Final Report

Highway 213 Corridor Alternative Mobility Targets

Oregon City, Oregon

Draft

December 2017

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Oregon City, Oregon

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Project No. 20651

December 2017

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EXECUTIVE SUMMARY

Oregon City's 2013 Transportation System Plan (TSP) determined that the Highway 213 (OR213) corridor from Redland Road 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 OR213 intersection with Molalla Avenue is anticipated to meet the target; however, Beavercreek Road and Redland Road are not anticipated to meet the target.

The existing mobility target at the OR213/Beavercreek Road intersection is a volume-to-capacity (v/c) ratio at or below 0.99 during the peak first and second hours. The existing mobility target at the OR213/Redland Road intersection is a v/c ratio at or below 1.1 during the peak first hour and 0.99 during the peak second hour, as this intersection is located in a regional center. The alternatives that would meet the existing mobility targets at the OR213/Beavercreek Road and OR213/Redland Road intersections are not cost feasible, given the financial constraints of the City and other agency partners. These alternatives can be further considered in the future if additional funding becomes available.

Lacking the financial capability of implementing major capacity-increasing projects at these locations, alternative mobility targets are necessary at each of these intersections; however, some improvements are feasible in the cost-constrained TSP to improve safety and minimize future congestion.

The following improvements are recommended for the intersection of OR213 and Beavercreek Road:

- Construct a westbound right-turn merge lane. High visibility pavement markings and signage are recommended for pedestrians and bicycles to cross the channelized lane safely, and consideration should be given to installing a rectangular rapid flash beacon (RRFB) for increased visibility.
- Infill sidewalk on Beavercreek Road from south of the Coltrane Path to north of Marjorie Lane.
- Install various safety improvements outlined on pages 33 and 35 of this report.

The above improvements will be added as projects in the TSP for future consideration.

For the intersection of OR213 and Beavercreek Road, the following mobility standards apply:

- During the first, second and third hours, a maximum v/c ratio of 1.00 shall be maintained. Calculation of the maximum v/c ratio will be based on an average annual weekday peak hour.

For the intersection of OR213 and Redland Road, the following mobility standards apply:

- During the first and second hours, a maximum v/c ratio of 1.10 shall be maintained. Calculation of the maximum v/c ratio will be based on an average annual weekday peak hour.
- During the third hour, a maximum v/c ratio of 1.05 shall be maintained. Calculation of the maximum v/c ratio will be based on an average annual weekday peak hour.

Changes to the TSP to incorporate these improvements and the alternative mobility targets will require a Legislative public review process before the City's Planning Commission and City Commission. The alternative mobility target and financially feasible improvements that are needed will need to be agreed upon by ODOT and approved by the Oregon Transportation Commission.

Section 2
Introduction

INTRODUCTION

Oregon City's 2013 Transportation System Plan (TSP) determined that the Highway 213 (OR213) corridor from Redland Road 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 would be necessary to meet the current target or whether an alternative mobility target is justified. The OR213 intersection with Molalla Avenue is anticipated to meet the target; however, Beavercreek Road and Redland Road are not anticipated to meet the target.

This project provides an overview of these two intersections including safety, operations, and cost analysis of the potential improvements at these intersections and identifies potential alternative mobility targets that would be necessary in conjunction with financially feasible operational and safety improvements. If alternative mobility targets are not adopted for the corridor, Oregon City will not be able to approve zone changes consistent with the Beavercreek Concept Plan. Outright zoned development will also be hindered until funding can be secured for long-term improvements.

The intersection of OR213 and Beavercreek Road is shown in **Exhibit 1**, and the intersection of OR213 and Redland Road is shown in **Exhibit 2**.

Exhibit 1 – Highway 213 (OR213) and Beavercreek Road Intersection

Exhibit 2 – Highway 213 (OR213) and Redland Road Intersection

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."*

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.

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 targets for the OR213 corridor set forth in the Oregon Highway Plan (OHP) and the 2013 TSP are 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 ratio 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 two study intersections:

- OR213/Beavercreek Road intersection: required to operate at or below a v/c ratio of 0.99 during the peak first and second hours.
- OR213/Redland Road intersection: required to operate at or below a v/c ratio of 1.1 during the peak first hour and 0.99 during the peak second hour.

The Synchro model (a traffic model used to evaluate v/c ratios and other metrics) analysis completed for the 2013 TSP shows the OR213/Beavercreek Road intersection operating with an intersection v/c ratio of 0.83 for the p.m. peak hour under 2011 existing conditions. The TSP did not include an analysis of the intersection of OR213 and Redland Road. Under 2017 existing traffic volumes and conditions, the intersection operates with a v/c ratio of 0.91. 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). 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
2017 Existing Conditions (May Counts)	0.91
2035 (2013 TSP Forecast)	1.05

The 2013 TSP did not include analysis of the OR213/Redland Road intersection. However, a long-term project to improve capacity at the OR213/Redland Road intersection is identified (project D79). The improvements identified in the TSP are part of Phase 2 of the "Jughandle" project, a project that focused on the intersection of OR213 and Washington Street that was implemented in 2013. The Phase 2 improvements, including improvements at OR213/Redland Road are already 90% designed. The improvements identified in Phase 2 future construction include an additional northbound and southbound through lane resulting in three northbound and three southbound lanes through the intersection. As this long-term solution has been identified, much of the analysis in the following sections of this report is focused on the OR213/Beavercreek Road intersection for the purpose of identifying a long-term improvement which will meet the existing mobility target for the corridor.

Section 3
Process

PROCESS

A Community Advisory Group (CAG) and Technical Advisory Group (TAG) were formed to help the City evaluate the feasibility and practicality of the alternatives set forth in this project. Three technical memorandums were produced and presented individually to the TAG and CAG. The following section outlines the contents of these memorandums and outcomes of the conversations with each group. All meeting notes and technical memorandums can be found in Appendix "A".

TECHNICAL MEMORANDUM #1/TAG AND CAG MEETING #1

Potential improvements for the intersection of Beavercreek Road and OR213 that focused on significantly increasing the intersection capacity to meet the current mobility target were presented to the TAG and CAG in December 2016 and January 2017. None of the alternatives were determined to be financially feasible, even by the 2035 horizon year of the TSP given the financial constraints of the city and other agency partners. In addition, some of the potential alternatives could have additional consequences including right-of-way impacts, environmental impacts, and could potentially complicate the provision of services for bicyclists, pedestrians, and transit users. Nonetheless, it is recommended that the alternatives be documented in the TSP for additional future consideration as part of the TSP's unconstrained plan. The unconstrained plan includes projects that are not currently anticipated to be financially feasible by 2035 but are projected to be needed and could be implemented if additional funding becomes available in the future.

TECHNICAL MEMORANDUM #2/TAG AND CAG MEETING #2

Because achieving the mobility target through a major capacity-expanding project at this intersection was determined to be beyond the financial capabilities of the city and its partner agencies, an alternative mobility target is necessary. A menu of potential alternative performance measures, reasonable target ranges, and a list of potentially feasible improvements to increase capacity and safety in the corridor was presented to the TAG and CAG in March 2017. The majority of TAG and CAG members agreed that an alternative mobility target allowing intersection volume-to-capacity ratios to exceed the current targets for no more than a specified number of hours per day would be appropriate for the corridor. The TAG and CAG were also in favor of further investigation of potential improvements to increase safety and capacity at the Beavercreek Road and OR213 intersection. Some improvements were identified that, while not allowing the mobility standard to be fully met, would increase the intersection capacity, improve safety, and are within the financial capabilities of the city and its partner agencies. The specific projects identified by the TAG and CAG for additional analysis were: 1) the provision of a merge lane for westbound right-turning vehicles at the OR213/Beavercreek Road intersection and 2) elimination of the second westbound left-turn lane at the OR213/Beavercreek Road intersection to increase left-turn storage on eastbound Beavercreek Road at Maple Lane Road. These improvements minimize future congestion and could be included in the cost-constrained TSP.

TECHNICAL MEMORANDUM #3/TAG AND CAG MEETING #3

The CAG and TAG reaffirmed support of an alternative mobility target allowing intersection volume-to-capacity ratios to exceed the existing targets for no more than a specified number of hours per day. In conjunction with alternative mobility targets, both groups were supportive of providing a merge lane for westbound right-turning vehicles at OR213/Beavercreek Road, but were not in favor of near-term or partial improvements at OR213/Redland Road, as it was determined that these would not be cost-feasible.

Section 4
Existing Conditions

EXISTING CONDITIONS

The existing conditions analysis identifies the transportation conditions and current operational and geometric characteristics of the roadways within the study area.

GEOMETRIC CHARACTERISTICS

At the OR213/Beavercreek Road intersection, OR213 has a 4-lane section and a speed limit of 55 mph and is classified as an Expressway to the north and a District Highway to the south. Beavercreek Road is classified as a Major Arterial with a 4/5-lane section and a speed limit of 35 mph. OR213 is under the jurisdiction of the Oregon Department of Transportation (ODOT), the west leg of Beavercreek Road is under the jurisdiction of Oregon City, and the east leg is under the jurisdiction of Clackamas County. OR 213 and Beavercreek Road are both designated as a Local Truck Routes in the City's TSP at the study intersection. The City designated truck routes in the TSP to ensure trucks can efficiently travel through and access major destinations in the City.

Sidewalks are provided along the north and south sides of Beavercreek Road, and a multi-use path is provided along OR213 south of Beavercreek Road along the east side of the highway. Bicycle lanes are provided along Beavercreek Road. TriMet operates Bus Route 32 between Clackamas Community College and Milwaukie City Hall. There are stops located on the west leg of Beavercreek Road at the intersection for both directions of travel (i.e. far-side for westbound and near-side for eastbound).

There is a stream running under the north leg of OR213 at the intersection, with corresponding wetlands. There are also geologic hazards in the vicinity of the intersection, with steep slopes and landslides primarily on the northwest corner. More details can be found in the Oregon City GIS maps in Appendix "B". The presence of these features increases the expense of any improvements requiring additional widening, as significant earthwork, culvert extensions, or wetland mitigation may be necessary.

PLANNED AREA IMPROVEMENTS

The City's TSP includes projects which may impact operations, safety, and travel patterns at the OR213/Beavercreek Road intersection. Many of the projects will increase connectivity in the vicinity of the OR213/Beavercreek Road intersection via parallel routes and roadway extensions between these parallel routes, providing alternate routes for those who do not need to pass through the intersection. All new roads and roadway upgrade projects will include facilities for bicycles and pedestrians. In addition, the TSP includes projects specifically to complete and enhance the bicycle and pedestrian networks. The roadway projects listed in the TSP which are likely to increase connectivity and impact safety and operations at the OR213/Beavercreek Road intersection are included in **Table 2** and **Figure 1.** **Figure 1** includes only those projects impacting vehicle travel and capacity.

Table 2 – 2013 Oregon City Transportation System Plan Projects located in the southeast part of the City

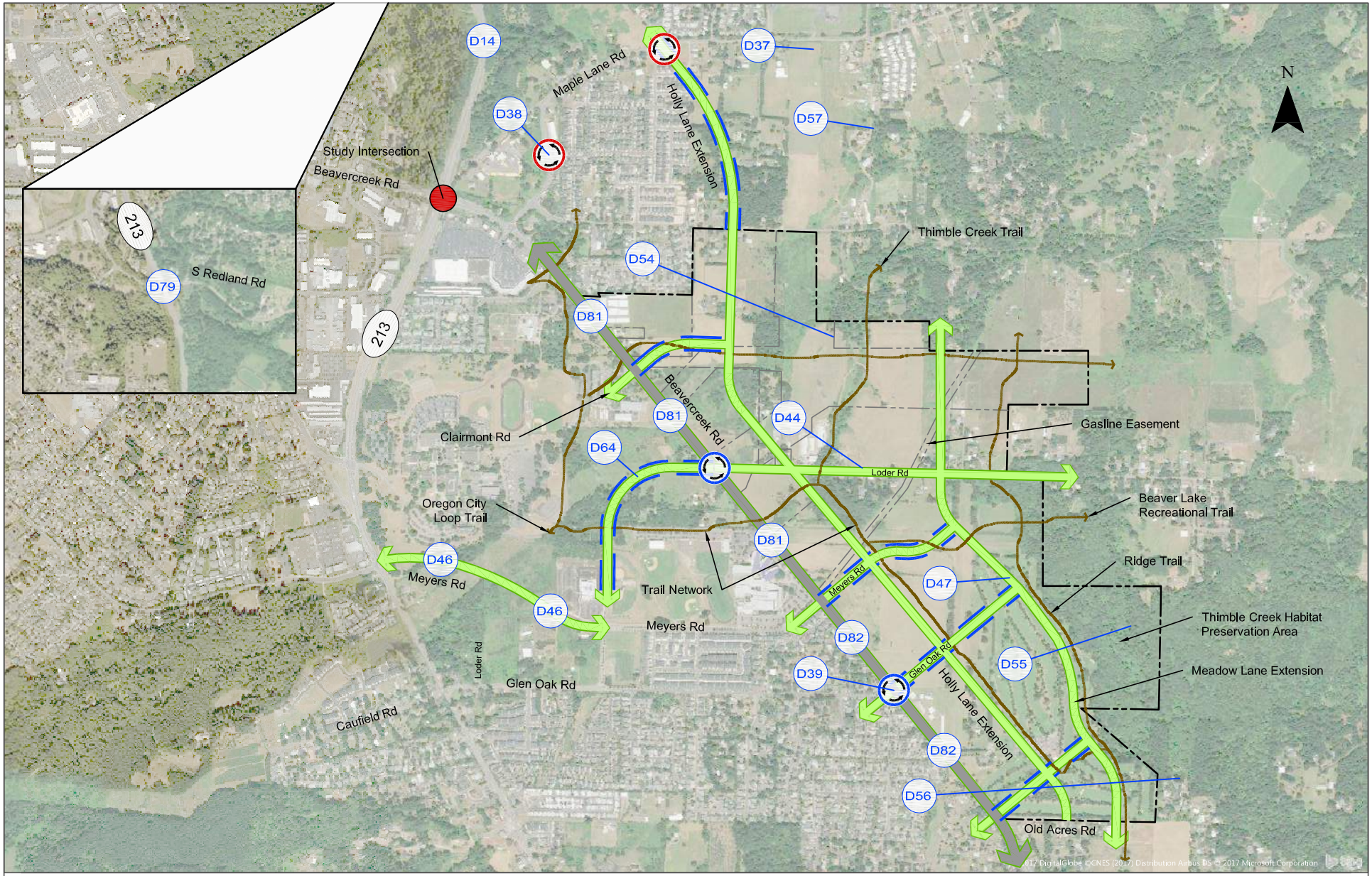
Project #	Project Description	Project Extent	Project Elements	Priority	Funded ?
D14	Southbound OR 213 Advanced Warning System	Southbound OR 213, north of the Beavercreek Road intersection	Install a queue warning system for southbound drivers on OR 213 to automatically detect queues and warn motorists in advance via a Variable Message Sign	Short-term	Likely
D37	Maple Lane Road/Holly Lane Operational Enhancement	Maple Lane Road/Holly Lane	Install a single-lane roundabout	Long-term	Unlikely
D38	Maple Lane Road/Walnut Grove Way Operational Enhancement	Maple Lane Road/Walnut Grove Way	Install a single-lane roundabout or realign Maple Lane Road in correlation with development	Long-term	Unlikely
D39	Beavercreek Road/Glen Oak Road Operational Enhancement	Beavercreek Road/Glen Oak Road	Install a roundabout	Long-term	Unlikely
D44	Beavercreek Road/Loder Road Extension Operational Enhancement	Beavercreek Road/Loder Road Extension	Install a roundabout	Medium-term	Likely
D46	Meyers Road West Extension	OR 213 to High School Avenue	Extend Meyers Road from OR 213 to High School Avenue as an Industrial Minor Arterial. Create a local street connection to Douglas Loop.	Short-term	Likely
D47	Meyers Road East extension	Beavercreek Road to the Meadow Lane Extension	Extend Meyers Road from Beavercreek Road to the Meadow Lane Extension as an Industrial Minor Arterial. Between the Holly Lane and Meadow Lane extensions, add a sidewalk and bike lane to the south side of the street, with a shared-use path to be added on north side per project S19. Modify the existing traffic signal at Beavercreek Road	Medium-term	Likely
D54	Clairmont Drive extension	Beavercreek Road to Holly Lane South Extension	Extend Clairmont Drive from Beavercreek Road to the Holly Lane South extension as an Industrial Collector. Add a sidewalk and bike lane to the south side of the street, with a shared-use path to be added on north side per project S17	Long-term	Likely
D55	Glen Oak Road extension	Beavercreek Road to the Meadow Lane Extension	Extend Glen Oak Road from Beavercreek Road to the Meadow Lane Extension as a Residential Collector. Install a roundabout at Beavercreek Road (per project D39)	Long-term	Likely
D56	Timbersky Way extension	Beavercreek Road to the Meadow Lane Extension	Extend Timbersky Way from Beavercreek Road to the Meadow Lane Extension as a Residential Collector. Add a sidewalk and bike lane to the south side of the street, with a shared-use path to be added on north side per project S20	Long-term	Likely

Table 2 – 2013 Oregon City Transportation System Plan Projects located in the southeast part of the City

Project #	Project Description	Project Extent	Project Elements	Priority	Funded ?
D57	Holly Lane South extension	Maple Lane Road to Thayer Road	Extend Holly Lane from maple Lane Road to Thayer Road as a Residential Collector. Add a sidewalk and bike lane to the west side of the street, with a shared-use path to be added on east side per project S14. Install a roundabout at Maple Lane Road (per project D37)	Medium-term	Likely
D58		Thayer Road to Meyers Road	Extend Holly Lane from Thayer Road to the Meyers Road extension as an Industrial Collector. Add a sidewalk and bike lane to the west side of the street, with a shared-use path to be added on east side per project S15	Medium-term	Likely
D59		Meyers Road to the Meadow Lane Extension	Extend Holly Lane from the Meyers Road extension to the Meadow Lane Extension as a Mixed-Use Collector. Add a sidewalk and bike lane to the west side of the street, with a shared-use path to be added on east side per project S16	Long-term	Likely
D64	Loder Road Extension	Beavercreek Road to Glen Oak Road	Extend Loder Road from Beavercreek Road to High School Avenue as an Industrial Collector. Add a sidewalk and bike lane to the west side of the street, with a shared-use path to be added on east side per project S18. Create a local street connection to Douglas Loop.	Short-term	Likely
D79	OR 213/Redland Road Capacity Improvements	Redland Road to Redland Road undercrossing	Add a third northbound travel lane on OR 213 north of the Redland Road undercrossing. Extend the third southbound travel on OR 213 south of the Redland Road intersection and merge the third lane before the Redland Road undercrossing. Add a right-turn lane (southbound OR 213 to westbound Redland). Convert the Redland Road approach to OR 213 to 1 receiving lane, 2 left-turn approach lanes, and 1 right-turn lane.	Long-term	Unlikely
D81	Beavercreek Road Upgrade	Clairmont Drive (CCC Entrance) to Meyers Road	Improve to Industrial Major Arterial cross-section	Medium-term	Likely
D82		Meyers Road to UGB	Improve to Residential Major Arterial cross-section	Long-term	Likely
B20	Holly Lane Bike Lanes	Donovan Road to Maple Lane Road	Add a bike lane to the west side of the street. A shared-use path will be added on east side per project S13	Included with project D83	Unlikely
B21	Maple Lane Bike Lanes	Walnut Grove Way to UGB	Add bike lanes to both sides of the street	Included with project D84	Unlikely
B22	Thayer Road Bike Lanes	Elder Road to UGB	Add bike lanes to both sides of the street	Long-term Phase 3	Unlikely
B23	Loder Road Bike Lanes	Beavercreek Road and the Holly Lane Extension	Add a bike lane to the north side of the street. A shared-use path will be added on south side per project S18	Included with project D85	Unlikely

Table 2 – 2013 Oregon City Transportation System Plan Projects located in the southeast part of the City

Project #	Project Description	Project Extent	Project Elements	Priority	Funded ?
B24	Loder Road Bike Lanes	Holly Lane Extension to the UGB	Add bike lanes to both sides of the street	Included with project D85	Unlikely
B25	High School Avenue Shared Roadway	Meyers Road to Glen Oak Road	Add wayfinding and shared lane markings	Long-term Phase 4	Unlikely
B26	Glen Oak Road Bike Lanes	Coquille Drive to Augusta Drive	Add bike lanes to both sides of the street	Long-term Phase 3	Unlikely
B27	Coquille Drive Shared Roadway	Glen Oak Road to Turtle Bay Drive	Add wayfinding and shared lane markings	Long-term Phase 4	Unlikely
B29	Beavercreek Road Bike Lanes	Pebble Beach Drive to UGB	Add bike lanes to both sides of the street	Included with project D82	Likely
W22	Holly Lane Sidewalk Infill	Donovan Road to Maple Lane Road	Complete sidewalk gaps on west side of the street. A shared-use path will be added on east side per project S13	Included with project D83	Unlikely
W23	Maple Lane Road Sidewalk Infill	Beavercreek Road to UGB	Complete sidewalk gaps on both sides of the street	Included with project D84	Unlikely
W24	Thayer Road Sidewalk Infill	Maple Lane Road to UGB	Complete sidewalk gaps on both sides of the street	Long-term Phase 3	Unlikely
W25	Loder Road Sidewalk Infill	Beavercreek Road to the Holly Lane Extension	Complete sidewalk gaps on north side of the street. A shared-use path will be added on south side per project S18.	Included with project D85	Unlikely
W26	Loder Road Sidewalk Infill	Holly Lane Extension to the UGB	Complete sidewalk gaps on both sides of the street	Included with project D85	Unlikely
W27	High School Avenue Sidewalk Infill	Meyers Road to Glen Oak Road	Complete sidewalk gaps on the west side of the street	Long-term Phase 3	Unlikely
W28	Glen Oak Road Sidewalk Infill	OR 213 to High School Avenue	Complete sidewalk gaps on both sides of the street	Long-term Phase 2	Unlikely
W29		Coquille Drive to Augusta Drive	Complete sidewalk gaps on both sides of the street	Long-term Phase 3	Unlikely
W31	OR 213 Sidewalk Infill	Molalla Avenue to Conway Drive	Complete sidewalk gaps on both sides of the street	Included with project D77	Unlikely



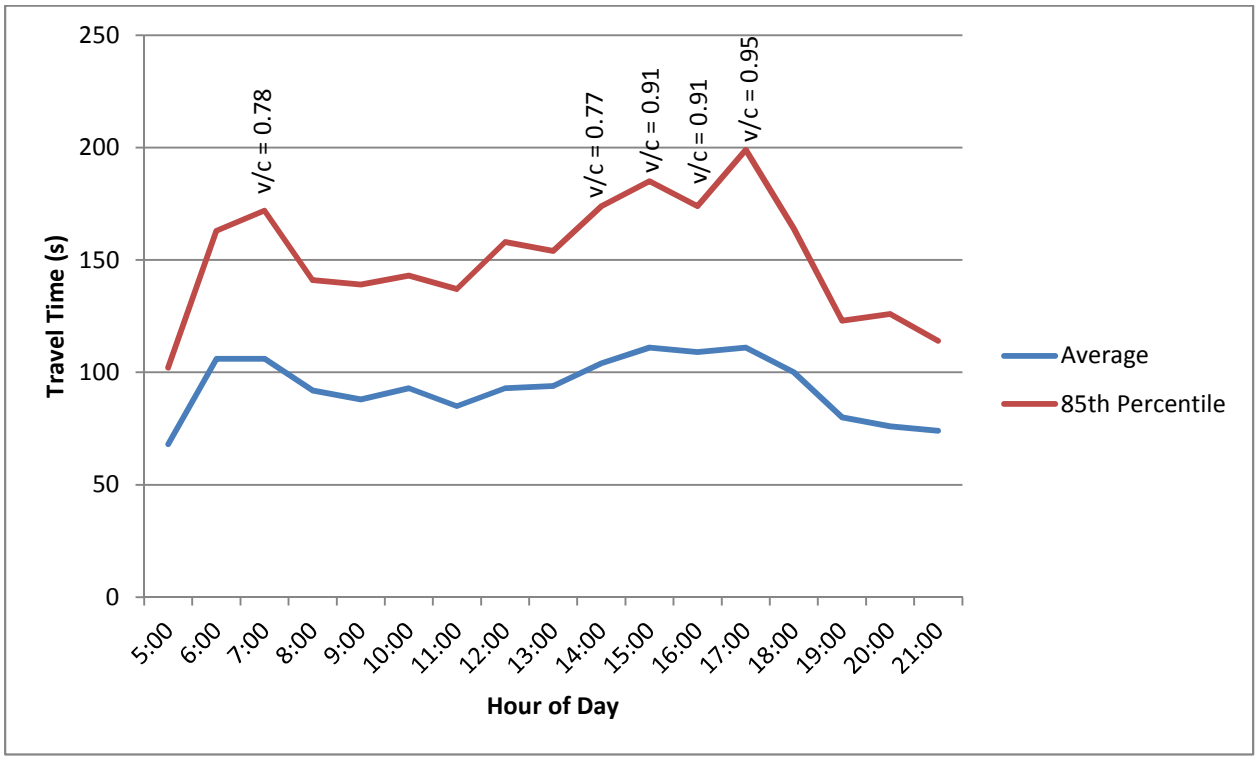
Conceptual Planned Area Connectivity Improvements Oregon City

Figure 1

OPERATIONS

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. Appendix "C" provides the differences in travel time by time of day for each movement at the intersection. The data in Appendix "C" reflects typical weekday conditions (Tuesday, Wednesday, and Thursday). **Exhibit 3** 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.

Exhibit 3 – Travel Time through OR213/Beavercreek Road Intersection



[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.

The cycle length of the traffic signal at the OR213/Beavercreek intersection is approximately 120 seconds. **Exhibit 3** 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 3** provides volume-to-capacity ratios for the five highest volume hours of the day[2]. These v/c ratios are noted on **Exhibit 3** during their corresponding hour.

Table 3 – 2017 Existing Intersection Operations for the Five Highest Volume Hours (OR213/Beavercreek Road)

Highest Hour	Time of Day	Total Entering Volume	V/C
1st	4-5 PM	6052	0.91
2nd	5-6 PM	5983	0.95
3rd	3-4 PM	5808	0.91
4th	2-3 PM	4948	0.77
5th	7-8 AM	4626	1.07[3]

[2] 2017 30th highest hour volumes were estimated by adjusting May 2017 count data by a seasonal factor of 7% to summer peak volumes.

[3] The v/c ratio for the AM peak hour is 1.07 due the high volume of westbound right-turns. If the westbound right-turns are excluded the intersection v/c is 0.78.

Section 5
Alternatives Analysis

ALTERNATIVES ANALYSIS

ALTERNATIVES DEVELOPMENT – OR213 AND BEAVERCREEK ROAD

Alternatives to modify the existing intersection configuration and traffic control, which would bring the intersection into compliance with the current mobility standards in the year 2035, were identified and include:

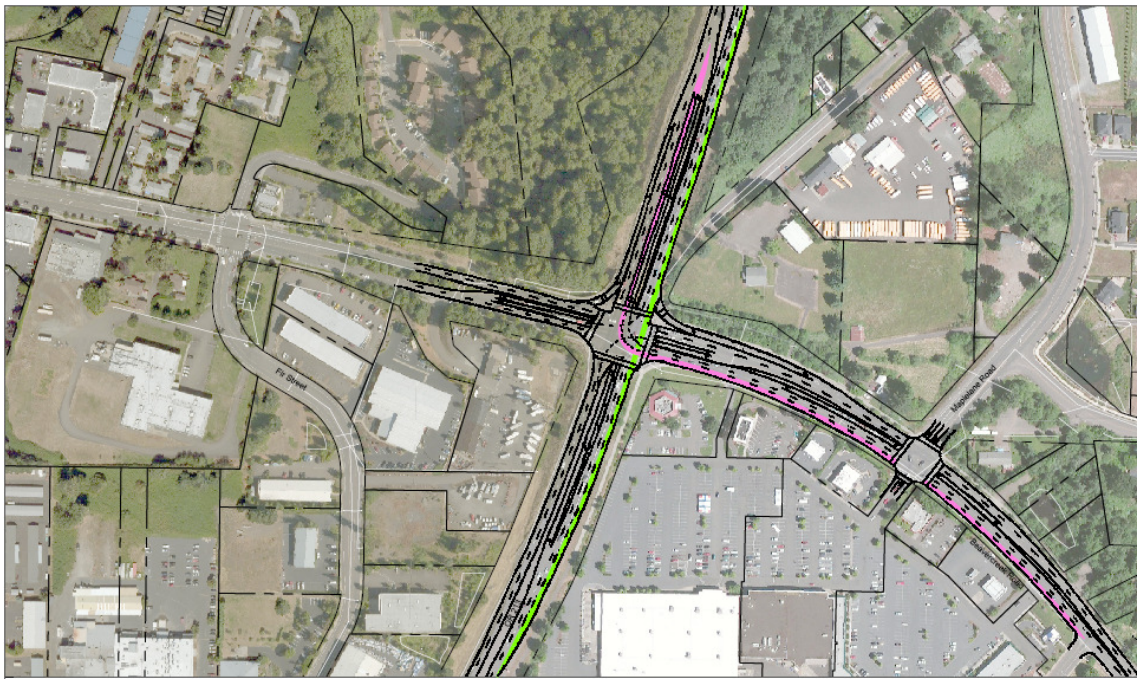
- Addition of lanes to current configuration,
- Quadrant road in the southwest quadrant of the intersection,
- Variations of displaced left-turns (also referred to as continuous flow intersection), and
- Grade-separated interchange forms.

The potential operational impacts of each alternative are shown in **Table 4** and evaluated for a variety of additional considerations in **Table 5**.

Alternative 1: Triple Left-Turns

To maintain the current mobility standard with the existing intersection control, a third southbound left-turn lane and a third northbound through lane through the intersection would be required to bring the intersection back to a v/c ratio of 0.90. A conceptual sketch of Alternative 1 can be seen in **Exhibit 4**. The existing separate northbound right-turn lane (not reflected in **Exhibit 4**) would be maintained. The effectiveness of the additional northbound through lane is dependent on the planned extension of Meyers Road from Beavercreek Road to OR213 which would allow some eastbound right-turns at the intersection to be converted to northbound through movements based on the new network connectivity.

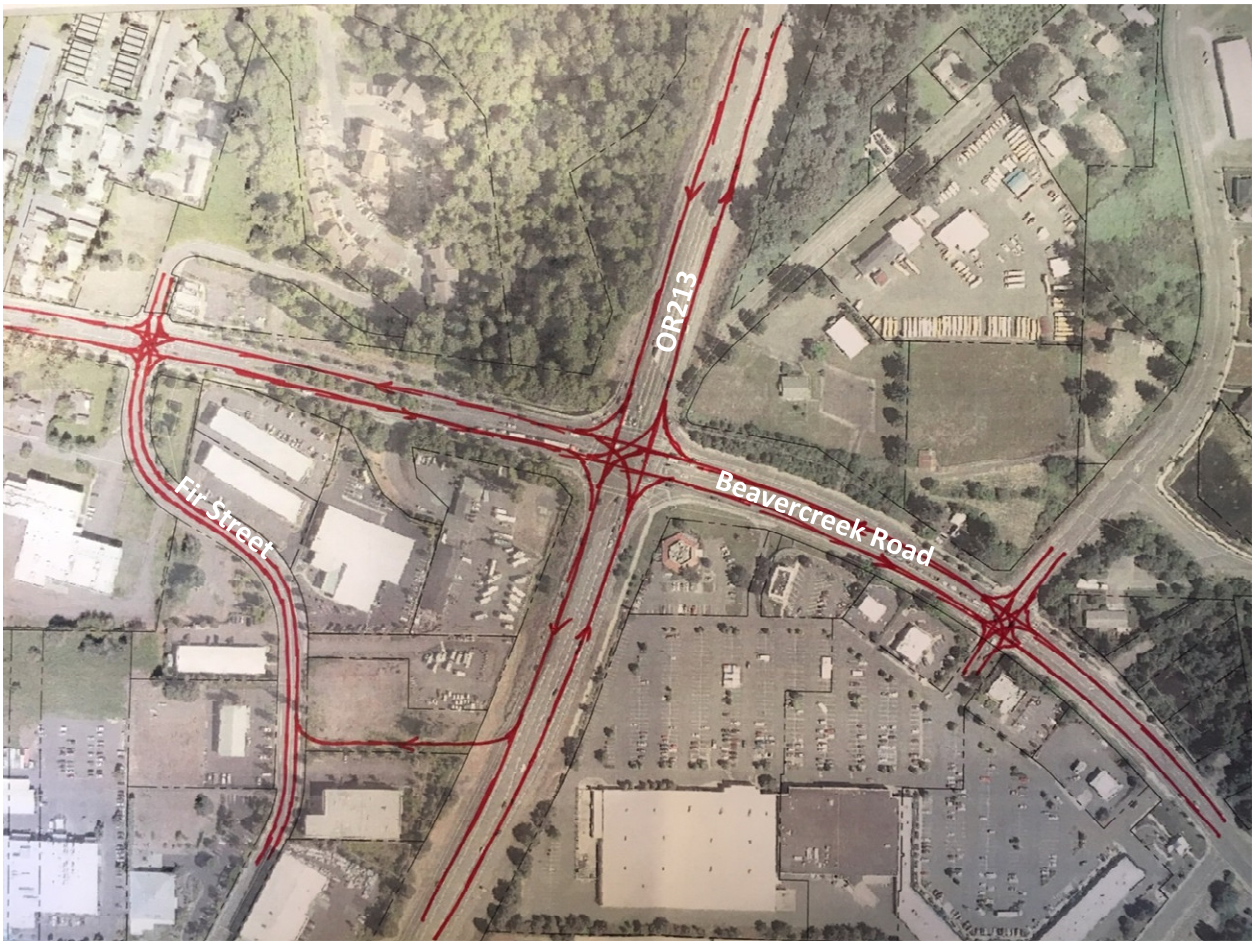
Exhibit 4 – Alternative 1: Triple Left-Turns



Alternative 2: Quadrant Road

A quadrant road, or indirect left, in the southwest corner of the intersection would allow southbound left-turns to be prohibited at the OR213/Beavercreek Road intersection. These vehicles would instead travel southbound through the intersection, turn right onto a new street to the south that would connect to Fir Street, and make a right-turn onto Beavercreek Road to continue east on their desired route. A third southbound through lane and third eastbound through lane would be necessary to accommodate the large volumes traveling through the intersection twice instead of once. This would reduce overall intersection delay but increase travel time for the southbound left-turn movement. The widening is likely to impact the culvert and retaining walls on the northwest and northeast corners of the intersection. The parcel where the connection to Fir Street shown in **Exhibit 5** is currently under development, making this connection infeasible. A quadrant road on the southeast corner was also considered, but the additional travel time incurred by circling the shopping center, or the impacts of cutting through the shopping center, made this alternative infeasible.

Exhibit 5 – Alternative 2: Quadrant Road Alternative

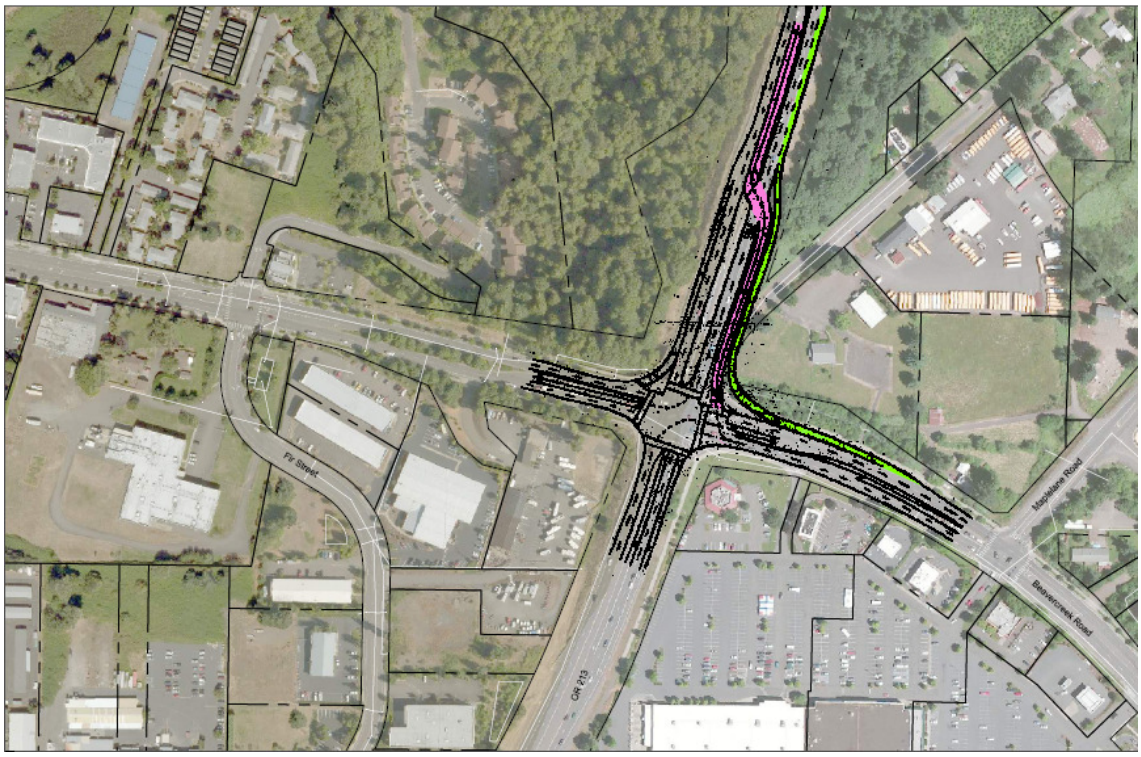


Alternatives 3 & 4: Displaced Left-Turns

In a displaced left-turn[4], or continuous flow, intersection, left-turns are removed from the main intersection and relocated to a new upstream signal. With proper coordination, vehicles are able to make a left-turn simultaneously with opposing through traffic. Displaced left-turn intersection alternatives would reduce the number of signal phases and conflict points in the OR213/Beavercreek Road intersection, thereby improving capacity and safety, but would require coordinated partial signals on the approaches with displaced left-turns. The heaviest left-turn movements at the OR213/Beavercreek Road intersection are on the southbound and eastbound approaches. **Exhibit 6** shows a sketch of a displaced left-turn for the southbound approach only. **Exhibit 7** shows a sketch of displaced left-turns for both the southbound and eastbound approaches. In either case, the southbound approach requires dual left-turn lanes. Consideration could be given to prohibiting the northbound and westbound left-turn movements as these movements have minimal traffic volumes and have alternate routes; however, these restrictions are not mandatory. Additional analysis (microsimulation) is necessary to fully understand the benefits of these potential restrictions.

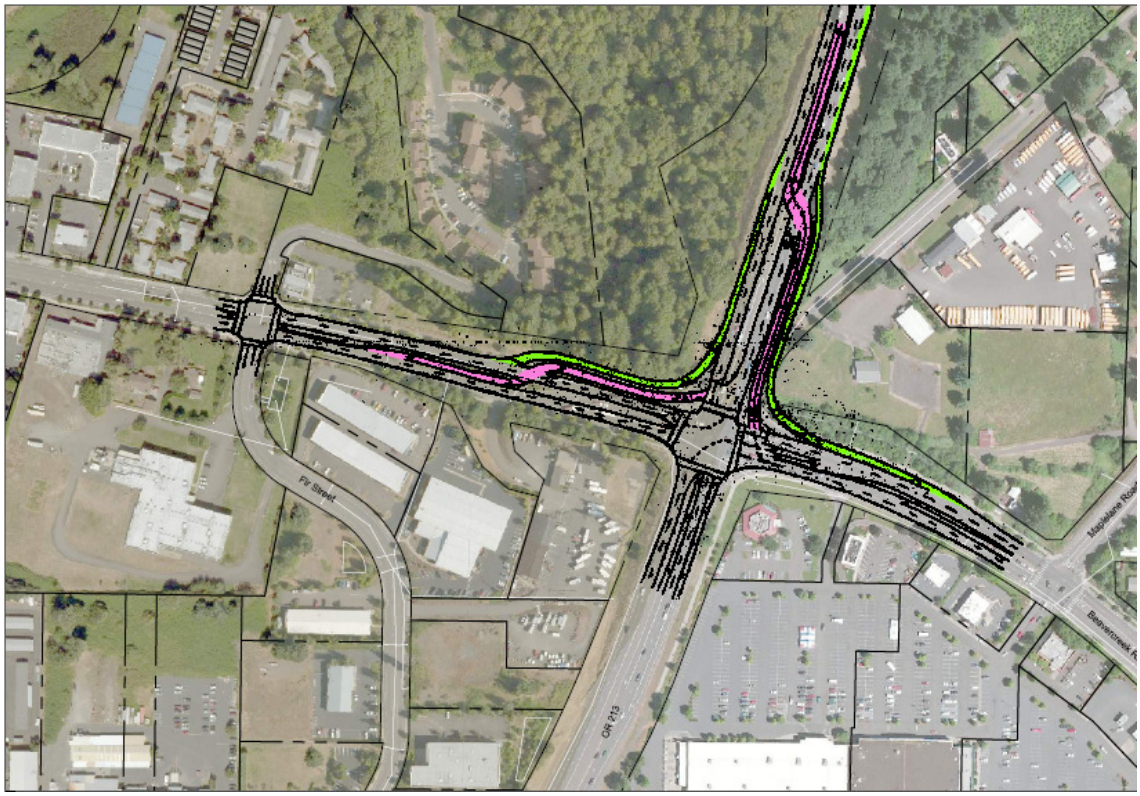
Alternative 3 includes impacts to the culvert and retaining walls in the northeast corner of the intersection. Alternative 4 includes culvert and retaining wall impacts to both the northwest and northeast corners of the intersection.

Exhibit 6 – Alternative 3: Displaced Southbound Left-Turns



[4] 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 7 – Alternative 4: Displaced Southbound and Eastbound Left-Turns



Alternatives 5 – 7: Grade-Separated Interchange Alternatives

Several grade-separated interchange configurations were considered including full diamond, half diamond (i.e., southbound off-ramp and northbound on-ramp only) and single-point interchanges. 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. The construction of an interchange at the OR213/Beavercreek Road intersection would have many challenges and impacts on surrounding land uses as shown in **Exhibit 8** through **Exhibit 10**.

Exhibit 8 – Alternative 5: Half Diamond Interchange Alternative

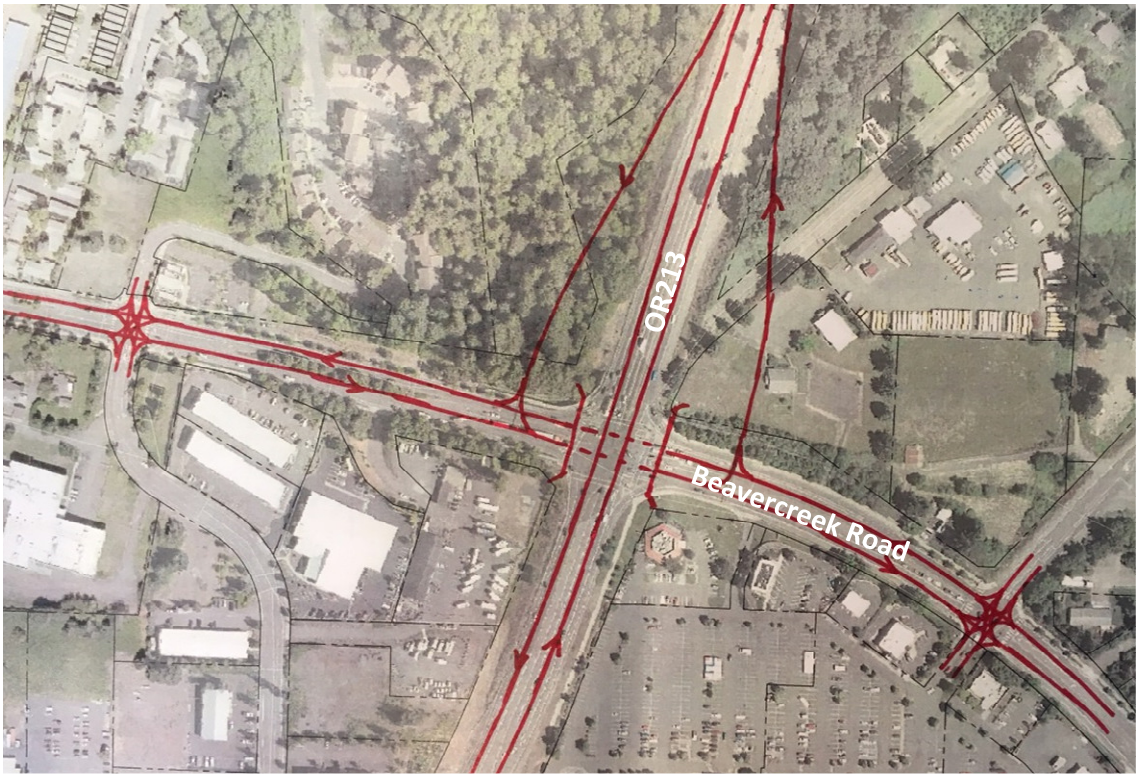


Exhibit 9 – Alternative 6: Full Diamond Interchange Alternative

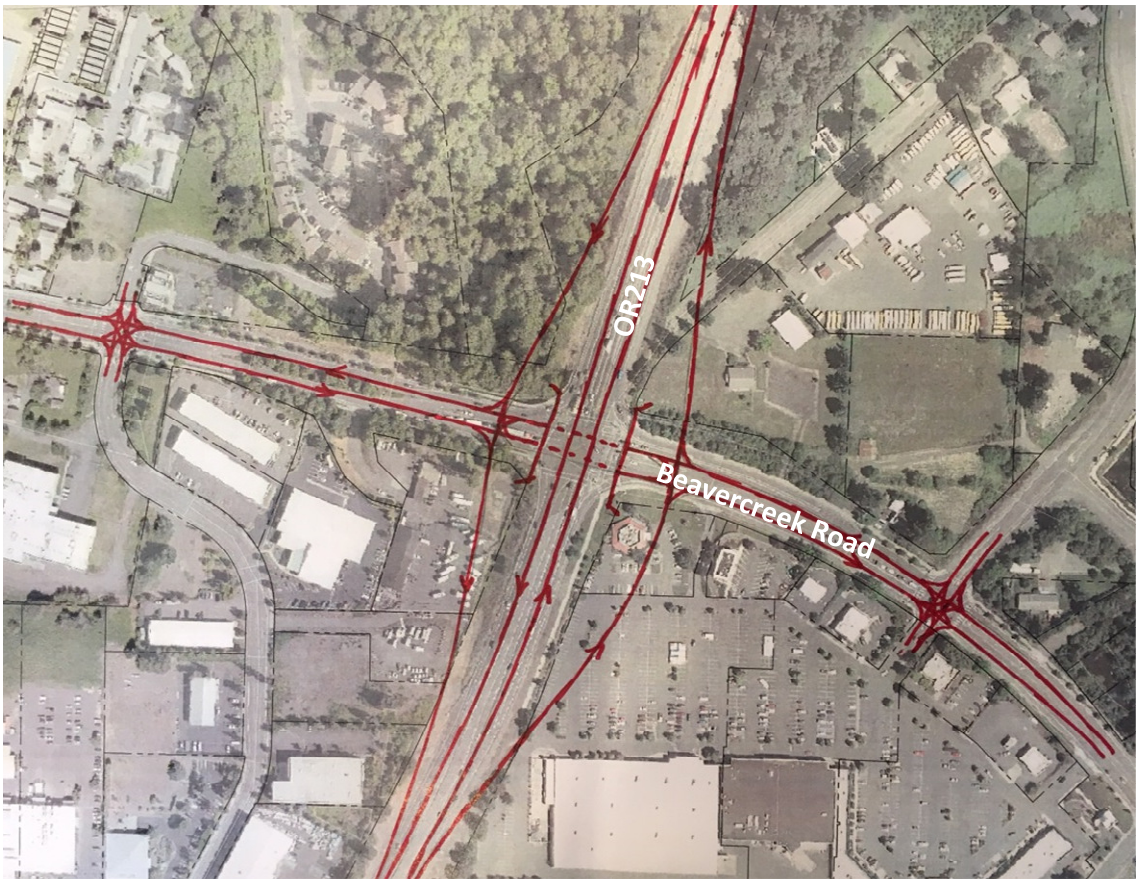
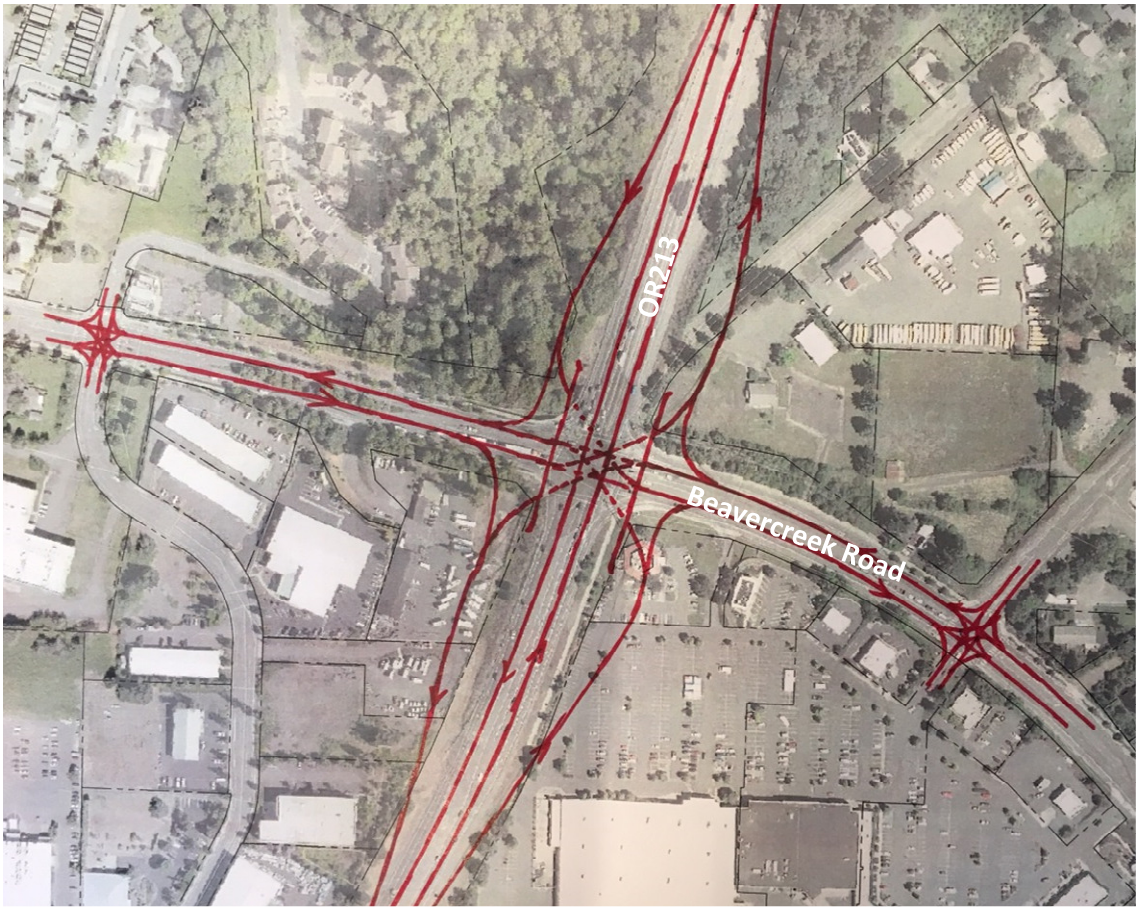


Exhibit 10 – Alternative 7: Single Point Interchange Alternative



ALTERNATIVES EVALUATION – OR213 AND BEAVERCREEK ROAD

The following provides an overview of operational analysis conducted on each alternative and summarizes the qualitative assessment for each alternative.

Operations Analysis

Planning level operational analysis was conducted using the CAP-X tool developed by FHWA[5], which can be used to evaluate alternative intersection forms and interchanges. The tool provides a total intersection (v/c) ratio. It was used for all alternatives to provide a consistent comparison of alternatives, but was found to be less conservative than Synchro in the base condition. **Table 4** summarizes the v/c ratios provided by CAP-X for each alternative. If one of these alternatives is identified as potential viable solution, it should be modeled in VISSIM to refine the forecast v/c ratio.

[5] Transportation Systems Institute (TSI). *Capacity Analysis for Planning of Junctions*. Version 1.2. 2011. http://tsi.cecs.ucf.edu/index.php/cap-x

Table 4 – CAP-X Alternatives Operations Analysis Summary (Year 2035[6])

Alternative		v/c	Exhibit
1	Lane Additions: Triple Southbound Left-Turn Lanes and Three Northbound Thru Lanes	0.90	Exhibit 4
2	Indirect Left (S/W Quadrant Road) with Three Southbound and Eastbound Thru Lanes	0.94	Exhibit 5
3	Southbound Displaced Left-Turn	0.86	Exhibit 6
4	Southbound and Eastbound Displaced Left-Turns	0.81	Exhibit 7
5	Full Diamond Interchange with Dual Eastbound and Westbound Left-Turn Lanes	0.82	Exhibit 8
6	Half Diamond Interchange with Dual Eastbound Left-Turn Lanes	0.79	Exhibit 9
7	Single Point Interchange with Dual Eastbound and Westbound Left-Turn Lanes	0.80	Exhibit 10

As shown, all alternatives meet the mobility target. Differences on their costs and impacts are provided in the following section.

Alternatives Assessment

Each of the alternatives was qualitatively evaluated for its impact to the intersection capacity, right-of-way impacts, environmental impact, bicycle and pedestrian impacts, cost, connectivity, and dependence on other projects. These factors are discussed below and summarized in **Table 5**.

Capacity

Each of the alternatives provides sufficient capacity to meet the current mobility standard in 2035. However, the triple left-turns and indirect left alternatives (Alternatives 1 and 2) still have an overall v/c ratio equal or greater than 0.90 and may represent a short-term fix rather than a long-term solution or may not provide benefit commensurate with the costs. The displaced left-turn alternatives (Alternatives 3 and 4) provide additional capacity nearly equal to the grade-separated interchange alternatives (Alternatives 5, 6 and 7) at a significantly lower cost.

Right-of-Way Impacts

Alternatives 1, 3, and 4 may be feasible within the existing right-of-way. Alternative 2 would require right-of-way through a vacant but developing parcel to connect OR213 to Fir Street. All of the grade separated interchange alternatives include large impacts to the right-of-way. The half diamond interchange reduces right-of-way takes as compared to the full diamond interchange without eliminating necessary movements through the intersection.

[6] 2035 30th highest hour volumes were estimated by adjusting winter count data by a seasonal factor of 8.5% to summer peak volumes. The count data, 2015 Base Year and 2040 Future Year volumes were post-processed using the NCHRP 255 methodology to produce 2035 turning movement volumes at each intersection.

Environmental Impacts

For all alternatives, any widening on the north side of Beavercreek Road, east or west of OR213 would impact the stream and wetlands and require mitigation. They would also require extending the existing culvert crossing under OR213 on the north side of Beavercreek Road and reconstruction of the retaining walls in the northwest and northeast corners of the intersection. Additional investigation is necessary to fully understand the costs of these potential impacts and to determine if the culvert can be extended or has to be upgraded or if the widening could be accommodated utilizing existing right-of-way on the south side of Beavercreek Road.

Alternative 1 is the only alternative with the potential to not impact the northwest and northeast corners. Alternative 3 may impact the northeast corner only. Alternatives 2 and 4 would impact the northwest and northeast corners and Alternatives 5, 6, and 7 would have significant impacts in the northwest and northeast quadrants.

Bicycle and Pedestrian Impacts

All alternatives can accommodate bicycles and pedestrians; however, Alternatives 1 and 2 include additional through lanes and would increase the intersection crossing distances which is an undesirable impact. Alternatives 3 and 4 reduce the crossing distances but result in two-stage crossing of some legs of the intersection. Alternatives 5, 6, and 7 increase and decrease crossing distances depending on the leg of the intersection and result in cyclists and pedestrians navigating two major intersections instead of one.

Cost

The costs of adding additional lanes, indirect lefts, or displaced left-turns are all of similar magnitude and may require extending or reconstructing the culvert and reconstructing retaining walls. Alternatives 3 and 4 also require the addition of partial signals on one or both of the southbound and eastbound legs of the intersection, respectively. Each of the interchange alternatives (Alternatives 5, 6 and 7) are assumed to be cost-prohibitive at a minimum cost of $25,000,000.

Connectivity

Turning movements to and from the south leg of OR213 are minimal due to the presence of parallel routes and/or other road network connections. The half diamond interchange alternative (Alternative 6) eliminates these movements, thereby improving capacity at the intersection. There is the potential to further improve the capacity of the displaced left-turn alternatives (Alternatives 3 and 4) by prohibiting the northbound and westbound left-turn movements as these movements have minimal traffic volumes; however, this is not a requirement of the alternatives. The connectivity improvements in the TSP are important to the flexibility and viability of these alternatives.

Dependence on Other Projects

As noted in the discussion of connectivity above, the half diamond interchange alternative (Alternative 6) is dependent on other projects in the area to provide the parallel routes necessary to accommodate the movements eliminated from the OR213/Beavercreek Road intersection. The practicality of the additional northbound through lane in the triple left-turns alternative (Alternative 1) is also dependent on the provision of road extensions, particularly the planned Meyers Road extension to OR213.

Table 5 – Alternatives Evaluation

Alternative		Additional Capacity	Right-of-Way Impacts	Environmental Impact	Bike/Ped Impacts	Cost	Eliminates Movements?
	Existing	None	None	None	No Improvement	NA	No
1	Triple Southbound Left / Three Northbound Thru	Some	None to Minimal	None to Minimal	Increased Crossing Distances	Medium ($5-$10M)	No
2A	Indirect Left (S/W Quadrant Road)	Some v/c=0.90	New Connection on Industrial Land	NW and NE Corners	Increased Crossing Distances	Medium ($5-$8M)	No
2B	Indirect Left (S/W and S/E Quadrant Roads)	Unknown	New Connection on Industrial Land and Shopping Center Impacts	NW and NE Corners	Increased Crossing Distances	Medium ($10-$15M)	No
3	Southbound Displaced Left-Turn	Significant v/c=0.86	None to Minimal	NE Corner	Reduced Crossing Distances	Medium ($5-$10M)	Would provide additional benefit
4	Southbound and Eastbound Displaced Left-Turns	Significant v/c=0.81	None to Minimal	NW and NE Corners	Reduced Crossing Distances	Medium ($8-$12M)	Would provide additional benefit
5	Full Diamond Interchange	Significant v/c=0.82	High	NW and NE Quadrants	Two intersections	High (>$25M)	Yes
6	Half Diamond Interchange	Significant v/c=0.79	High	NW and NE Quadrants	Two intersections	High (>$25M)	No
7	Single Point Interchange	Significant v/c=0.80	High	NW and NE Quadrants	Increased Crossing Distances	High (>$25M)	No

The following alternatives were identified for further review to determine physical and financial feasibility:

- Alternative 1: Triple Left-Turns
- Alternative 3: Displaced Southbound Left-Turns
- Alternatives 5 & 7: Full Diamond Interchange and Single Point Interchange

Table 6 lists these alternatives, as well as their relative benefits, constraints, opportunities, and risks.

Table 6 – 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 new intersection type for Oregon
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 improvements for the intersection of Beavercreek Road and OR213 that focused on significantly increasing the intersection capacity to meet the current mobility target were presented to the TAG and CAG in December 2016 and January 2017. None of the alternatives were determined to be financially feasible, even by the 2035 horizon year of the TSP given the financial constraints of the city and other agency partners. In addition, some of the potential alternatives could have additional consequences including right-of-way impacts, environmental impacts, and could potentially complicate the provision of services for bicyclists, pedestrians, and transit users. These alternatives can be further considered in the future if additional funding becomes available.

ALTERNATIVES – OR213 AND REDLAND ROAD

As Phase 2 of the "Jughandle" Project (D79 in the TSP) has already been identified to resolve capacity deficiencies at OR213/Redland Road, no additional alternatives were developed for the intersection.

Section 6
Alternative Mobility Target and Financially Feasible Improvements Assessment

ALTERNATIVE MOBILITY TARGET AND FINANCIALLY FEASIBLE IMPROVEMENTS ASSESSMENT

ALTERNATIVE MOBILITY TARGET

The OR213/Beavercreek Road and OR213/Redland Road intersections are 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. Technical Memo #2 in Appendix "A" documents the menu of performance measure options that were discussed with the TAG and CAG to measure congestion both at an intersection and along the Highway 213 corridor, from Redland Road to Molalla Avenue.

The majority of TAG and CAG members agreed that an alternative mobility target allowing intersection volume-to-capacity ratios to exceed the existing targets for no more than a specified number of hours per day would be appropriate for the corridor based on a range of considerations including ease of application and applicability to development review. The following sections describe the safety and operational analysis that was used to recommend cost-feasible improvements and corresponding alternative mobility targets.

SAFETY AND CAPACITY ANALYSIS

The TSP does not identify a large capacity project at the intersection of OR213 and Beavercreek Road, but several smaller feasible projects are identified. The TSP identifies a large capacity project at the intersection of OR213 and Redland Road, but it is not likely to be funded. Because achieving the mobility standard through a major capacity-expanding project at these intersections has been determined to be beyond the financial capabilities of the city and its partner agencies, an alternative mobility target will be necessary. As a result of this study, some improvements were identified that, while not allowing the mobility standard to be fully met, would increase the intersection capacity, improve safety, and are within the financial capabilities of the city and its partner agencies. Safety and operational improvements are identified below that minimize future congestion and can be included in the cost-constrained TSP.

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 targets. 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 7** lists these improvements, as well as their relative benefits, constraints, opportunities, and risks.

Table 7 – 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
Improve lighting	Increase safety for all modes	North and south legs of intersection	N/A	N/A
Provide merge 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

The TAG and CAG were in favor of further investigation of potential improvements to increase safety and capacity at the Beavercreek Road and OR213 intersection. The specific projects identified by the TAG and CAG for additional analysis included: 1) the provision of a merge lane for westbound right-turning vehicles and 2) elimination of the second westbound left-turn lane to increase left-turn storage on eastbound Beavercreek Road at Maple Lane Road. The provision of a westbound right-turn merge lane is described in the following sections and shown in **Figure 2**. The elimination of the second westbound left-turn lane to increase left-turn storage on eastbound Beavercreek Road at Maple Lane Road was highly supported by the CAG and was found to be viable and not impact the intersection v/c ratio; however it is recommended that this be considered at a later date in combination with potential improvements at the Beavercreek Road/Maple Lane intersection.

Beavercreek Road - Right Turn Reconfiguration

Conceptual Design Subject to Change
Date: March 30, 2017

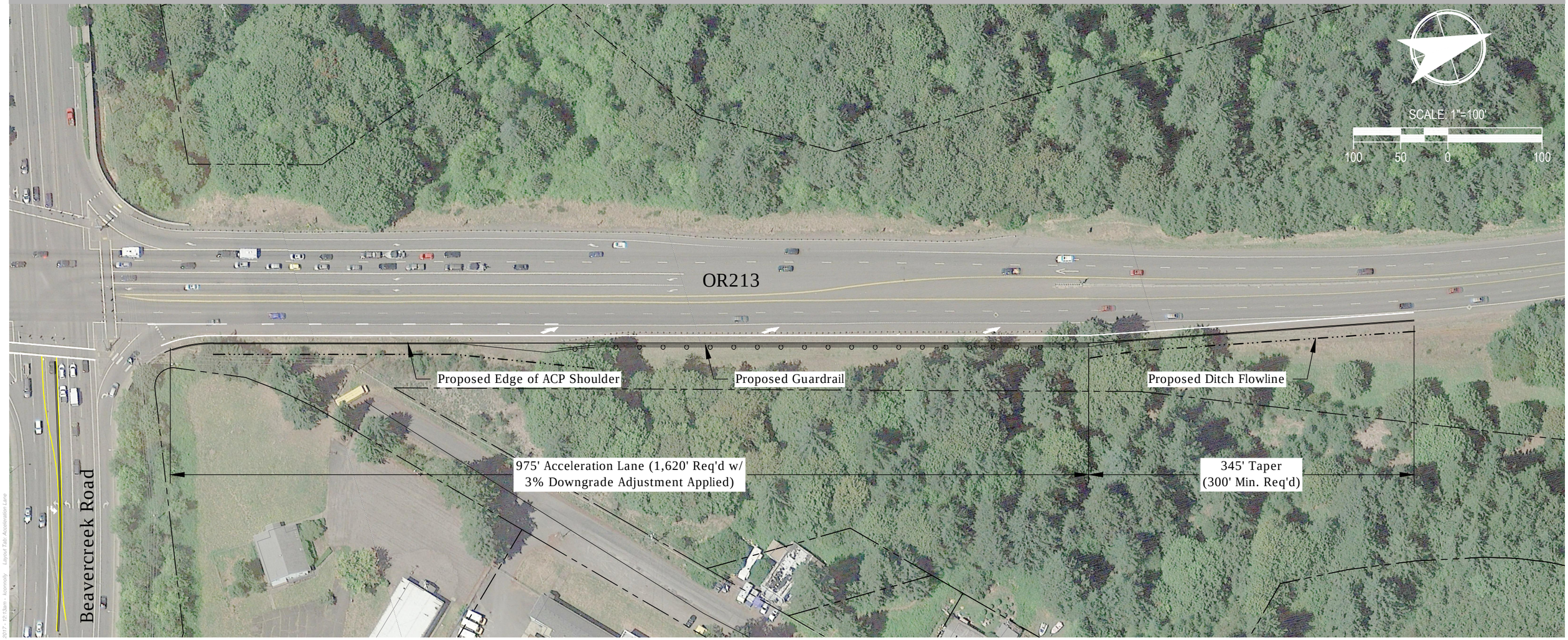


Figure 2

KITTELSON & ASSOCIATES
PHONE: (503) 228-5230 CONTACT: Susan Wright or Hermanus Steyn

OR213 & Beavercreek Road
City of Oregon City

Additional safety improvements identified by the City for further investigation, or to be included as part of future projects in the area include:

- Install intersection enhancements including potential raised crosswalks, bike lane striping continuation, ladder-style crosswalks, and lane narrowing.
- Add wayfinding signage for people walking and biking.
- Enhance bike lanes on Beavercreek Road with additional markings and green striping in transition areas.
- Add buffers to bike lanes on Beavercreek Road where feasible.
- Add ADA curb ramps in the OR213/Beavercreek Road area where missing.
- Add pedestrian facilities to Maple Lane Road between Beavercreek Road and Thayer Road.
- Add transit stop amenities to existing stops in the area.

The following provides an overview of safety and operations at OR213/Beavercreek Road and OR213/Redland Road, and cost estimates of potential cost-feasible safety and operational improvements that could be implemented at the OR213/Beavercreek Road intersection in conjunction with alternative mobility targets.

Safety Analysis

The OR213/Beavercreek Road intersection was identified in the 2013 TSP as a high collision intersection. The Oregon Department of Transportation (ODOT) Crash Analysis and Reporting Unit provided crash records at the intersection for the 5-year period from January 2010 through December 2014. **Table 8** summarizes the reported crash data. The crash data is included in Appendix "D".

Table 8 - OR213/Beavercreek Road Intersection Crash Summary and Crash Rate Assessment (2010-2014)

Crash Type				Severity			Total	Critical Crash Rate by Intersection Type	Critical Crash Rate by Volume	Observed Crash Rate at Intersection	Observed Crash Rate>Critical Crash Rate?
Rear-End	Turning	Angle	Other	PDO	Injury	Fatal					
116	7	5	5	58	74	1	133	0.59	0.50	1.20	Yes

PDO = Property Damage Only
Crash Rate = crashes per million entering vehicles

The intersection was in the top 5% of the ODOT Safety Priority Index System (SPIS) List for the years 2012-2014. The SPIS List is maintained by ODOT and updated each year with the latest available year of crash records and traffic volumes. 2012-2014 is the most current SPIS list. The intersection also has a crash rate that exceeds the Critical Crash Rate meaning that it exceeds the crash rate of other comparable intersections.

As shown in **Table 8**, the most predominant crash type at the OR213/Beavercreek Road intersection is rear-end crashes. Beavercreek Road is the first at-grade intersection on OR213 for over two miles south of Redland Road, in a corridor that generally feels rural. A lack of driver expectation of southbound queues from the signal may contribute to the high number of reported rear-end crashes at the

intersection. The reported fatality occurred in 2011, and was an angle crash in which the driver ran a red light under dark and rainy conditions. The 2010-2014 crash rate of 1.20 is already lower than the crash rate of 2.05 identified in the 2013 TSP, indicating that safety and/or driver attentiveness have improved in recent years. Lengthening the dual eastbound left-turn lanes to provide additional storage (Project D27; funded) and an advanced queue warning system on southbound 213 will further improve safety at the intersection.

Crash data for the OR213/Redland Road intersection was obtained from the February 2017 Serres Farm Annexation Traffic Impact Study for the 3-year period from January 2013 through December 2015. **Table 9** summarizes the reported crash data. The crash data is included in Appendix "D".

Table 9 - OR213/Redland Road Intersection Crash Summary and Crash Rate Assessment (2013-2015)

Crash Type				Severity							
Rear-End	Turning	Angle	Other	PDO	Injury	Fatal	Total	Critical Crash Rate by Intersection Type	Critical Crash Rate by Volume	Observed Crash Rate at Intersection	Observed Crash Rate>Critical Crash Rate?
22	4	0	1	8	19	0	27	0.39	0.54	0.44	Yes

PDO = Property Damage Only
Crash Rate = crashes per million entering vehicles

Both the OR213/Beavercreek Road and OR213/Redland Road intersections have observed crash rates which exceed the Critical Crash Rate, meaning that they exceed the crash rate of other comparable intersections. For this reason, applicable TSP planned improvements and other potential improvements were analyzed at each intersection to determine their impact on the expected crash frequency at each intersection. **Table 10** summarizes the improvements in the TSP.

Table 10 – 2013 Oregon City Transportation System Plan Projects located in the southeast part of the City

Project #	Project Description	Project Extent	Project Elements	Priority	Funded?
D14	Southbound OR 213 Advanced Warning System	Southbound OR 213, north of the Beavercreek Road intersection	Install a queue warning system for southbound drivers on OR 213 to automatically detect queues and warn motorists in advance via a Variable Message Sign	Short-term	Likely
D79	OR 213/Redland Road Capacity Improvements	Redland Road to Redland Road Undercrossing	Add a third northbound travel lane on OR 213 north of the Redland Road undercrossing. Extend the third southbound travel on OR 213 south of the Redland Road intersection and merge the third lane before the Redland Road undercrossing. Add a right-turn lane (southbound OR 213 to westbound Redland). Convert the Redland Road approach to OR 213 to 1 receiving lane, 2 left-turn approach lanes, and 1 right-turn lane.	Long-term	Not Likely

In addition to these planned improvements, the impact of a westbound right-turn merge lane at OR213/Beavercreek Road and an additional southbound through lane (shared with the southbound right-turn lane) at OR213/Redland Road were analyzed. The intersections and improvements were

analyzed using HiSafe[7] software and crash modification factors (CMF) from the CMF Clearinghouse. **Tables 11 and 12** show the 2035 expected annual crashes with and without these improvements.

Table 11 – OR213/Beavercreek Road 2035 Expected Annual Crashes

Existing Configuration	With Westbound Right-Turn Merge Lane (CMF #295 applied to westbound rear-end crashes)	With Southbound Advanced Queue Warning System (CMF #76 applied to southbound rear-end injury crashes)	With Both Improvements
26.39	25.75	25.77	25.13
-	-2.4%	-2.3%	-4.8%

Table 12 – OR213/Redland Road 2035 Expected Annual Crashes

Existing Configuration	With 3rd Southbound Through/Right Lane (CMF #7924 applied to southbound crashes)	With 3 Northbound and 3 Southbound Through Lanes (CMF #7924 applied to northbound and southbound crashes)
8.82	8.24	7.92
-	-6.6%	-10.2%

As shown in **Tables 11 and 12**, the planned TSP and potential financially feasible improvements will reduce the number of expected annual crashes at the OR213/Beavercreek Road and OR213/Redland Road intersections. The potential financially feasible improvements at OR213/Beavercreek Road are predicted to reduce crashes at the intersection by almost 5%, and planned improvements at OR213/Redland Road are predicted to reduce crashes by more than 10%.

Operations Analysis

Count data for OR213 at Beavercreek Road and Redland Road was collected in May 2017. The five highest volume hours were collected for each intersection, based on historical count data at the OR213/Beavercreek Road intersection, under the assumption that they follow the same hourly volume profile. Due to the large amount of commuter traffic from outlying communities, a large portion of the traffic through each intersection is made up of the same vehicles a matter of seconds apart. The raw count data can be found in Appendix "E". The raw data represents annual average conditions and was adjusted to represent summer peak volumes[8]. The adjustment calculations can be found in Appendix "E".

[7] HiSafe companion software to the Highway Safety Manual (HSM) applies HSM Predicative Method for estimating the average number of expected annual crashes for quantitative assessment of safety performance.

[8] In order to calculate the 30th highest hour, the data was seasonally adjusted to summer peak volumes using the average of two representative Automatic Traffic Recorder (ATR) locations in Clackamas County (03-017 and 03-018). A factor of 7% was calculated using the procedures outlined in ODOT's Analysis Procedures Manual (APM) and applied to the May counts to adjust them to summer peak volumes.

Metro provided 2015 Base Year and 2040 Future Year hourly turn movement volumes for OR213/Beavercreek Road and OR213/Redland Road. These volumes reflect the most current land use assumptions and include full build-out of Oregon City's urban growth boundary areas in addition to growth in the rest of the region, including through traffic from outlying communities. These hourly plots can be found in Appendix "E". The count data, 2015 Base Year and 2040 Future Year volumes were post-processed using the NCHRP 255[9] methodology to produce 2040 turning movement volumes at each intersection under both the annual average and 30th highest hour conditions. The calculations for this process can be found in Appendix "E".

A Synchro (traffic model used to evaluate v/c ratios and other metrics) analysis was conducted for the five highest traffic volume hours at the OR213/Beavercreek Road and OR213/Redland Road intersections under both the annual average (typical May peak hours) and 30th highest hour (typical August peak hour) conditions. The results of this analysis are summarized in **Tables 13 and 14**. The full reports can be found in Appendix "F".

Table 13 – 2040 Synchro Volume-to-Capacity Analysis Summary: Annual Average Conditions

Scenario	Peak Hour 4:00 pm	2nd Highest Hour 5:00 pm	3rd Highest Hour 3:00 pm	4th Highest Hour 2:00 pm	5th Highest Hour 7:00 am
213/Beavercreek	1.11	1.11	1.10	0.96	1.34[1]
213/Beavercreek with Right-Turn Merge Lane	0.98	1.00	0.99	0.87	0.90
213/Redland	1.10	1.09	1.04	0.99	0.91

[1]The 5th highest overall volume hour at OR213/Beavercreek Road under the existing intersection configuration has a higher v/c because certain movements in this hour exhibit higher volumes than in the peak hour. For example, during the morning peak the westbound right-turn movement is significantly higher than during the afternoon peak, impacting v/c.

Table 14 – 2040 Synchro Volume-to-Capacity Analysis Summary: 30th Highest Hour Conditions

Scenario	Peak Hour 4:00 pm	2nd Highest Hour 5:00 pm	3rd Highest Hour 3:00 pm	4th Highest Hour 2:00 pm	5th Highest Hour 7:00 am
213/Beavercreek	1.15	1.15	1.14	1.00	1.39[1]
213/Beavercreek with Right-Turn Merge Lane	1.01	1.04	1.03	0.90	0.93
213/Redland	1.13	1.12	1.07	1.02	0.94

[1]The 5th highest overall volume hour at OR213/Beavercreek Road under the existing intersection configuration has a higher v/c because certain movements in this hour exhibit higher volumes than in the peak hour. For example, during the morning peak the westbound right-turn movement is significantly higher than during the afternoon peak, impacting v/c.

The analysis in **Tables 13 and 14** shows that, without improvements, the OR213/Beavercreek Road and OR213/Redland Road intersections will exceed current mobility targets in 2040 (shown in red). With potentially financially feasible improvements in place (i.e. a westbound right-turn merge lane at OR213/Beavercreek), the intersections will still exceed the existing mobility targets under 30th highest

[9] This document sets forth procedures to refine computerized traffic volume forecasts by comparing base year and future year volumes to count data.

hour traffic conditions. Therefore, it is recommended that alternative mobility targets be based on average annual conditions, allowing the v/c ratio to exceed 0.99 for one hour per day at the OR213/Beavercreek Road intersection (upper limit of 1.0) and three hours per day at the OR213/Redland Road intersection (upper limit of 1.1).

Merge Analysis

The intersection of OR213 and Beavercreek Road was evaluated to ensure that the segment north of Beavercreek Road on OR213 would provide acceptable traffic operations with the proposed merge lane. The evaluation was performed both for a merge length of 1,300' and 2,000'. A 1,300' merge meets ODOT standards based on a length reduction for grade. A 2,000' merge exceeds ODOT standards for the existing grade on OR213 and places the end of the merge within a horizontal curve. Additionally, the analysis below shows that the 2,000' merge has a negative impact on delay due to greater difficulty merging at higher speeds.

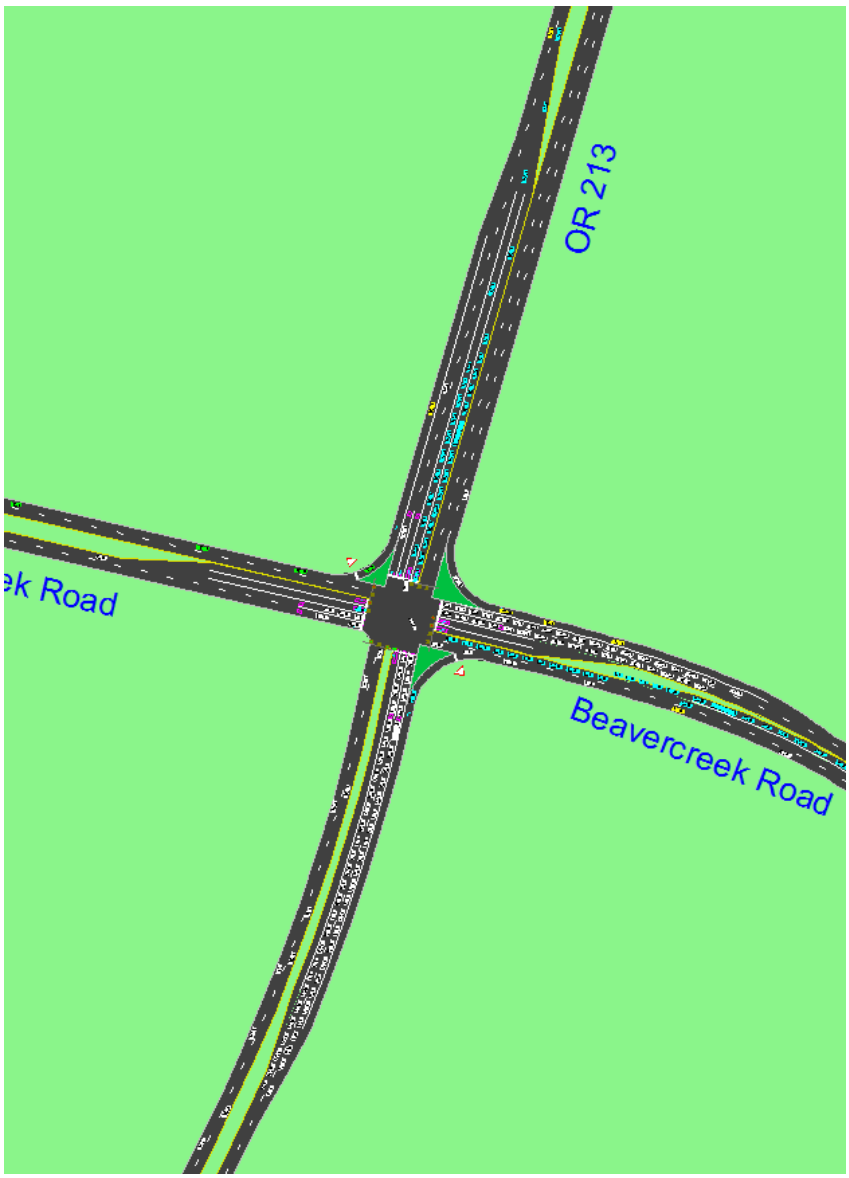
Segment Analysis Methodology

A traffic simulation analysis was conducted using the 2040 annual average traffic volumes and the proposed westbound right-turn merge lane. The simulation analysis used the SimTraffic software (sample graphic shown in **Exhibit 11**). The parameters were adjusted according to the ODOT Analysis and Procedures Manual (APM). The traffic simulation generates random patterns of vehicle movements consistent with the peak hour traffic volumes, so that no single simulation generates "the" answer. The AM and PM peak hour traffic volumes were each run through the SimTraffic simulation five times. The results of the five simulation runs were averaged to generate the final results. This is consistent with standard recommended methodologies for reporting results from traffic simulations. The outputs include:

- Average speeds and delays on the segment in the northbound direction.
- Average delays on the westbound right-turn movement.

The simulation is sensitive to delays caused by difficult merge or lane-change movements. If any of these movements are particularly difficult, the simulation would report slow speeds or queues on the affected segments.

Exhibit 11 – Sample Traffic Simulation (SimTraffic), OR213/Beavercreek Road Intersection



Segment Speeds

The Highway Capacity Manual defines level of service for urban street segments based on travel speed as a percentage of free-flow speed. Level of service (LOS) C corresponds to an average speed between 50 and 67 percent of free-flow speed. Assuming a free-flow speed of 55 mph on OR213 north of Beavercreek Road, LOS C operation would be an average speed between 27.5 and 36.9 mph.

The average speeds and delays for OR213 through the westbound to northbound merge from Beavercreek Road (north of the signal) based on the simulation analysis are reported in **Table** .

Table 15 – OR213 and Beavercreek Road Speeds and Delays, 2040 Annual Average Volumes

Scenario	Peak Hour	Average Speed (mph)	Average Delay per Vehicle (seconds)
1300' Merge	AM	34.0	9.8
	PM	36.0	8.1
2000' Merge	AM	39.0	10.1
	PM	41.0	8.3

Average speeds are within an acceptable (LOS C) range for the proposed 1,300' merge and even higher for the 2,000' merge. Keeping in mind that most vehicles are accelerating from a stop through the Beavercreek Road signal, and will not have to slow significantly during the merge, the difference in speeds is primarily attributed to the additional distance for vehicles already on OR213 to accelerate. Additionally, the average delay per vehicle is higher with the 2,000' merge, indicating that the merging maneuver actually creates more conflicts when there are higher speeds on OR213.

The segment merge analysis shows that acceptable levels of service can be maintained with a 1,300' merge lane for the westbound right-turn movement. A 2,000' merge would occur within a horizontal curve on OR213, increasing the risk of sideswipe and run-off-the-road crashes. Therefore, it is recommended that a 1,300' merge length be provided.

Westbound Right Turn Operations

The traffic simulation tested the operations of the proposed free-right turn lane from westbound Beavercreek Road to northbound OR213. The operational analysis considered the capacity of the right-turn lane as well as the capacity of the merge with northbound traffic on OR213, but does not reflect delay caused by pedestrian movements at the intersection.

Table 16 – OR213 and Beavercreek Road Westbound Right-Turn Delay, 2040 Annual Average Volumes

Scenario	Peak Hour	Average Delay per Vehicle (seconds)
1300' Merge	AM	13.6
	PM	16.6
2000' Merge	AM	13.9
	PM	16.5

The average delays on the right-turn movement are similar with either the 1300' or 2000' merge, as shown in **Table 16**. The longer merge does not significantly reduce delay, and in fact increases delay during the AM peak hour, which is the critical westbound right-turn movement volume.

Pedestrian Crossing

High visibility pavement markings and signage are recommended for pedestrians and bicycles to cross the channelized lane safely, and consideration should be given to installing enhanced pedestrian

improvements. This could include a rectangular rapid flash beacon (RRFB) for increased visibility. This type of treatment has been installed at similar locations in Boise, Idaho (see **Exhibit 12**).

Exhibit 12 – RRFB on the west leg of E Myrtle St and S Broadway Ave in Boise, Idaho

Queuing Analysis

The capacity improvements identified in Phase 2 of the "Jughandle" Project were evaluated to determine the impact of these improvements on queuing. **Table 17** provides a summary of Synchro queuing results in the southbound direction at OR213 and Redland Road under existing conditions and with the implementation of Phase 2 of the "Jughandle" Project.

Table 17 – 2040 Synchro Queuing Analysis Summary: 30th Highest Hour Conditions, Southbound Direction

Scenario	Peak Hour 4:00 pm	2nd Highest Hour 5:00 pm	3rd Highest Hour 3:00 pm	4th Highest Hour 2:00 pm	5th Highest Hour 7:00 am
213/Redland Existing Configuration	1947	1998	1701	1430	985
213/Redland with TSP Improvements	982	998	870	774	620

The results in **Table 17** show that the TSP improvements reduce the queues towards the I-205 interchange by approximately half. However, without the TSP improvements the southbound queues in Synchro are around 1800-1900 feet which is just past 213/Washington St/Clackamas River Drive.

Cost Estimates

The cost of adding an additional northbound and southbound through lane at OR213/Redland Road, consistent with TSP project D79, was recently estimated by OBEC to be almost $10 million.

The cost of the westbound right-turn merge lane at OR213/Beavercreek Road is estimated to be approximately $2.7 million based on the design shown in **Figure 2**. This estimate does not include right-of-way acquisition.

The KAI and OBEC cost estimates, as well as exhibits of the proposed financially feasible improvements at OR213/Beavercreek Road can be found in Appendix "G".

CONCLUSIONS

The intersection improvement alternatives that would meet the existing mobility target at the OR213/Beavercreek Road intersection are not cost feasible, given the financial constraints of the City and other agency partners. These alternatives can be further considered in the future if additional funding becomes available.

Phase 2 of the "Jughandle" project at the OR213/Redland Road intersection is not part of the financially constrained plan in the 2013 TSP. Like the OR213/Beavercreek Road intersection, major capacity-increasing improvements at this intersection were determined to be beyond the financial capabilities of the city and its partner agencies during the TSP development process. It is recommended that this planned improvement for three through lanes in the northbound and southbound directions remain in the unconstrained TSP project list.

Lacking the financial capability of implementing major capacity-increasing projects at these locations, alternative mobility targets are necessary at each of these intersections; however, some improvements may be feasible in the cost-constrained TSP to improve safety and minimize future congestion.

The following alternative mobility targets are recommended:

For the intersection of OR213 and Beavercreek Road, the following mobility standards apply:

- During the first, second and third hours, a maximum v/c ratio of 1.00 shall be maintained. Calculation of the maximum v/c ratio will be based on an average annual weekday peak hour.

For the intersection of OR213 and Redland Road, the following mobility standards apply:

- During the first and second hours, a maximum v/c ratio of 1.10 shall be maintained. Calculation of the maximum v/c ratio will be based on an average annual weekday peak hour.
- During the third hour, a maximum v/c ratio of 1.05 shall be maintained. Calculation of the maximum v/c ratio will be based on an average annual weekday peak hour.

In conjunction with these alternative mobility targets, the financially feasible improvement to construct a westbound right-turn merge lane at OR213/Beavercreek Road should be included in the City's financially unconstrained plan. The merge lane should have a length of approximately 1300', including the taper. High visibility pavement markings and signage are recommended for pedestrians and bicycles to cross the channelized lane safely, and consideration should be given to installing a rectangular rapid flash beacon (RRFB) for increased visibility.

Appendix A
CAG and TAG Meeting Notes and Technical Memorandums

Appendix B
Oregon City GIS Maps

Appendix C
BlueMAC Data

Appendix D
Crash Data

Appendix E
Traffic Volumes

Appendix F
Operations Analysis

Appendix G
Cost Estimates