KITTELSON & ASSOCIATES
610 SW ALDER STREET, SUITE 700
PORTLAND, OR 97205
P 503.228.5230 F 503.273.8169

MEMORANDUM #2

Date: February 24, 2017 Project #: 20651

To: Dayna Webb, P.E.
Public Works Department
City of Oregon City
625 Center Street
Oregon City, Oregon 97045

From: Susan Wright, P.E. and Kristine Connolly

Project: Highway 213 & Beavercreek Road Alternative Mobility Targets (PS 16-024)

Subject: Alternative Mobility Target Methodology and Feasible Improvements

Oregon City's 2013 Transportation System Plan (TSP) determined that the Highway 213 (OR213) corridor from Redland to Molalla Avenue (including the intersection of Beavercreek Road) will exceed the current mobility target in 2035, resulting in more congestion than is allowed. The TSP recommended a project be conducted to identify what improvements may be necessary to meet the current target or whether an alternative mobility target is necessary. Potential improvements for the intersection of Beavercreek Road and Highway 213 were presented to the Technical Advisory Group (TAG) and Community Advisory Group (CAG) in December 2016 and January 2017, respectively. The feasibility of these alternatives is still under review; however, it is likely that none of the alternatives will be found to be cost-feasible in the near-term and although portions of the improvements may be implemented, an alternative mobility target will be necessary. This memorandum provides a menu of potential measures that could be used for establishing an alternative mobility target, reasonable target ranges, and a list of potentially feasible improvements to increase capacity and safety in the corridor. If mobility cannot be achieved, these measures and improvements will be reviewed and discussed with the TAG and CAG to select a target methodology and appropriate range, as well as recommend improvements.

POLICY CONTEXT

Mobility targets are the measure by which the state assesses the existing or forecasted operational conditions of a facility. As such, they are a key component the Oregon Department of Transportation (ODOT) uses to determine the need for, or feasibility of providing highway, or other transportation system improvements. They impact local land use and transportation planning as well as development review. Recent years have seen notable changes to Oregon's transportation planning and land use policies and requirements. These changes reflect statewide policy to support transportation solutions that encourage economic development, contribute to public health, offer multi-modal choices for all users, and reflect the uncertain fiscal realities and limited transportation funding.

Oregon's Transportation Planning Rule (TPR)

Mobility targets for state highways, as established in this policy or as otherwise adopted by the Oregon Transportation Commission (OTC) as alternative mobility targets, are considered the highway system performance standards in compliance with the Transportation Planning Rule (TPR) (OAR 660-012), including applicability for actions that fall under Section -0060 of the TPR.

The TPR Section -0060 applies when cities or counties are considering zone changes or plan amendments that would allow for additional development that would significantly impact or worsen the performance of existing or planned transportation facilities. Currently, significant impacts are found to exist when levels of automobile traffic cause roadway facilities to exceed motorized vehicle standards, such as mobility targets. If there is a significant impact, jurisdictions are required to *"ensure that allowed land uses are consistent with the identified function, capacity, and performance standards of the facility measured at the end of the planning period identified in the adopted Transportation System Plan."*

EXISTING PERFORMANCE MEASURE AND TARGET

Mobility, or congestion, may be measured and regulated in a variety of ways. In the context of this project, mobility performance measures are methods to objectively measure the transportation system, such as travel time, or reliability. Mobility targets describe an acknowledged acceptable level of performance for a measure, such as a certain level of congestion.

The existing mobility target for the OR213/Beavercreek Road intersection set forth in the Oregon Highway Plan (OHP) and the 2013 TSP is based on volume-to-capacity Ratio (v/c). The v/c ratio is a measure that reflects mobility and quality of travel. It compares roadway demand (vehicle volumes) with roadway supply (carrying capacity). For example, a v/c of 1.00 indicates the roadway facility is operating at its capacity. An intersection can have an overall v/c ration of 1.00 yet have v/c ratios greater than 1.00 for individual movements where it may take more than one signal cycle to get through the intersection and queues build up. The following mobility target is set forth in the 2013 TSP for the OR213/Beavercreek Road intersection:

- During the highest one-hour period of the day, a maximum volume-to-capacity (v/c) ratio of 0.99 shall be maintained.

The Synchro model (a traffic model used to evaluate v/c ratios and other metrics) analysis completed for the 2013 TSP shows the intersection operating with an intersection v/c ratio of 0.83 for the p.m. peak hour under 2011 existing conditions. The TSP analysis also indicates that by 2035, without improvement, the intersection will function beyond the current mobility target. Under 2035 Planned

System Conditions (which includes planned, but potentially unfunded, roadway improvements), the intersection is expected to operate with a v/c ratio of 1.05, exceeding the existing mobility target (a maximum v/c ratio of 0.99). Under 2016 traffic volumes, the intersection operates with a v/c ratio of 0.97, just below the existing mobility target. The southbound left-turn and eastbound left-turn movements exhibit higher than average v/c ratios, while the westbound left-turn and northbound left-turn movements exhibit lower than average v/c ratios.

Table 1 – OR213/Beavercreek Road Intersection Operations

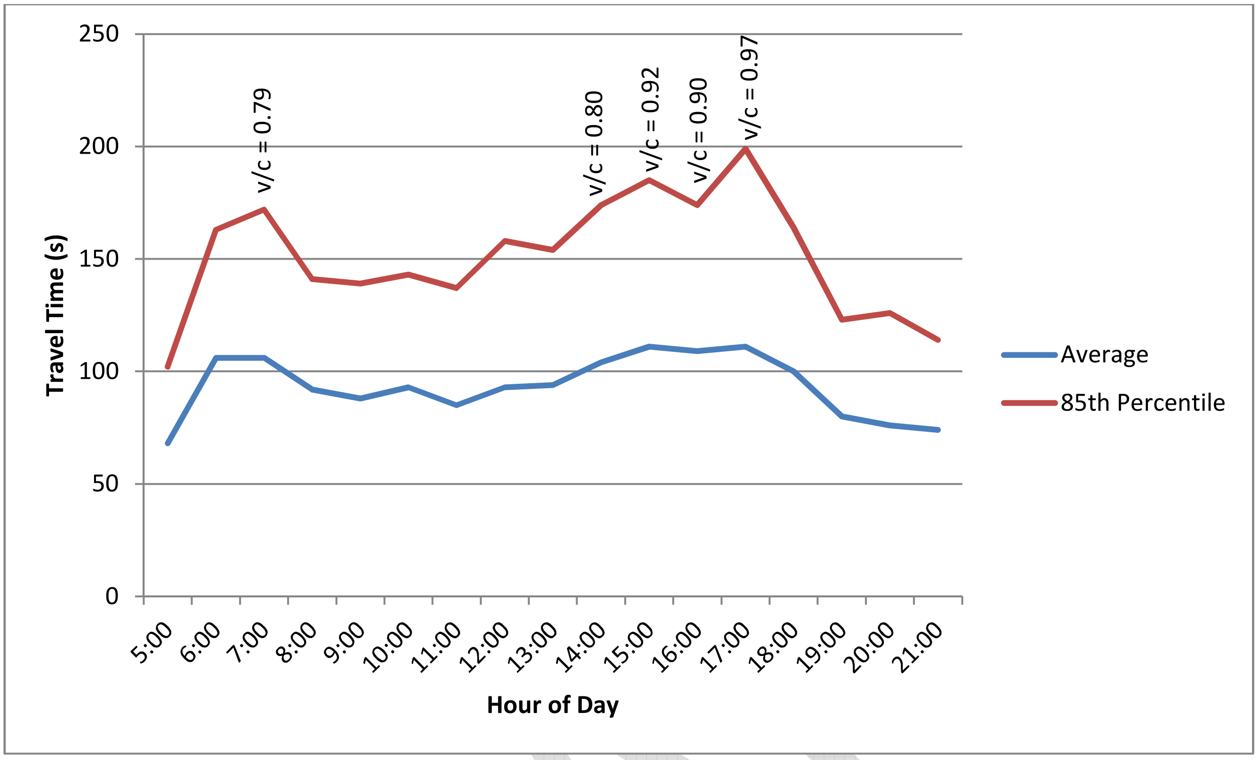
Year	PM Peak Volume-to-Capacity Ratio (v/c)
2011 (2013 TSP Existing Conditions)	0.83
2016 Traffic Volumes	0.97
2035 (2013 TSP Forecast)	1.05

Peak Hours

A travel time study was conducted at the OR213/Beavercreek Road intersection in January 2017 to evaluate the variability of traffic conditions throughout the day. This study utilized BlueTooth data collection units (BlueMAC) at each leg of the intersection to identify the travel speed and travel time for each movement (northbound left, northbound through, northbound right, etc.) separately[1]. The data was collected 24-hours per day for 7 days, allowing comparison of results by time of day and day of week. Attachment "A" provides the differences in travel time by time of day for each movement at the intersection. The data in Attachment "A" reflects typical weekday conditions (Tuesday, Wednesday, and Thursday). Exhibit 1 shows the travel time through the intersection averaged for all movements. Note that the graph provides the average travel time to traverse the intersection; some movements may experience higher travel times. The weekday PM peak hour represents the highest travel times of the day, with higher than average travel times extending from 3:00 to 6:00 PM. Above average travel times also occur during weekday midday and AM peak hours. There are approximately 5 hours per day currently experiencing high travel times compared to the rest of the day which could indicate congestion and possible cycle failure for some movements. This can be considered in evaluating the potential performances measures in the following section.

[1] Data was collected at a distance of approximately 1000' from the intersection on each leg, with the exception of the north leg, where data was collected approximately 2000' from the intersection.

Exhibit 1 –Travel Time through OR213/Beavercreek Road Intersection



The cycle length of the traffic signal at the OR213/Beavercreek intersection is approximately 120 seconds. Exhibit 1 shows that during the a.m. and p.m. peak hour periods, the average time it takes to traverse the intersection is 110 seconds. Average travel time and v/c ratio are not directly linked; however, the average travel times increase and decrease with v/c ratio. Table 2 provides volume-to-capacity ratios for the five highest volume hours of the day. These v/c ratios are noted on Exhibit 1 during their corresponding hour.

Table 2 – 2016 Existing Intersection Operations for the Five Highest Volume Hours (OR213/Beavercreek Road)

Highest Hour	Time of Day	Total Entering Volume	V/C
1st	5-6 PM	6059	0.97
2nd	4-5 PM	5858	0.90
3rd	3-4 PM	5623	0.92
4th	2-3 PM	4972	0.80
5th	7-8 AM	4619	1.04[2]

[2] The v/c ratio for the AM peak hour is 1.04 due the high volume of westbound right-turns. If the westbound right-turns are excluded the intersection v/c is 0.79. This is under further review.

Oregon Highway Plan Policy 1F

The Oregon Highway Plan (OHP) defines polices and investment strategies for Oregon's state highway system for the next 20 years. The OHP gives policy and investment direction to corridor plans and transportation system plans that are being prepared around the state, but it leaves the responsibility for identifying specific projects and modal alternatives to those plans.

The OHP Policy 1F establishes mobility targets (as defined by motorized vehicle volume-to-capacity ratios) for state facilities that vary by region, facility classification, and whether or not the roadway is located inside an urban growth boundary (UGB). It states, *"It is the policy of the State of Oregon to maintain acceptable and reliable levels of mobility on the state highway system, consistent with expectation for each facility type, location and functional objectives. Highway mobility targets will be the initial tool to identify deficiencies and consider solutions for vehicular mobility on the state system. Specifically, mobility targets shall be used for:*

- *Identifying state highway mobility performance expectations for planning and plan implementation;*
- *Evaluating the impacts on state highways of amendments to transportation plans, acknowledged comprehensive plans and land use regulations pursuant to the Transportation Planning Rule (OAR 660-12-0060); and*
- *Guiding operations decisions such as managing access and traffic control systems to maintain acceptable highway performance."*

The OHP Policy 1F allows for development of alternative mobility targets in areas where it is "infeasible or impractical to meet the mobility targets". The policy allows for the use of alternative mobility targets to *"balance overall transportation system efficiency with multiple objectives of the area being addressed."* It requires that targets *"shall be clear and objective and shall provide standardized procedures to ensure consistent application of the selected measure. The alternative mobility target(s) shall be adopted by the Oregon Transportation Commission as an amendment to the OHP."* The OHP currently includes alternative mobility targets in many locations throughout the State; however, none have been adopted within the Portland Metro area to date.

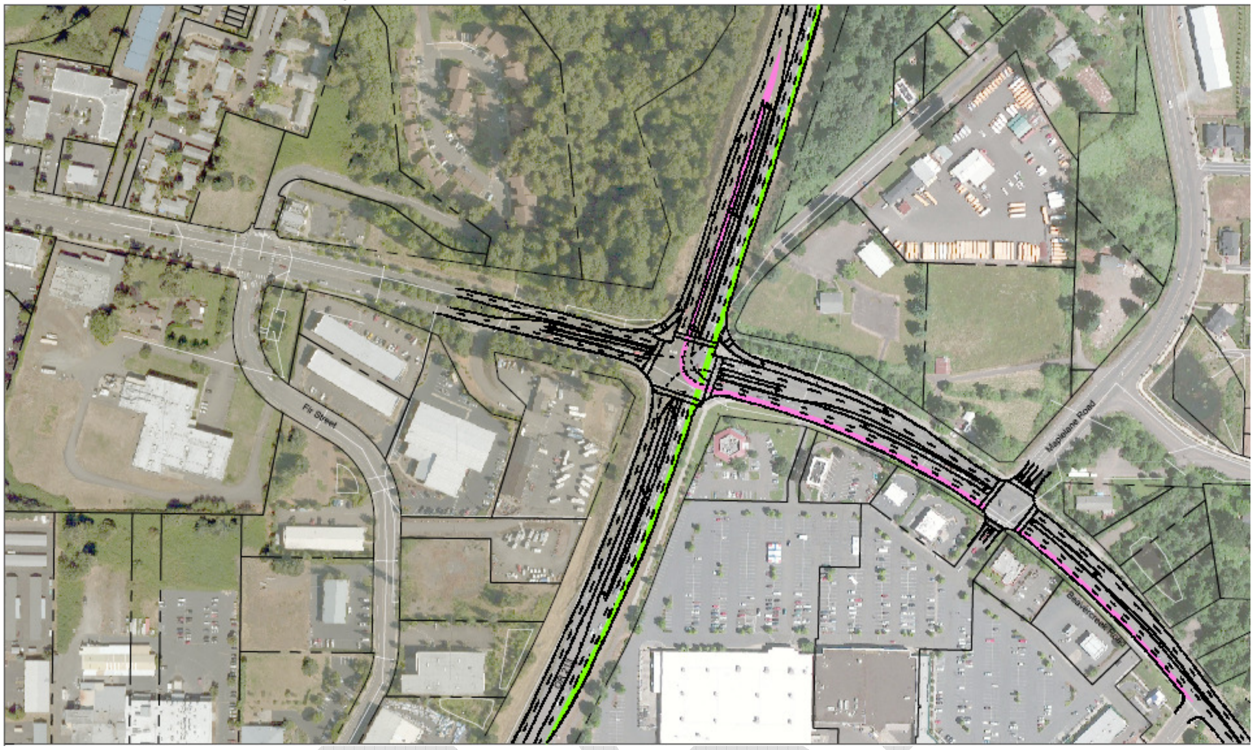
MAJOR IMPROVEMENT ALTERNATIVES (MEMORANDUM #1)

The following alternatives from Technical Memorandum #1 are still under review to determine physical and financial feasibility. This additional work will discussed at the next set of advisory committee meetings. Table 5 lists these alternatives, as well as their relative benefits, constraints, opportunities, and risks.

Alternative 1: Triple Left-Turns

Add a third southbound left-turn lane and a third northbound through lane through the intersection while continuing to maintain a separate northbound right-turn lane (not reflected in Exhibit 2). This is projected to operate at a v/c ratio of 0.90 in the 2035 TSP horizon year. A conceptual sketch of Alternative 1 can be seen in Exhibit 2.

Exhibit 2 – Alternative 1: Triple Left-Turns

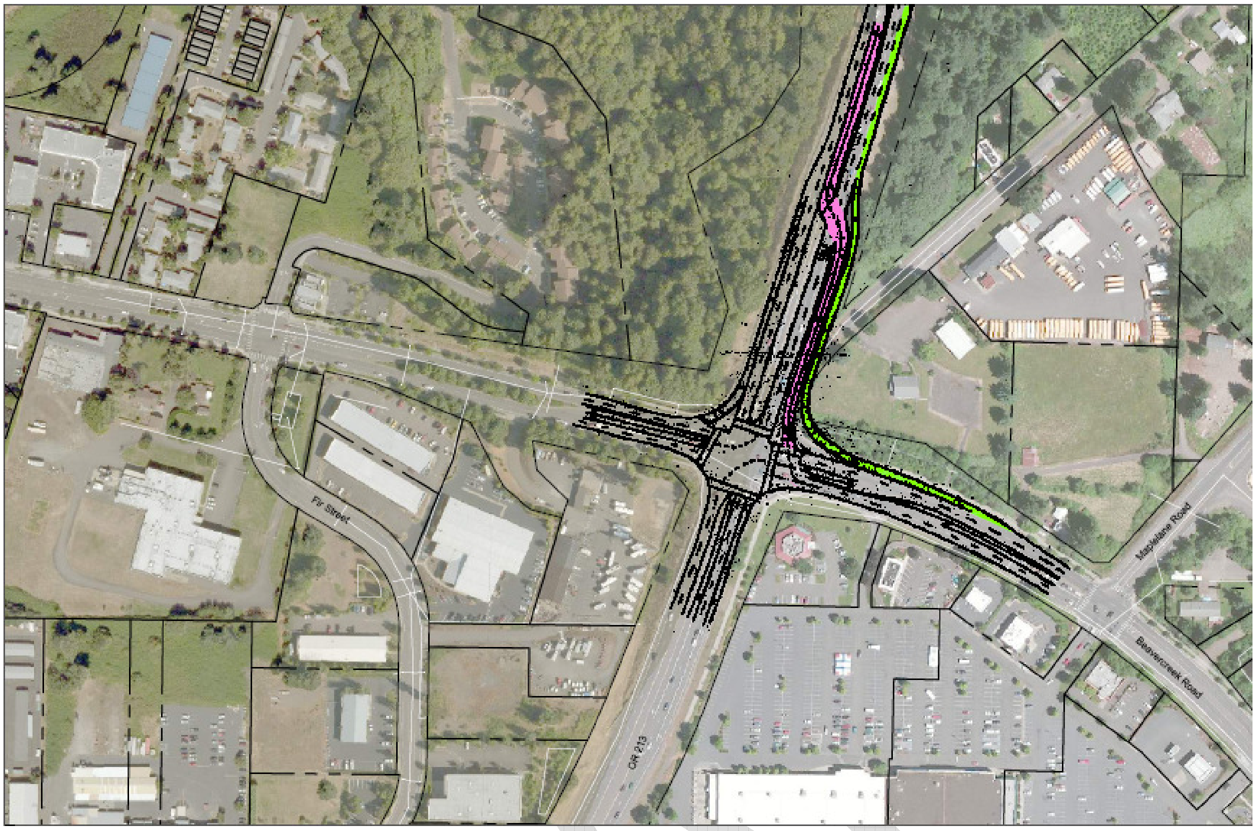


Alternative 3: Displaced Southbound Left-Turns

Construct a southbound displaced left-turn[3] (or continuous flow) intersection. Displaced left-turns reduce the number of signal phases and conflict points at the intersection, thereby improving capacity and safety, but require coordinated partial signals on the approaches with displaced left-turns. Alternative 3 likely includes impacts to the culvert and retaining walls in the northeast corner of the intersection. A conceptual sketch of Alternative 3 can be seen in Exhibit 3.

[3] Steyn, H., Z. Bugg, B. Ray, and A. Daleiden. *Displaced Left-Turn Informational Guide.* FHWA, Washington, D.C., 2014. http://safety.fhwa.dot.gov/intersection/alter_design/pdf/fhwasa14068_dlt_infoguide.pdf

Exhibit 3 – Alternative 3: Displaced Southbound Left-Turns



Alternatives 5 and 7

A project to construct an interchange at this location was removed from the 2013 TSP Update. The interchange was eliminated due to livability, multi-modal access and funding constraints within the 2035 planning horizon. Additionally, at the request of ODOT as it was determined to be financially infeasible given other regional priorities. Conceptual sketches of Alternatives 5 and 7 can be seen in Exhibits 4 and 5, respectively.

Exhibit 4 – Full Diamond Interchange

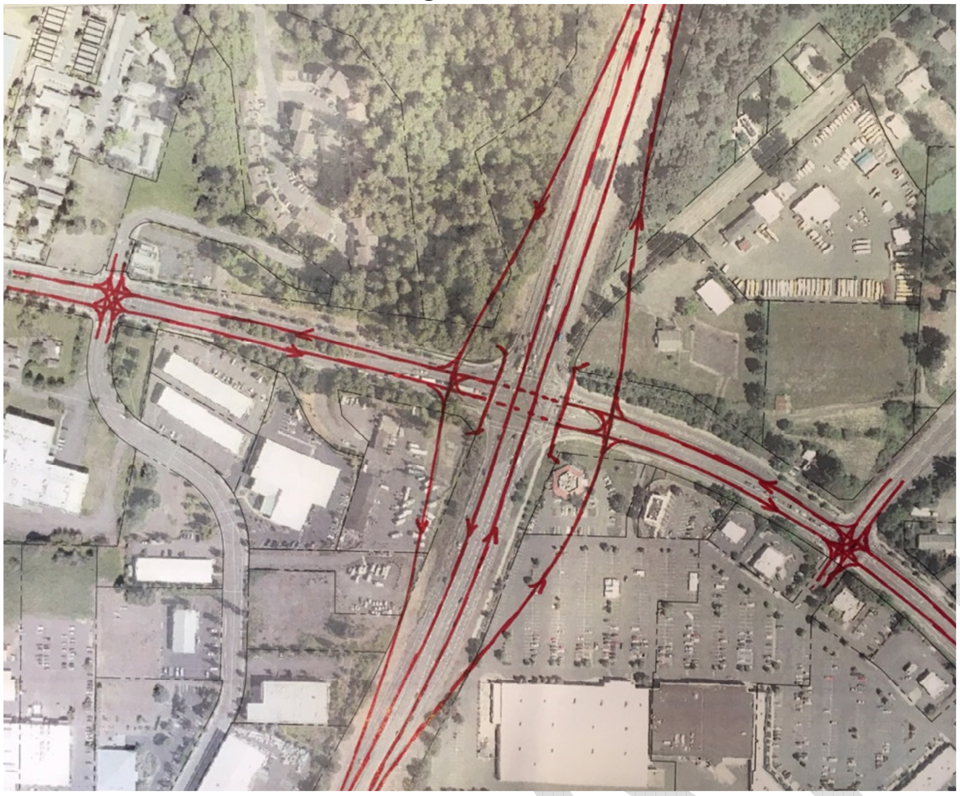


Exhibit 5 – Single Point Interchange

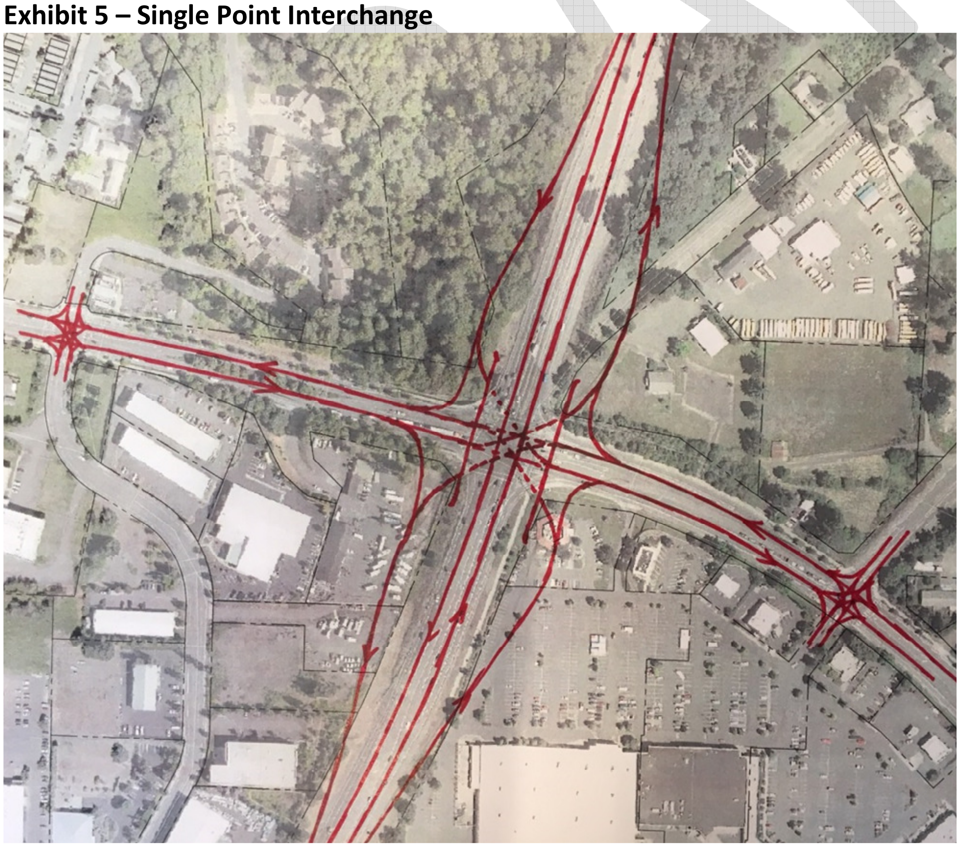


Table 3 – Intersection Alternatives Considered

Alternative	Benefits	Opportunities	Constraints	Risks
Alternative 1: Triple Left-Turns	Meets current mobility target in 2035	North and east legs of intersection	Cost; vehicle navigation of three left-turn lanes	Increase sideswipe crashes through turn and downstream weave
Alternative 3: Displaced Southbound Left Turns	Meets current mobility target in 2035	North leg of intersection	Cost; impact to existing culvert and retaining walls	Driver confusion with uncommon intersection type
Alternative 5: Full Diamond Interchange	Meets current mobility target in 2035; greatly increases capacity for through traffic on OR213	All approaches of the intersection	Cost; right-of-way	Increased intersection exposure (i.e., two large ramp terminals) for pedestrians and bicyclists
Alternative 7: Single-Point Interchange	Meets current mobility target in 2035; greatly increases capacity for through traffic on OR213	All approaches of the intersection	Cost; right-of-way	

POTENTIAL PERFORMANCE MEASURES

The OR213/Beavercreek Road intersection is currently experiencing deficiencies in capacity and safety for vehicular modes of travel. Mobility is currently measured by using v/c to measure the average level of congestion for motorists entering all legs of an intersection. With this project, we will explore the menu of options available to measure congestion both at an intersection and along the Highway 213 corridor, from Redland Road to Molalla Avenue. While it is important that the intersection be complete and accessible by all modes, the potential performance measures set forth in this memorandum primarily address vehicle mobility. Table 3 provides a menu of potential alternative mobility measures and reasonable target ranges which can be used in development review. The menu was developed based on a performance measure literature review of published engineering manuals, rating systems, and academic sources conducted by Kittelson & Associates, Inc.

Table 4 – Potential Performance Measures and Alternative Mobility Target Ranges

Measure	Definition	Potential Target	Ease of Application
Mobility			
Volume to Capacity (v/c) Ratio	This is the current performance measure, measured as an average of all potential movements through an intersection. V/C ratio is a measure that reflects mobility and quality of travel. It compares roadway demand (vehicle volumes) with roadway supply (carrying capacity). For example, a v/c of 1.00 indicates the roadway facility is operating at capacity. *Existing and Forecast v/c ratios:* Year 2011: 0.83 Year 2016: 0.97 Year 2035: 1.05	Maintain current target of 0.99, but allow intersection to exceed this ratio for no more than a specified number of hours per day. OR Increase current target to a higher ratio, such as 1.1, not to be exceeded during the peak hour of the day.	Could be applied with existing analysis tools used in Traffic Impact Studies. May require additional hours of traffic count data collection.
Intersection Delay	The average total vehicle delay of all movements through an intersection. Vehicle delay is a method of quantifying several intangible factors, including driver discomfort, frustration, and lost travel time. *Existing and Forecast Intersection Delay:* 2011: 40.7s 2016: 56.8s 2035: 73.4s	Average intersection delay shall not exceed "X" seconds during the peak hour of the day. OR Average intersection delay shall not exceed "X" seconds for more than a specified number of hours per day.	Could be applied with existing analysis tools used in Traffic Impact Studies. May require additional hours of traffic count data collection.
Intersection Level of Service (LOS)	A quantitative stratification on an A through F scale that represents a traveler's perceptions of quality of service by a facility. For autos, level of service is based on the average delay. *Existing and Forecast Intersection LOS:* 2011: D 2016: E 2035: E	Maintain overall intersection LOS of "X" or better during the peak hour of the day. Individual movements may exceed this LOS. OR Maintain overall intersection LOS of "X" or better for more than a specified number of hours per day.	Could be applied with existing analysis tools used in Traffic Impact Studies. May require additional hours of traffic count data collection.
Critical Movement Delay	A measure of delay at an intersection for the critical movement. *Existing and Forecast Critical Movement Delay:* 2011: EBL 60s 2016: EBL 112s 2035: EBL 123s	Critical movements (southbound left turn, northbound through, eastbound left turn and westbound through) may not exceed a delay of "X" seconds per vehicle during the peak hour of the day. OR Critical movement delay may not exceed "X" seconds per vehicle for more than a specified number of hours per day.	Could be applied with existing analysis tools used in Traffic Impact Studies. May require additional hours of traffic count data collection.

Average Travel Time	A measure of the time it takes, on average, for a vehicle to navigate the intersection, including queued time for red light or congestion.	Average travel time through the intersection or corridor may not exceed "X" minutes for any movement. OR Average travel time through the intersection or corridor may not exceed "X" minutes for any movement for more than a specified number of hours per day.	Would require travel time data collection and additional tools to predict future travel time.
Travel Time Reliability	Travel time reliability measures the variability in the expected travel time vs. the actual travel time experienced due to demand fluctuations, traffic control devices, traffic incidents, weather, work zones, and physical capacity. ▪ Buffer Index – compares the 95th percentile travel time to the average travel time. 95th percentile travel time is the time you would plan for your trip in order to be on-time 95% of the time. A buffer index of 45% means the 95th percentile travel time is 45% longer than the average travel time and you must plan 45% more time for your trip to be on time 95% of the time. ▪ Planning Time Index –compares the 95th percentile travel time to the free flow travel time. For example, 2.25 means the 95th percentile travel time is 2.25 times as long as when conditions are free-flowing. Can be measured by comparing peak hour travel time to off-peak travel time through the intersection.	Buffer Index shall not exceed "X"%. OR Planning Time Index shall not exceed "X".	Would require travel time data collection and use of Dynamic Travel Assignment model to predict future travel time reliability.
Average Speed	The average speed (including stopped time) at which a vehicle is able to navigate through the intersection. This is typically slower for turning vehicles than for through vehicles.	Average speed through the intersection or corridor shall be within a specified range during the peak hour of the day.	Would require speed data collection and additional tools to predict future travel speeds.
Congestion Duration	The proportion of the day, in hours, that an intersection experiences congestion.	Allow the intersection to exceed one of the above targets for a specified number of hours per day.	Could be applied with existing analysis tools used in Traffic Impact Studies. May require additional hours of traffic count data collection.

Intersection Completeness	Percent of facilities that are constructed. May consider whether facilities are built to current standards.	Intersection shall include: ▪ Complete bicycle facilities up to stop bar ▪ Bicycle boxes and bicycle pavement markings to serve designated bicycle routes ▪ Detection and actuation for bicycles ▪ Countdown signal displays for pedestrians ▪ Lighting	No new data or analysis required.
Safety			
Crash Rate	The rate of crashes occurring at an intersection or on a segment, often measured in crashes per million entering vehicles or crashes per million VMT.	Lower predicted crash rate than existing condition ▪ Total crashes by mode per million entering vehicles ▪ Total fatal and serious injury crashes by mode per million entering vehicles	Easy to calculate. Any increase in trips from development would have an impact on the measure. These could be difficult to mitigate once all identified safety improvements at a location are complete but could result in implementation of systemic safety countermeasures.
Crash Frequency	The number of crashes occurring at a site, facility, or network in a one year period. Can be differentiated by severity.	Lower predicted crash frequency than existing condition ▪ Total crashes by mode ▪ Total fatal and serious injury crashes by mode	
Excess Proportions of Specific Crash Types	This is the difference between the observed proportion of a specific crash type for a site and the threshold proportion (such as a statewide average) for the reference population.	Specific crash type rates shall not exceed average statewide crash rates by more than "X%".	

In the context of long-term planning, safety measures and intersection completeness can be used to determine whether planned improvements are adequate to accommodate growth. However, in development review they can only be used to make sure that the appropriate improvements or proportionate share of improvements have been provided.

SAFETY AND CAPACITY IMPROVEMENTS

Safety and capacity improvements to OR213 from Redland Road to Molalla Avenue (including the Beavercreek Road intersection) could be implemented in tandem with the proposed alternative mobility target. These approaches, while not providing adequate capacity to meet the current mobility target, would increase capacity and/or safety at the intersection, providing an overall improvement. Table 4 lists these improvements, as well as their relative benefits, constraints, opportunities, and risks.

Table 5 – Intersection Improvement Approaches Considered

Improvement	Benefits	Opportunities	Constraints	Risks
Increase all-red time	Reduces red-light running crashes, particularly turning and angle crashes	All approaches of the intersection	Reduces intersection capacity and increases queueing. Helps reduce turning and angle crashes, which are not prevalent at this intersection.	Increase rear-end crashes, the most common type at signalized intersection
Install red-light cameras	Reduces red-light running crashes, particularly turning and angle crashes	All approaches of the intersection	Community Opposition. Helps reduce turning and angle crashes, which are not prevalent at this intersection.	Increase rear-end crashes, the most common type at signalized intersection
Increase shoulder width	Safer bicycle travel	North leg of intersection	Costs/Impacts to retaining wall	N/A
Install pedestrian countdown signal displays	Increase safety and ease for pedestrians	All approaches of the intersection	N/A	May require costly improvements to comply with the Americans with Disabilities Act (ADA)
Improve lighting	Increase safety for all modes	North and south legs of intersection	N/A	N/A
Provide acceleration lane for WB to NB right turning vehicles	Reduce queuing between OR213 and Maple Lane, and increase capacity of westbound approach	North leg of intersection	Retaining wall in northeast corner of the intersection	Increase sideswipe crashes
Eliminate westbound left-turn lane and extend eastbound left turn storage onto Maple Lane	Reduce queuing and crashes related to queues on Beavercreek Road at Maple Lane	East leg of intersection	Rerouting of westbound lefts to Meyers Road and potential increased travel time	Confusion by drivers resulting in illegal maneuvers

SUMMARY

The OR213 corridor from Redland Road to Molalla Avenue (including the Beavercreek Road intersection) is forecasted to exceed the current mobility target by 2035. Each of the alternatives identified in the Technical Memorandum #1 provides sufficient capacity to meet the current standard in 2035; however, the additional capacity is provided at varying degrees and each alternative has cost and other impacts to consider in determining if they are feasible solutions for the City. If none of the alternatives is found to be feasible, an alternative mobility target approach needs to be pursued.

This memorandum provided the policy context for intersection performance measures, a menu of potential measures that could be used for establishing an alternative mobility target, reasonable target ranges, and a list of potentially feasible low-cost improvements to improve operations and increase safety at the intersection.

NEXT STEPS

Potential measures and alternative mobility target ranges will be reviewed with the TAG and CAG. Future meetings with the TAG and CAG are planned to discuss the feasibility of intersection improvements and potential alternative mobility measures and targets. Any changes will likely require a Legislative public review process before the City's Planning Commission and City Commission. If the project concludes that alternative mobility targets and measures will be needed, they will need to be agreed upon by ODOT and approved by the Oregon Transportation Commission.

Attachment A: OR213/Beavercreek Road Intersection Travel Times (2017)