relative fault of State on the one hand and of City on the other hand in connection with the events which resulted in such expenses, judgments, fines or settlement amounts, as well as any other relevant equitable considerations. The relative fault of State on the one hand and of City on the other hand shall be determined by reference to, among other things, the Parties' relative intent, knowledge, access to information and opportunity to correct or prevent the circumstances resulting in such expenses, judgments, fines or settlement amounts. State's contribution amount in any instance is capped to the same extent it would have been capped under Oregon law, including the Oregon Tort Claims Act, ORS 30.260 to 30.300, if State had sole liability in the proceeding.
7. With respect to a Third Party Claim for which City is jointly liable with State (or would be if joined in the Third Party Claim), City shall contribute to the amount of expenses (including attorneys' fees), judgments, fines and amounts paid in settlement actually and reasonably incurred and paid or payable by State in such proportion as is

City of Klamath Falls/ODOT
Agreement No. 31165

appropriate to reflect the relative fault of City on the one hand and of State on the other hand in connection with the events which resulted in such expenses, judgments, fines or settlement amounts, as well as any other relevant equitable considerations. The relative fault of City on the one hand and of State on the other hand shall be determined by reference to, among other things, the Parties' relative intent, knowledge, access to information and opportunity to correct or prevent the circumstances resulting in such expenses, judgments, fines or settlement amounts. City's contribution amount in any instance is capped to the same extent it would have been capped under Oregon law, including the Oregon Tort Claims Act, ORS 30.260 to 30.300, if it had sole liability in the proceeding.

8. The Parties shall attempt in good faith to resolve any dispute arising out of this Agreement. In addition, the Parties may agree to utilize a jointly selected mediator or arbitrator (for non-binding arbitration) to resolve the dispute short of litigation.
9. This Agreement may be executed in several counterparts (facsimile or otherwise) all of which when taken together shall constitute one agreement binding on all Parties, notwithstanding that all Parties are not signatories to the same counterpart. Each copy of this Agreement so executed shall constitute an original.
10. This Agreement and attached exhibits constitute the entire agreement between the Parties on the subject matter hereof. There are no understandings, agreements, or representations, oral or written, not specified herein regarding this Agreement. No waiver, consent, modification, or change of terms of this Agreement shall bind either Party unless in writing and signed by both Parties and all necessary approvals have been obtained. Such waiver, consent, modification, or change, if made, shall be effective only in the specific instance and for the specific purpose given. The failure of State to enforce any provision of this Agreement shall not constitute a waiver by State of that or any other provision.

THE PARTIES, by execution of this Agreement, hereby acknowledge that their signing representatives have read this Agreement, understand it, and agree to be bound by its terms and conditions

City of Klamath Falls/ODOT
Agreement No. 31165

CITY OF KLAMATH FALLS, by and through
its elected officials

By [Signature]
City Manager

Date 6-22-16

STATE OF OREGON, by and through
its Department of Transportation

By _____
Region 4 Manager

Date _____

APPROVED AS TO LEGAL SUFFICIENCY

By [Signature]
Council Counsel

Date 6-22-16

APPROVAL RECOMMENDED

By _____
State Traffic Engineer

Date _____

By [Signature]
Region 4 Maintenance and Operations
Manager

Date 6-23-16

City Contact

Kelly Brennan - Maintenance Manager
1190 S Spring St.
Klamath Falls, OR 97601

State Contact

David Hirsch - Region 4 Traffic Signals
Coordinator
53066 N. Hwy 97
Bend, OR 97701

APPROVED AS TO LEGAL
SUFFICIENCY

By Mark Schumock
Assistant Attorney General

Date 03/02/16

EXHIBIT A

CITY OF KLAMATH FALLS SIGNALS MAINTAINED BY STATE				
NO	SIGNAL ID	LOCATION	STATUS	PRIORITY
1	11004	Campus Way @ Dahlia St	Existing	3
2	11005	S 6 th St @ Avalon St	Existing	2
3	11006	S 6 th St @ Main St	Existing	2
4	11007	S 6 th St @ Washburn Way	Existing	1
5	11008	S 6 th St @ Austin St	Existing	1
6	11015	S 6 th St @ Shasta Way	Existing	2
7	11030	Washburn Way @ Shasta Way	Existing	1
8	11031	Washburn Way @ Crosby Ave	Existing	1
9	11032	Washburn Way @ Hilyard Ave	Existing	1
10	11033	Washburn Way @ Laverne Ave	Existing	1
11	11036	Washburn Way @ OC&E Trail – PED SIGNAL	Existing	3
12	11056	Shasta Way @ Avalon St	Existing	2
13	11213	Washburn Way @ Onyx Ave	Existing	1

EXHIBIT B

STATE SIGNALS MAINTAINED BY CITY OF KLAMATH FALLS				
NO	SIGNAL ID	LOCATION	STATUS	PRIORITY
1	11001	Crater Lake Pkwy (OR39) @ Campus Dr	Existing	1
2	11002	Crater Lake Pkwy (OR39) @ Esplanade Ave	Existing	1
3	11003	Crater Lake Pkwy (OR39) @ Washburn Way	Existing	1
4	11009	S 6 th St @ Altamont Dr	Existing	2
5	11010	S 6 th St @ Crest St	Existing	2
6	11011	S 6 th St @ Summers Ln	Existing	1
7	11012	S 6 th St @ Crater lake Pkwy (OR39)	Existing	1
8	11013	S 6 th St (OR39) @ Hope St	Existing	1
9	11014	S 6 th St (OR39) @ Homedale Rd	Existing	1
10	11017	S 6 th St (OR39) @ Malin St	Existing	1
11	11018	S 6 th St (OR39) @ Seaside St - FIRE	Existing	1
12	11020	S 6 th St (OR39) @ Patterson St	Existing	1
13	11021	S 6 th St (OR39) @ Home Depot	Existing	1
14	11022	S 6 th St (OR39) @ Malin Jct (OR140)	Existing	1
15	11024	Crater Lake Pkwy (OR39) @ Portland St - PHB	Existing	2
16	11025	Crater Lake Pkwy (OR39) @ Shasta Way	Existing	1
17	11026	Crater Lake Pkwy (OR39) @ Main St	Existing	1
18	11035	Falls Hwy (OR140) @ Greensprings D (OR66)	Existing	2
19	11038	Southside Expy (OR 140) @ Washburn Way	Existing	2

EXHIBIT c

A. Categories shall be assigned to each signal listed on Exhibits A and B. These categories are:

1. (HIGHEST LEVEL OF RESPONSE) Intersections operating at Level of Service (LOS) F when in flash condition during the 9th highest hour of the day. This condition requires a high priority response to a trouble call.
2. (INTERMEDIATE LEVEL OF RESPONSE) Intersections operating at LOS F when in flash condition during the peak traffic hour but not during the 8th highest hour of the day. This condition requires a response to a trouble call before the next known rush hour.
3. (LOWEST LEVEL OF RESPONSE) Typically remote location intersections operating at LOS E or better in flash condition during the peak traffic hour of the day. Response to a trouble call will be made before the end of the next regular work shift.

B. ODOT and City agree to the following definition:

EMERGENCY: When the situation seriously impedes the flow of traffic or a serious hazard to the public exists. Listed below are some examples which should be classified as emergency situations. These are high priority responses and are responded to as quickly as circumstances allow. The list shown below is not meant to be all-inclusive, and other situations may arise which could be classified as emergency:

- Traffic signal knock down (poles, cabinet, etc.)
- All signal indications are out (excluding power outages)
- Category 1 intersections on flash

NON-EMERGENCY: When the situation has little or no effect on traffic and does not appear to pose a serious problem to the public as determined by Region 4 Traffic Manager. These are regular work priority responses and are responded to as resources are available. Listed below are some examples which should be classified as non-emergency situation. The list shown is not meant to be all-inclusive, and other situations may arise which may be classified as non-emergency:

- A single Indicator of a dual indication movement burned out
- Damaged signal hardware (intersection still functioning)
- Stuck pedestrian push button
- Malfunctioning vehicle detector

Response times to signal modifications or major reconstruction will be agreed upon between ODOT and City for each project requested.