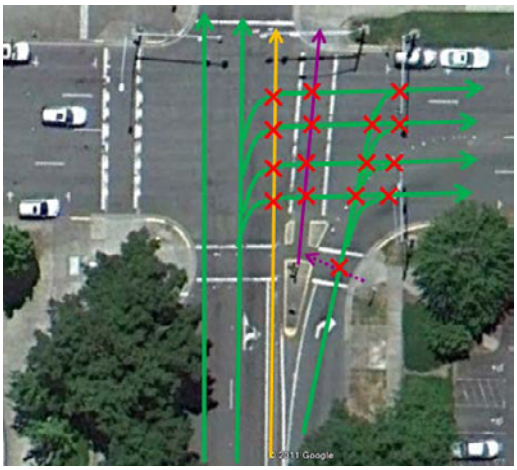

Salem Transportation Safety Analysis

Spring 2011 • Portland State University

Civil and Environmental Engineering

Pamela C. Johnson • Civil Engineering

Dr. Chris Monsere • Assistant Professor • Civil and Environmental Engineering

UNIVERSITY OF OREGON

SCI

Sustainable Cities Initiative

Acknowledgements

Special thanks to Kevin Hottman, P.E., City of Salem City Traffic Engineer, for his help and guidance.

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About SCI

The Sustainable Cities Initiative (SCI) is a cross-disciplinary organization at the University of Oregon that seeks to promote education, service, public outreach, and research on the design and development of sustainable cities. We are redefining higher education for the public good and catalyzing community change toward sustainability. Our work addresses sustainability at multiple scales and emerges from the conviction that creating the sustainable city cannot happen within any single discipline. SCI is grounded in cross-disciplinary engagement as the key strategy for solving community sustainability issues. We serve as a catalyst for expanded research and teaching, and market this expertise to scholars, policymakers, community leaders, and project partners. Our work connects student energy, faculty experience, and community needs to produce innovative, tangible solutions for the creation of a sustainable society.

About SCY

The Sustainable City Year (SCY) program is a year-long partnership between SCI and one city in Oregon, in which students and faculty in courses from across the university collaborate with the partner city on sustainability and livability projects. SCY faculty and students work in collaboration with staff from the partner city through a variety of studio projects and service-learning courses to provide students with real-world projects to investigate. Students bring energy, enthusiasm, and innovative approaches to difficult, persistent problems. SCY's primary value derives from collaborations resulting in on-the-ground impact and forward movement for a community ready to transition to a more sustainable and livable future. SCY 2010-11 includes courses in Architecture; Arts and Administration; Business Management; Interior Architecture; Journalism; Landscape Architecture; Law; Planning, Public Policy, and Management; Product Design; and Civil Engineering (at Portland State University).

About Salem, Oregon

Salem, the capital city of Oregon and its third largest city (population 157,000, with 383,000 residents in the metropolitan area), lies in the center of the lush Willamette River valley, 47 miles from Portland. Salem is located an hour from the Cascade mountains to the east and ocean beaches to the west. Thriving businesses abound in Salem and benefit from economic diversity. The downtown has been recognized as one of the region's most vital retail centers for a community of its size. Salem has retained its vital core and continues to be supported by strong and vibrant historic neighborhoods, the campus-like Capitol Mall, Salem Regional Hospital, and Willamette University. Salem offers a wide array of restaurants, hotels, and tourist attractions, ranging from historic sites and museums to events that appeal to a wide variety of interests. 1,869 acres of park land invite residents and visitors alike to enjoy the outdoors.

Course Participants

Dr. Chris Monsere, Assistant Professor

Bonnie Way and Cascade Drive
Kwabena Afrifa, Civil Engineering Undergraduate
Peter Reich, Undergraduate Civil Engineering
Jonathan Walker, Undergraduate Civil Engineering

The Intersection of Winter Street, Fairgrounds Road, and Jefferson Street
Olga Bocharov, Civil Engineering Undergraduate
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Colby Riddle, Civil Engineering Undergraduate
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Judson Middle School
Tom Brennan, Civil Engineering Graduate
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Chloe Ritter, Graduate Urban Studies and Planning

Traffic Calming on Residential Streets in Salem
Eric Albright, Civil Engineering Graduate
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Mike Burkart, Civil Engineering Undergraduate
Emily Lind, Civil Engineering Undergraduate
Peter Wirtz, Civil Engineering Undergraduate
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Lancaster Drive and Sunnyview Road; A High Crash Location
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Qianwen Lu, Civil Engineering Undergraduate

The Intersection of Marion Street and Summer Street
Brian Marcum, Civil Engineering Undergraduate
Elizabeth Edgar, Civil Engineering Undergraduate
William Lee, Civil Engineering Undergraduate
Jessie Gwinn, Civil Engineering Undergraduate

Intersection of Market Street and Hawthorne Boulevard
Rasha Kroonen, Civil Engineering Graduate
Homa Rabiee, Civil Engineering Graduate
Andy Vosper, Civil Engineering Graduate

Cordon Road Bridge Crossing
Jessie Boudart, Civil Engineering Graduate
Kristina Currans, Civil Engineering Graduate
Chris Muhs, Civil Engineering Graduate
Courtney Slavin, Civil Engineering Graduate

Interstate 5 Ramps in Salem
Chris Goya, Civil Engineering Undergraduate
Joe Strobel, Civil Engineering Undergraduate
Justin Willard, Civil Engineering Undergraduate

Table of Contents

Executive Summary

The City of Salem is adapting its current transportation infrastructure to enhance alternative modes of travel within the city. Salem is complying with the goals set forth in Vision 2020 – a comprehensive effort to secure a vibrant future for the downtown core and to create a more sustainable transportation system.

Portland State University's Department of Civil and Environmental Engineering explored various traffic safety concerns in the City of Salem. The Salem Transportation Safety Analysis was conducted by Portland State University civil engineering students. Intersections with high crash statistics and other safety issues were selected by the City of Salem for evaluation. Some of the locations did not have traffic problems but needed improved facilities to increase walking and biking.

The students were asked to recommend possible modifications and solutions to existing traffic safety concerns. Ten separate studies were conducted by the civil engineering students. The groups evaluated the existing traffic conditions and developed recommendations using traffic safety evaluation methods learned in the Transportation Safety Analysis course.

Intersection studies were divided into three groups; Neighborhoods, Major Intersections, and Interstate 5 Intersections.

Neighborhoods

The recommendations for the Bonnie Way and Cascade Drive intersection include vegetation clearance, better road markings and a mini roundabout. For the intersection of Winter Street, Fairgrounds Road, and Jefferson Street, it was recommended that the streets be reconfigured with two-way left turn lanes and restricted access on Winter Street. It is recommended that Judson Middle School provide new crosswalks with curb extensions and speed bumps. For general traffic calming in residential neighborhoods where emergency vehicle access can be a challenge, the use of chicanes is recommended.

Major Intersections

Center Street and Liberty Street recommendations include a change to existing traffic signs, new lane markings, and a curb extensions. Lancaster Drive and Sunnyview Road recommendations include a bus bay and new signal timing. It was recommended that the right turn lane be removed from Summer Street at the intersection of Marion Street and Summer Street. At Market Street and Hawthorne Boulevard, the signal timing could be improved.

Interstate 5 Intersections

A new multiuse bridge should be developed near the Cordon Bridge. For the Interstate 5 off- and on-ramps at Kuebler Boulevard, a package of recommendations was given, such as new pavement markings and a larger

turning radius for trucks. It was also recommended that a new off ramp at Commercial Street and Interstate 5 be further investigated after a preliminary study in this report suggests that the ramp may be possible to construct.

Introduction

The objective of the Salem Transportation Safety Analysis project is to evaluate existing intersections and make recommendations to improve the level of safety in accordance with goals set forward by the Salem Transportation System Plan. The Plan's goals include reducing the number of pedestrian accidents by 50 percent by the year 2015 as well as "developing a multifaceted transportation system with sufficient capacity to move people and goods efficiently and conveniently." This can be accomplished by evaluating potentially dangerous intersections and improving the level of safety for all users. The City of Salem is currently working on the Bike and Walk Salem Plan, an update to the Bicycle and Pedestrian element of the Transportation System Plan, which aims to update plans for bicyclists and pedestrians, prioritize bike and pedestrian transportation facilities and services, and obtain public input and support for these project concepts.

The study was conducted in the spring of 2011 as the focus of the Traffic Safety Analysis course, led by Dr. Chris Monsere, assistant professor in the Department of Civil and Environmental Engineering at Portland State University. Intersections with high crash statistics and other safety issues were selected for the students' evaluation by Kevin Hottman, City Traffic Engineer at the City of Salem. Some of the locations did not have traffic problems but needed improved facilities to increase walking and biking.

Ten separate studies were conducted by the civil engineering students. The students were asked to recommend possible modifications and solutions to existing traffic safety concerns. The groups evaluated the existing traffic conditions and developed recommendations using traffic safety evaluation methods learned in the course. Possible countermeasures were explained and final recommendations were made using one or a combination of countermeasures.

Neighborhoods

Bonnie Way and Cascade Drive

Bonnie Way, Cascade Drive, and Park Way Drive form a four-way intersection with stop signs on the minor road. Bonnie Way, which is the major street, approaches the intersection from the west. Cascade Drive approaches the intersection from the south and changes direction to the east at the intersection. Park Way Drive approaches the intersection from the north (see Figure 1).

Figure 1: Map of Bonnie Way and Cascade Drive.

Figure 2: View heading east on Bonnie Way.

Heading east, Bonnie Way has a significant downhill slope, often causing traffic to exceed 25 miles per hour. Due to the curves – first left and then right – the view is limited for oncoming traffic approaching the intersection from the opposite direction.

Figure 3: View from stop sign on southern approach.

Figure 4: Driveway hazards.

The minor road changes from Cascade Drive heading north into Park Way Drive. At Cascade Drive, stop visibility is extremely limited to the right due to the downhill angle of the curve, vegetation, and the placement of a sign.

It is also worth noting that two driveways are within a short distance from the intersection.

Findings

For intersections with a stop sign on the minor street, The American Automotive State Highway and Transportation Officials (AASHTO) sets the minimum required site distance at 150 feet from the center of the crossing lane to the east. Applying these standards to the Bonnie Way and Cascade Drive intersection, the visibility falls short of the minimum standards by 75 feet.

Figure 5: Site distances for Bonnie Way and Cascade Drive.

With low visibility and a downhill terrain leading to speeds of over 30 miles per hour on the major road, the intersection of Bonnie Way and Cascade Drive is currently a high risk area for collisions.

Countermeasures

Vegetation clearance is the cheapest, fastest, and most effective countermeasure to alleviate the visibility issues at the intersection. This may include any or all of: cutting the lower branches on the trees, removing some of the bushes, and relocating the sign to another location. As an example, the Florence (Oregon) City Code requires that vegetation not hang over a sidewalk at a height of any less than 8 feet, and at a street height of any less than 13 feet 4 inches. A clear vision area is defined as “a triangle extending inward 20

feet on each street from where both curb lines would come to a point if the curb was not rounded." Vegetation within this triangle may not exceed 30 inches height. Applying the Florence City Code to the Bonnie Way and Cascade Drive intersection, a visibility triangle is generated as shown in Figure 6.

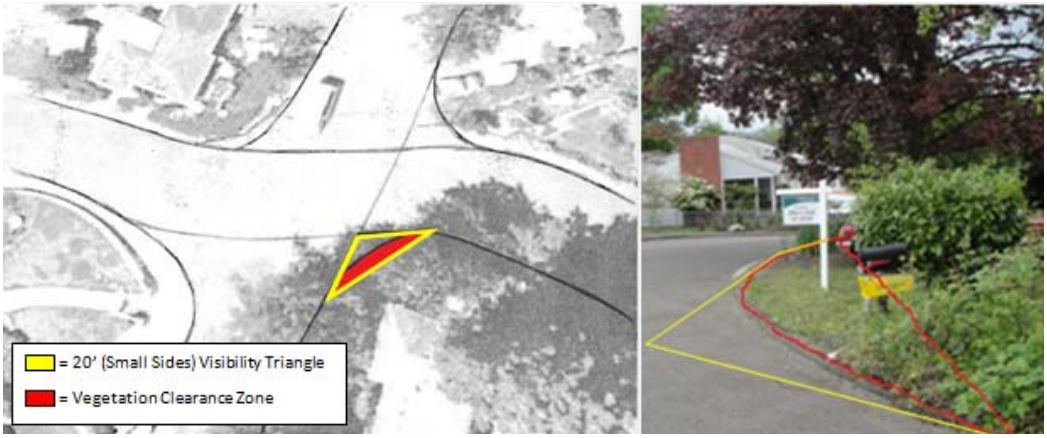


Figure 6: 20-Foot visibility triangle applied to Bonnie Way and Cascade Drive.

The mini roundabout is another traffic calming treatment to be considered at this intersection. The roundabout forces drivers to yield to other vehicles, creating a safe passage through the intersection. For this particular location, the mini roundabout would need to be elliptical in shape and designed to follow the slope of the land. The ellipse would be about 13 feet at its narrowest and up to 23 feet wide on the opposite axis, and would have a skewed placement.

Figure 7: Rough sketch of potential mini roundabout design.

Recommendations

The following are the recommended high and low cost options. It is recommended that the higher cost option be implemented due to its potential speed control and crash reduction features.

$ LOW COST OPTION

- Vegetation clearance on southeast corner property to enhance visibility
- No street parking on Cascade Drive east for first 200 feet
- Striping on Bonnie and Cascade Drive east to keep traffic separated

$$ HIGH COST OPTION (Recommended)

- Vegetation clearance on southeast corner property to enhance visibility
- No street parking on Cascade Drive east for first 200 feet
- Striping on all four approaches to keep traffic separated
- Yield sign installations on all 4 approaches to reduce speeds without inhibiting traffic flow
- Mini roundabout to reduce speeds and eliminate left hand turns

Figure 8: Recommendations for Bonnie Way and Cascade Drive.

The Intersection of Winter Street, Fairgrounds Road, and Jefferson Street:

Winter Street, Fairgrounds Road, and Jefferson Street come together to create a six legged intersection north of downtown Salem.

Figure 9: Aerial view of the intersection of Winter Street, Fairgrounds Road, and Jefferson Street.

Both Winter Street and Jefferson Street have stop signs. Fairgrounds Road has no traffic control devices. There are also no crosswalks for pedestrians within the intersection, but traffic stop bars are located on Jefferson Street and Winter Street. Land use near the intersection is a combination of residential and local business properties along Fairgrounds Road. On-street parking is also available on all of the streets, and motor vehicle volume for each street is relatively low.

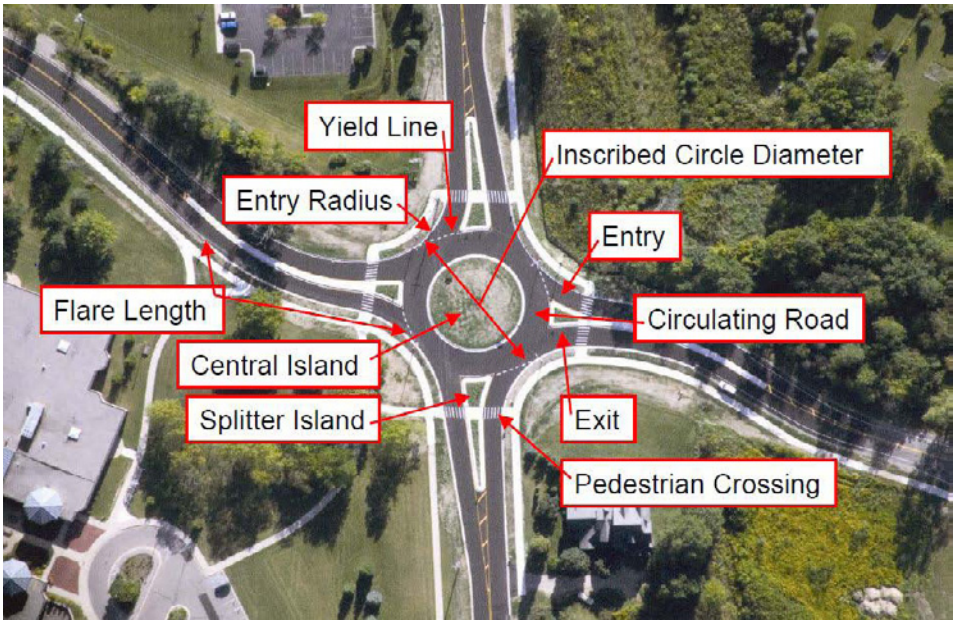
Findings

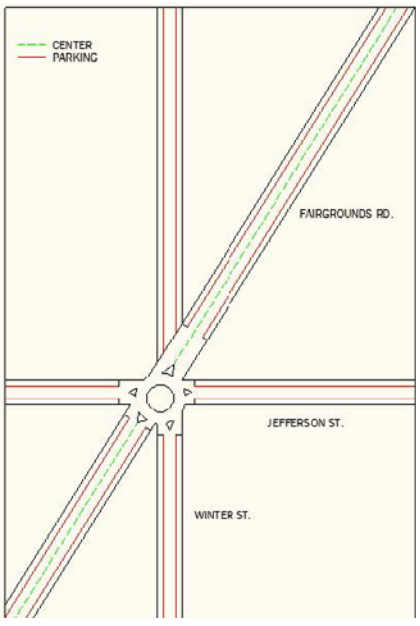
No collisions have been recorded at this intersection; the focus of this study is to increase safety and improve facilities for pedestrians and cyclists as well as to improve traffic flow for motor vehicles.

Countermeasures

A roundabout can improve traffic flow through an intersection and can minimize delays. Currently, there are 36 conflict points for autos and pedestrians at the intersection. Implementing a roundabout would minimize the conflict points to 12. One of the challenges of a roundabout at this intersection is incorporating the northern leg of Winter Street. In order to implement the roundabout at this intersection, restricting access to Winter Street would be necessary.

Another possible solution would be to reconfigure Fairgrounds Road with one lane in each direction and a center left turn lane, referred to as a Two Way Left Turn Lane (TWLTL) on Fairgrounds Road. The total roadway width is 40 feet: two 12 foot lanes with 8 feet for street parking on both sides of the road. With the TWLTL design, on-street parking would be removed. A left turn lane





Figures 10 and 11: Example design of a roundabout; Design of roundabout option.

would minimize rear end crashes on Fairgrounds and reduce the number of angle crashes at the intersection.

Another design option would be to restrict access by closing some streets to the intersection. Because of the surrounding land use and the number of access points along Fairgrounds Road, Winter Street could be closed to vehicle traffic at the intersection. This area of Salem is built on a grid system with Fairgrounds Road bisecting this neighborhood. If Winter Street loses access to Fairgrounds, there is another street that intersects 300 feet away. By restricting access to Fairgrounds Road, conflict points would decrease from 36 to 24. This would also make the intersection less complex for drivers and pedestrians.

Recommendations

It is recommended that a combination of TWLTL installation and restricting access to the intersection be implemented. When approaching this intersection from Jefferson Street, there is limited sight distance because of on-street parking. As part of the implementation of a TWLTL, on-street parking would be eliminated. By restricting access to the intersection from Winter Street, conflict points are minimized to 24. An additional recommendation would be to add crosswalks for pedestrians. There are currently no crosswalks at the intersection and providing them would make this intersection more pedestrian friendly.

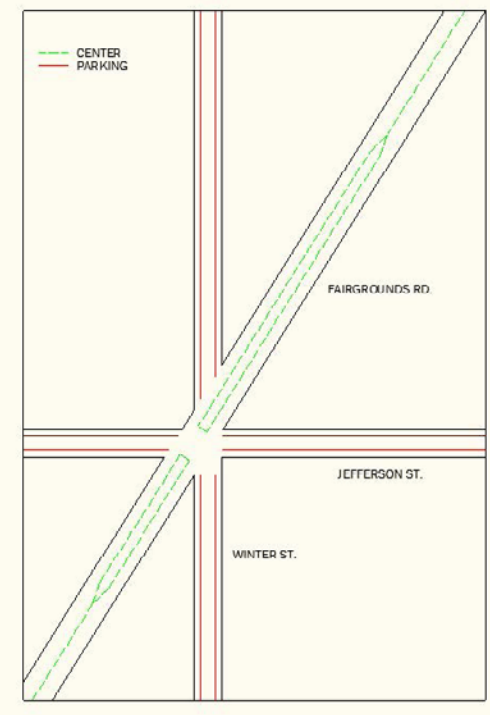


Figure 12: TWLTL design.

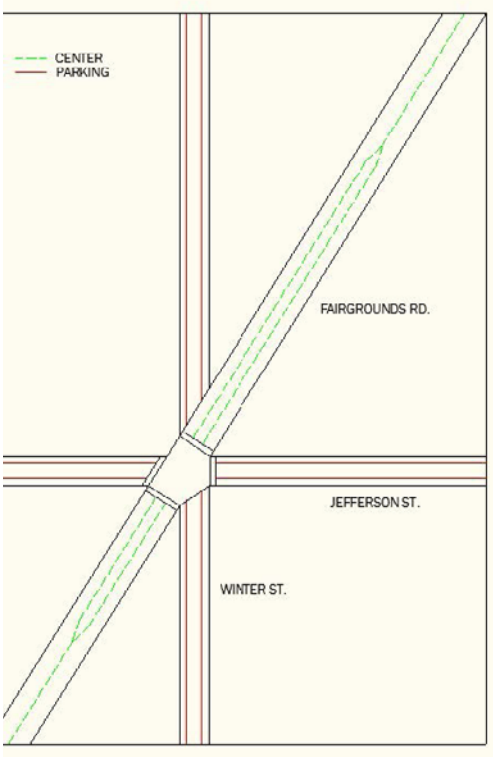


Figure 13: Final recommended design of intersection.

Judson Middle School

Transportation officials from the City of Salem and representatives from the Salem-Kaiser School District have expressed concern about the current status of traffic operations and pedestrian safety near Judson Middle School in Salem, Oregon.

Judson Middle School facilities include:

- a parking lot with designated bus pickup lanes adjacent to the building curb

- a separate through lane within the school parking lot
- a pullout area for parents in vehicles waiting along the northbound lane of Jones Road
- an agreement to use a large privately owned parking lot directly across Jones Road

The lack of pedestrian safety facilities along Jones Road has resulted in numerous parent complaints and parking enforcement issues.

Figure 14: Judson Middle School site.

The primary safety concern is the absence of pedestrian crosswalks on Jones Road. The school's transportation plan includes the use of a private parking lot across Jones Road, but no pedestrian facilities are provided for the students. A secondary safety concern involves crossing the parking lot. Although pedestrian crosswalks are painted within the school parking lot, directly in front of the school exit, school office staff have observed cars driving through the parking lot faster than the posted 5 mile per hour warning. Also, pedestrians do not always

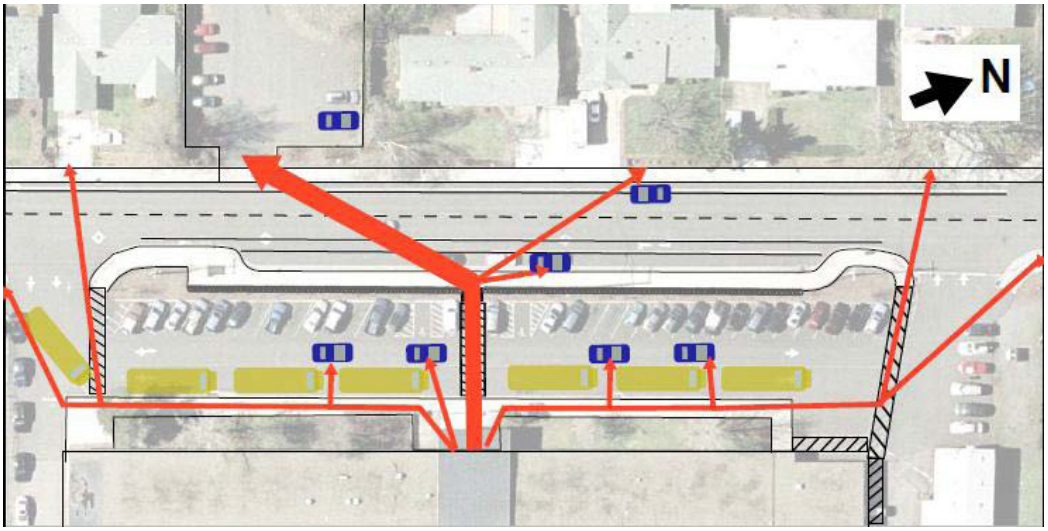


Figure 15: Student walking paths from Judson Middle School front door.

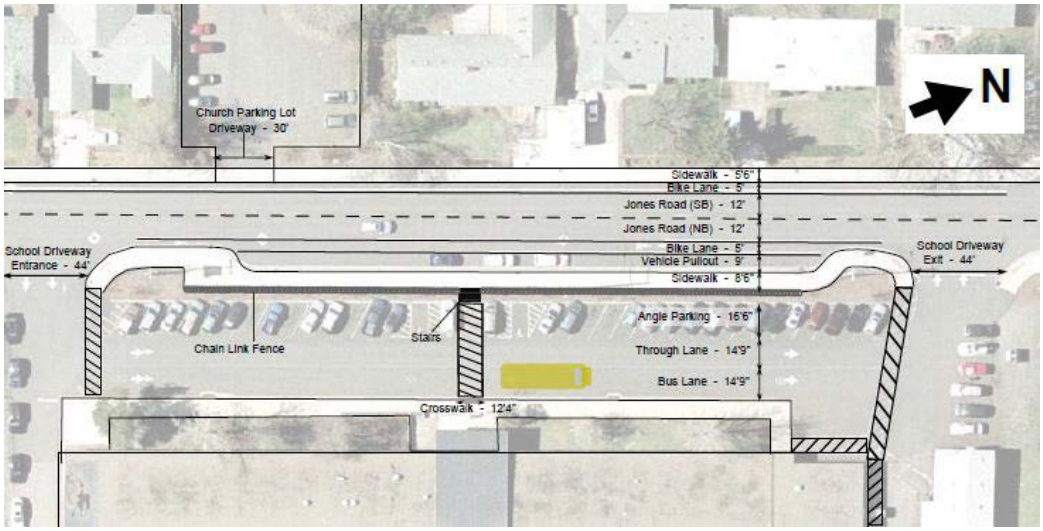


Figure 16: Existing roadway geometry at Judson Middle School.

use the crosswalks because they terminate at the sidewalk on the east side of Jones Road.

Findings

Students conducted a meeting with school officials and police officers assigned to the school to learn more about the reasons for the lack of pedestrian facilities. Previously, the school district and city officials considered possible remedies for the current safety concerns. According to the safety committee meeting minutes, “The team determined that a crosswalk/crossing guard would not be

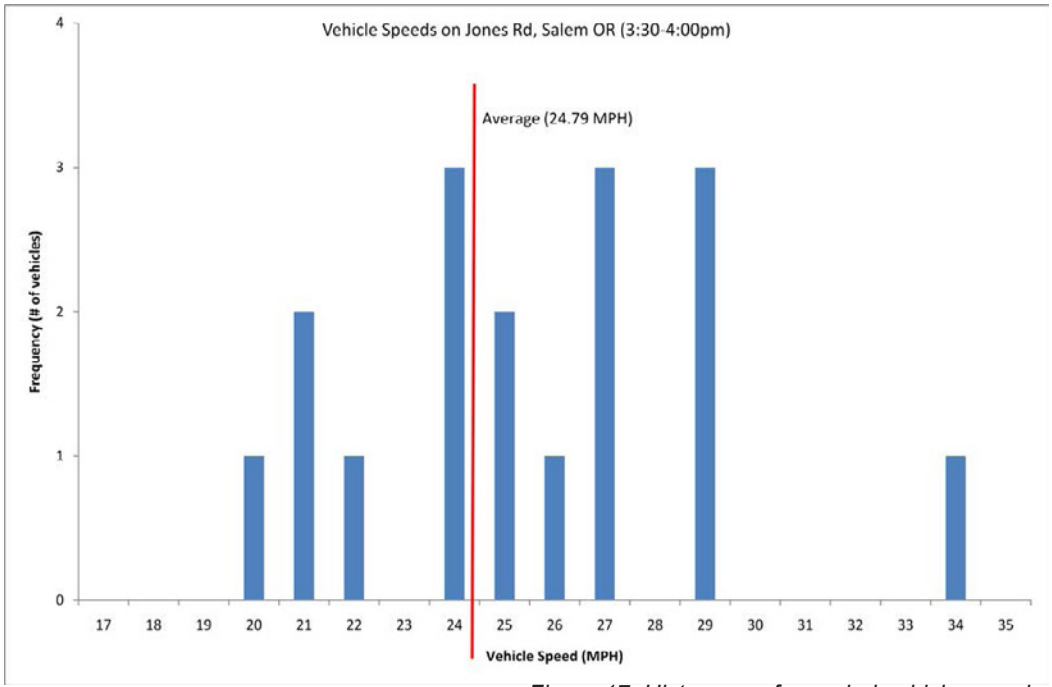


Figure 17: Histogram of sampled vehicle speeds.

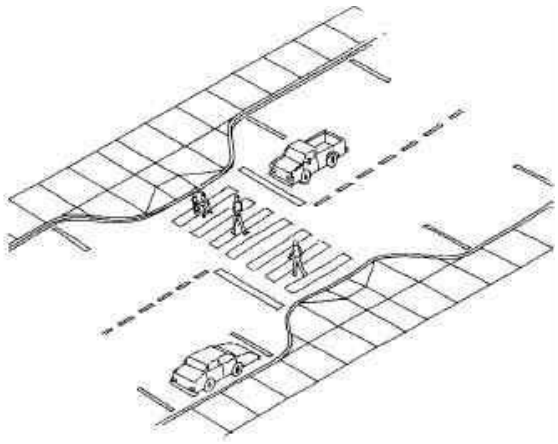
cost effective." Judson Middle School is the only middle school in the Salem-Keizer school district without a crosswalk and crossing guard.

Students took a small sample of vehicle speeds along Jones Road between 3:30 and 4:00 PM. Speeds ranged from 20 to 34 miles per hour, with an average speed of 25 miles per hour (see Figure 17). Approximately half of all vehicles tested were in violation of the 25 mile per hour posted speed limit.

Countermeasures

The installation of a crosswalk on Jones Road would create a continuously defined crossing corridor extending from the curb in front of the school, across the parking lot in front of Judson Middle School, and linking sidewalks on both sides of Jones Road.

In addition to the crosswalk, the installation of a curb extension at the east end of the crosswalk in the pullout parking lane is recommended. This would allow pedestrians to stand closer to Jones Road without the risk of cars pulling into a vehicle exclusion zone marked only by road striping.



Figures 18 and 19: Curb extension illustration; Conceptual illustration of curb extension and raised crosswalk on Jones Road.

Constructing an 8- to 10-foot-wide elevated crosswalk would enhance pedestrian visibility to motorists, particularly for smaller children. The elevated crosswalk would also serve as a traffic calming device during times of the day when school zone speed restrictions are not in effect.

Multiple lighted signal options are available to improve driver awareness of prominent crossing locations. Ideally, the City of Salem should consider adding both the elevated crosswalk and appropriate lighted beacons to alert motorists of this significant crossing.

To improve safety of pedestrians within the confines of school district property, additional or alternative measures may be taken, such as:

- Coordinate with school transportation officials to ensure school buses arrive prior to the release of students.
- Instruct school bus drivers to pull their vehicles as close as possible to the bus in front of them to prevent students from walking in between buses and risking injury from the bus directly or from unseen traffic.
- Assign a school employee to act as a crossing guard within the parking lot and require that person to arrive on duty before students are released and not leave until all buses have departed.
- Provide crossing guard with traffic control signage.
- Install a speed bump prior to the crosswalk within the parking lot.

Recommendations

To address the multiple concerns discussed in this report, a “package” of pedestrian facilities and traffic calming element are summarized in the table on the following page.

A crosswalk and curb extension are the minimum recommendations for pedestrian access improvements near Judson Middle School, but additional design elements can help increase driver awareness of pedestrians and create safe crossing opportunities.

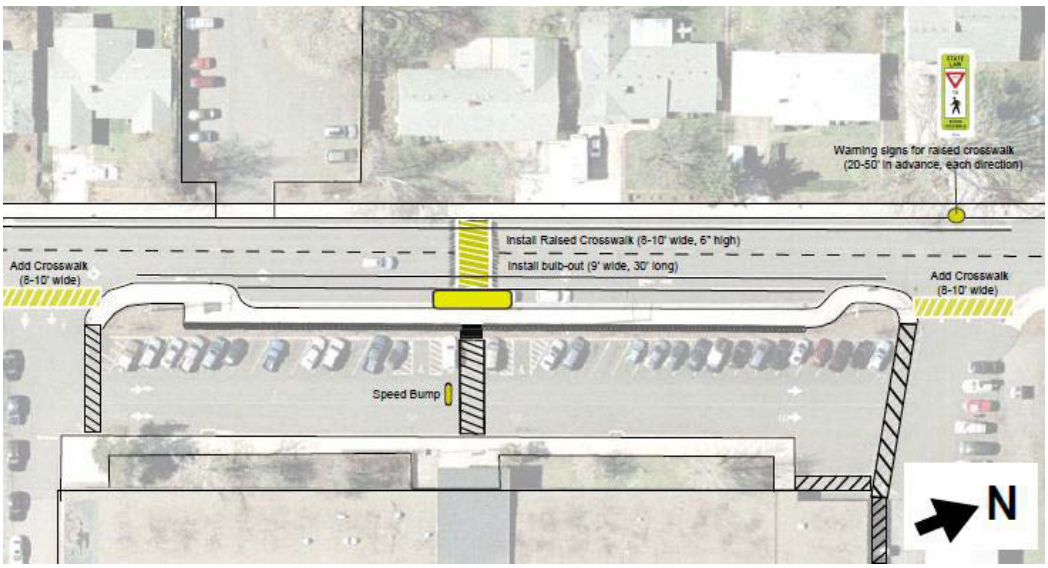


Figure 20: Plan view of recommended pedestrian safety improvements.

Figure 21: Summary of proposed recommendations.

Problem	Recommendation	Benefits	Tradeoffs
Lack of safe crossings on Jones Rd	Locate crosswalk from central exit of school parking lot across Jones Rd	• Encourages the most direct crossing path from school entrance • Reinforces where most students already cross	• West side of crosswalk is directly in front of private residence • Stair access from school parking lot is not ADA compliant
	Raise Crosswalk on a "speed table"	• Increases visibility of pedestrians • Reduces vehicle speeds	• Increased costs • Slows emergency vehicles and buses
	Include ADA-compliant color and texture at crosswalk ends	• Increases detectability of crossing location for visually impaired pedestrians	
Poor visibility of pedestrians waiting to cross from behind parked cars on Jones Rd	Install curb extension on east side of road in pullout parking lane	• Increases pedestrian visibility • Reduces crossing distance	• Eliminates some parking spaces • Increases costs
	Install signs, warning lights and other crossing enhancements	• Enhances awareness of pedestrian presence to drivers • More important if the crosswalk is not raised	• Adds costs
Lack of clear crossing paths in school parking lot	Restripe existing crosswalks in parking lot	• Reinforces pedestrian crossing paths • Increases driver awareness and expectation	• Adds initial costs
	Stripe new crosswalks across parking lot entrance and exit	• Indicates preferred crossing locations • Increases driver awareness and expectation	• Adds initial costs
High vehicle speeds in parking lot	Install speed bump(s) in parking lot	• Reduces vehicle speeds in lot	• Adds initial costs
Minimal coordination of students during school release time	Assign adult crossing guards in parking lot and on Jones Rd with appropriate signage	• Increases driver awareness of pedestrians • Encourages greater compliance from pedestrians and drivers • Improves overall organization of school dropoff/pickup activities	• Adds ongoing costs
	Coordinate school bus arrivals	• Reduces student wait time on the curb and associated risk	• May impact other schools
	Coordinate school bus parking locations	• Reduces opportunities for pedestrians to dart between buses	

Traffic Calming on Residential Streets in Salem

Some traffic calming techniques have already been implemented in Salem. These include signing, pavement markings, and horizontal and vertical roadway deflections. Narrowing of vehicle lanes is also used to induce slower vehicle speeds without imposing treatments such as speed bumps. Lane narrowing can also be accomplished by allowing parking on both sides of the street, a tactic common in several Salem neighborhoods. Permitting parking on both sides of the street can reduce access and increase response times for emergency vehicles.

Figure 22: A narrow street in Salem with ample on-street parking and a driveway on every property.

Emergency response agencies have raised concern over the deliberate narrowing of lanes. There are three main requirements for neighborhood street access:

- Adequate on-street parking
- The need for appropriate traffic calming measures to ensure vehicle speeds are kept within the desirable range
- The need for safe and efficient access for fire trucks and other emergency vehicles

Findings

Several neighborhoods were identified by Salem officials as areas containing streets that were problematic for fire truck access. These streets tend to be about 26 to 30 feet wide, often varying by block, with parking on both sides.

Students made a site visit to Salem to observe travel conditions and parking availability, and to determine any issues that might restrict fire trucks' access. Many neighborhood properties had a driveway, garage, or both in which to store personal vehicles. Although there was ample space for parking both on and off the street, several bottlenecks were observed in instances where two vehicles were parked directly across from one another. This creates an obstacle for fire trucks and makes it difficult to maneuver on neighborhood streets. The types of neighborhoods where these bottleneck conditions occurred are diverse. Some are in northeast Salem, with higher density and lower income residential areas. Other Salem neighborhoods, such as around Lincoln Street, are more affluent and have a lower residential home density.

Fairmount Street and Fir Street between Lincoln Street and Superior Street was chosen as the sample block for evaluation. This block was chosen for its narrow

street width and unaltered parking facilities. Several streets in Salem are narrow, but many of these streets have received alternative parking treatments, such as parking restrictions.

To ensure adequate parking, a minimum number of parking spaces was determined from the site characteristics. There was an average of 8.3 homes per block, which require 17 parking spaces per block. The average number of potential parking spaces available is 36 spaces, indicating a surplus of about 19 spaces per block.

Countermeasures

One method for improved emergency vehicle access on neighborhood streets is the removal of on-street parking from one side of the street. Assuming two 8-foot parallel parking lanes and one 10-foot travel lane, this solution would keep one 8-foot parallel parking lane and introduce two 9-foot through lanes which, when combined, would function as an 18 foot through lane for emergency vehicle access. This solution diminishes the benefits associated with lane narrowing and removes the traffic calming features already associated with many of Salem's neighborhood streets.

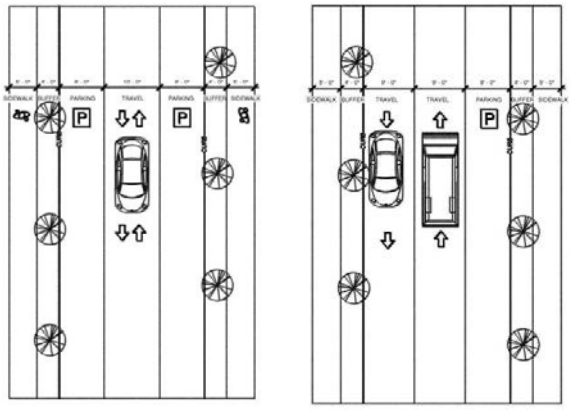


Figure 23: Plan view of the base conditions (left) and Alternative Plan #1 (right).

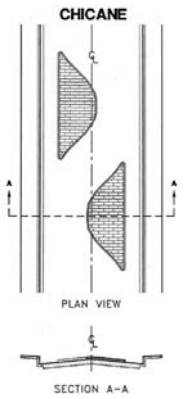


Figure 24: Chicane design. Source: http://www.acgov.org/pwa/programs_services_traffic_calming_level_3_chicanes.shtml

An alternative solution makes use of chicanes to ensure emergency vehicle access while retaining the traffic calming qualities inherent in streets with parking on both sides. Chicanes are a horizontal deflection traffic calming treatment consisting of curb bulb-outs at midblock locations that force motorists to maneuver through an angled roadway section. Chicanes reduce straight stretches of roadway with a tapered bulb-out.

Chicanes may be constructed using landscaped islands or extended walkways, though it is possible to create the effect of a chicane using alternating parallel parking with landscaped bulb-outs.

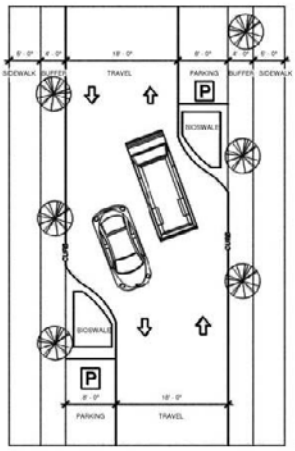


Figure 25: Traffic calming chicanes, plan view.

Figure 26: Rendering of traffic calming chicanes.

Parking-based chicanes provide traffic calming qualities while preserving the equivalent of one-sided on-street parking and maintaining a constant maximum-width through lane. Emergency response vehicles, given the opportunity to take both lanes of travel, are able to travel straight down the roadway.

Recommendations

It is recommended that the city of Salem employ chicanes on residential streets on the basis that it satisfies emergency vehicle access on streets and traffic calming in neighborhoods. Parking spaces would be reduced from 36 in the base scenario to 20-22 spaces, still exceeding the amount of parking needed for residences.

Major Intersections

The Intersection of Center Street and Liberty Street

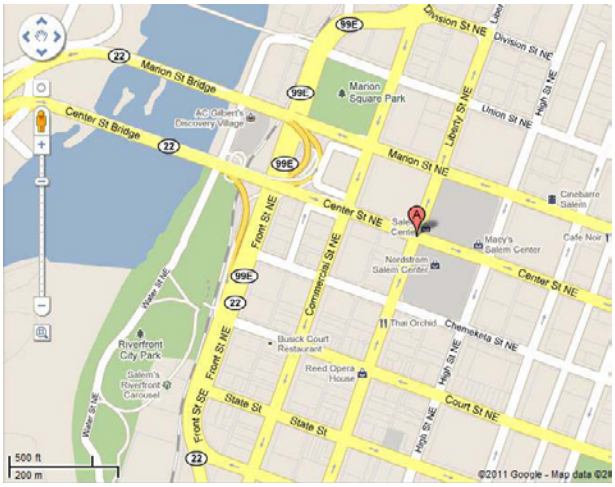


Figure 27: Intersection of Center Street and Liberty Street in Salem.

The intersection of Center Street NE and Liberty Street NE is located in the central commercial district of Salem. This intersection has been designated as a high vehicle crash area. The intersection is located approximately 1500 feet east of the Center Street Bridge and receives much of the traffic exiting the bridge eastbound. The Center Street Bridge heading east, along with the Marion Street Bridge heading west, serve as the sole automobile access between the east and west sides of Salem.

Center Street NE and Liberty Street NE are both four-lane one-way minor arterials. The Center Street approach has a left-turn-only lane, a left-turn/through lane, and two through lanes. The Liberty Street approach has a right-turn-only lane, a right-turn/through lane, and two through lanes. Average annual daily traffic volumes at this intersection are 24,460 vehicles per day for the eastbound approach on Center Street and 16,160 vehicles per day for the northbound approach on Liberty Street.

According to the City of Salem Public Works Department, a disproportionately large number of collisions at this intersection occur between vehicles in the turn-only lanes attempting to continue straight, striking turning vehicles in the turning/through lanes.

Findings

Several observations were made during the site investigation:

- Pedestrian and turning vehicle movements were given the right-of-way simultaneously. Note that a vehicle in the inside lane would block the pedestrians' view of cars in the outside turning lane.
- The "Right Lane Must Turn Right" signs on Liberty Street were obstructed by foliage and construction vehicles.

Figure 28: Pedestrian using the crosswalk spanning Liberty Street.

Figures 29 and 30: "Right Lane Must Turn Right" sign obstructed by tree on Liberty Street near intersection with Center Street; "Right Lane Must Turn Right" sign obstructed by construction vehicles on Liberty Street.

Figures 31 and 32: Low traffic volume in the right lane of Liberty Street north of intersection; Lane control signage at Center Street and Liberty Street.

- The traffic volume for the rightmost lane of Liberty Street north of the intersection with Center Street was low.
- Drivers in the turn-only lanes are mistakenly looking to the turning/through lane signs.

Countermeasures

A possible solution to the problem of drivers following the wrong signage would be to replace the two existing lane control signs with a single sign. Black backings could also be placed on the signs to increase visibility.

An affordable and simple solution would be to increase visibility of the current signage by pruning foliage.

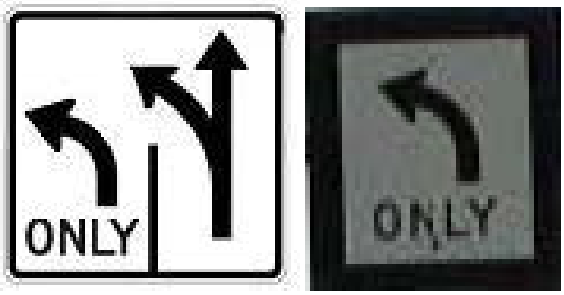


Figure 33: Lane control signage.

Another option involves repainting the roadway in order to increase driver awareness of lane markings. Re-striping the two turning lanes would be relatively inexpensive.

Constructing a curb-extension on the northeast corner of the intersection could deter right-turn movements on Liberty Street and left-turn movements on Center Street from traveling through the intersection. Currently, drivers in the turn-only lanes looking through the intersection see their lanes continue. Installing a curb extension may serve as a visual cue that the lane no longer continues.

Recommendations

The following countermeasures are recommended in order of increasing cost:

- The foliage covering the “Right Lane Must Turn Right” signage along Liberty Street should be trimmed or removed so as to increase the visibility of these signs for drivers.
- Back plates should be installed on the “Turn Only” and “Turn/Through” signage for Center Street to increase the visibility of these signs.
- The lane markings for the two turning lanes on Center Street should be restriped in order to make these markings more prominent to drivers.
- The two lane control signs for Center Street should be replaced with a single sign to avoid driver confusion about which of the turning lanes is the turn/through lane.
- A curb extension at the northeast corner of the intersection would serve as a traffic-calming device, would encourage pedestrian safety, and would reduce accidents caused by vehicles in the turn-only lane continuing through the intersection.

Lancaster Drive and Sunnyview Road; A High Crash Location

The intersection of Lancaster Drive NE and Sunnyview Road NE is located in a commercial area east of Interstate 5 in Salem. Lancaster Drive has an annual average daily traffic volume (AADT) of 30,000 vehicles per day. Sunnyview Drive has an AADT volume of 15,000 vehicles per day. This intersection experiences the second most number of crashes in Salem. The intersection with the highest number of crashes is directly north of this intersection, at Lancaster Drive and Market Street.

Figure 34: Lancaster Drive and Sunnyview Road.

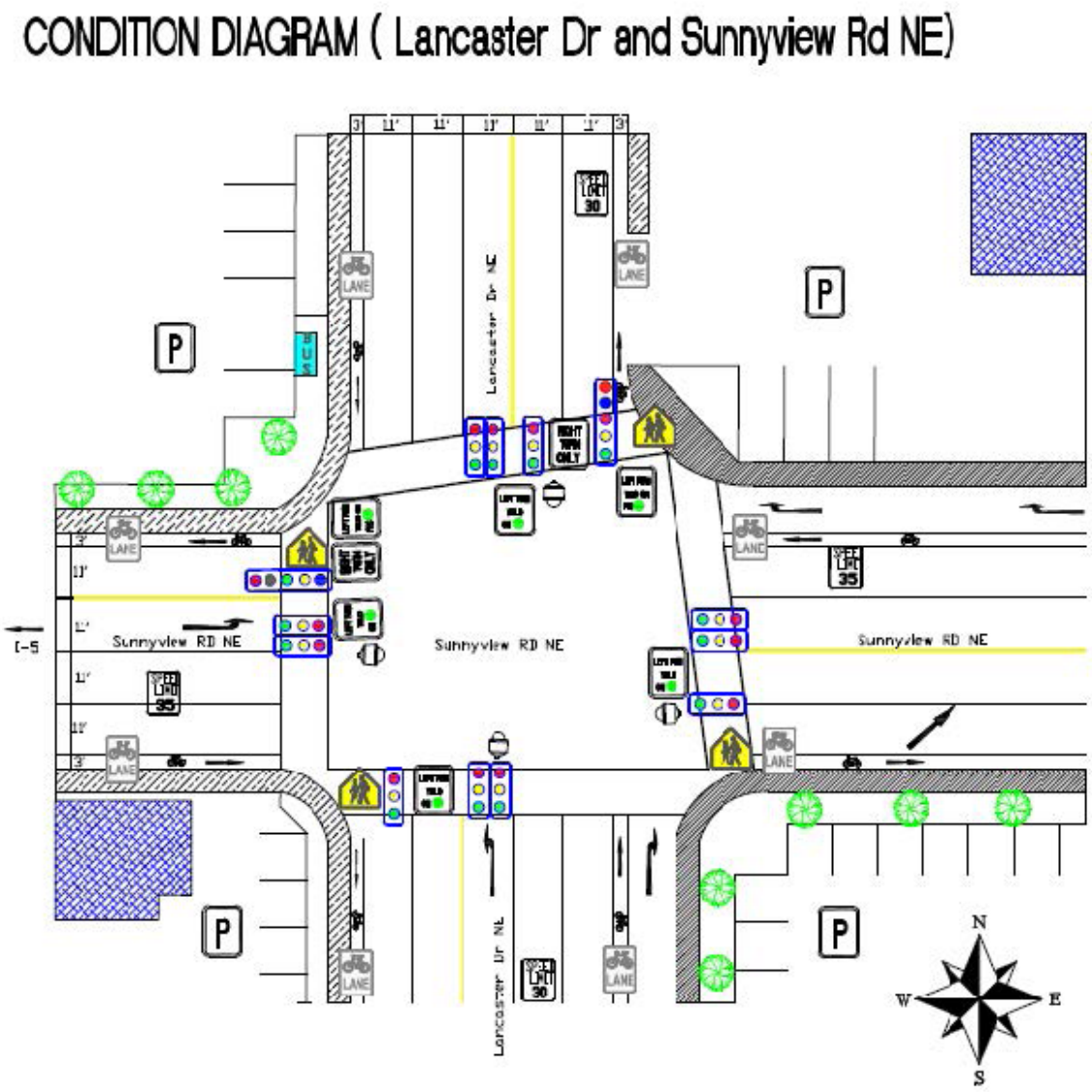


Figure 35: Detailed condition diagram.

Findings

During a site visit of the intersection students observed the following conditions:

- Too many large signs promoting area businesses at heights similar to traffic signs create visual clutter.
- Access points to businesses are too close to the intersection.
- Driver behavior was aggressive, particularly in getting into left-turn lanes and into private driveways and business entrances.

Thirty-two crashes occurred at the intersection between 2006 and 2008. The most common types of accidents at the intersection were:

- Left-turn collisions
- Rear-end collisions
- Angle collisions

Figure 36: Visual clutter.

Countermeasures

One possible solution that could improve traffic flow at the intersection is to add a bus bay on Lancaster Drive at the northwest corner of the intersection. There are 15 minute headways for bus route 11 on weekdays along Lancaster Drive. Frequent bus service and close proximity of bus stop to intersection cause delays for both automobile drivers and buses.

Figure 37: Current bus stop.

A bus bay could be constructed by converting an underutilized parking lot behind the stop,. This would reduce the queue during peak hours, eliminate vehicles making erratic movements in order to avoid the queue, and most

importantly, it would reduce the number of crashes at this intersection, especially for rear-end and side-swipe crashes. A concern about this countermeasure, however, is that bus drivers may experience difficulties when pulling out of the bus bay to rejoin the traffic flow. This can cause delays to the bus service and may lead to bunching of buses.

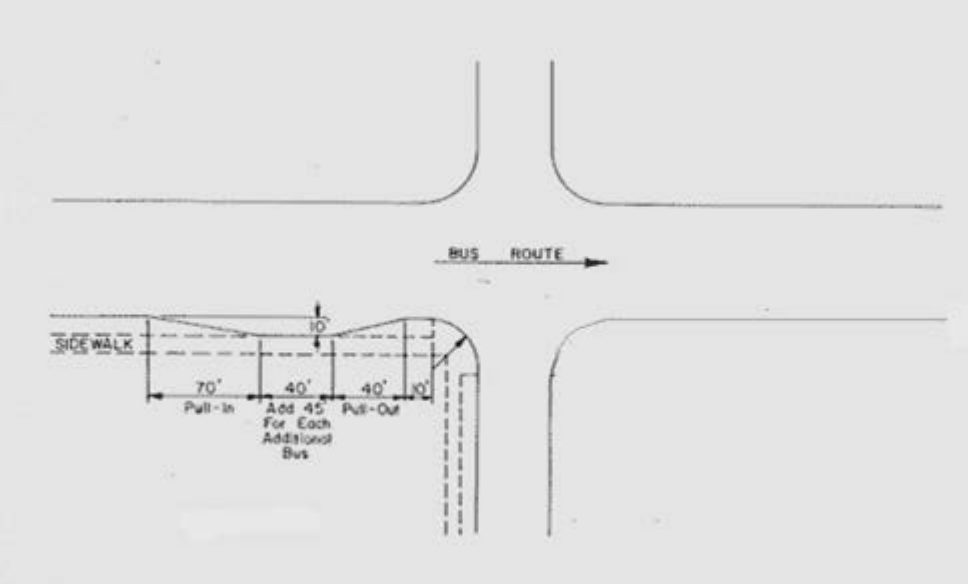


Figure 38: Potential bus bay design.

Figure 39: Example bus bay.

The protected left-turn signal time on Lancaster Drive was observed to be too short. An increase to the left-turn-green time on Lancaster Drive would reduce the green phase length on Sunnyview Road without changing the signal cycle length for the intersection. This is an inexpensive alternative, but it could cause delays on Sunnyview Road.

Visual clutter exists at this intersection. Visual clutter can cause drivers to get distracted or become confused. It is recommended that traffic signs be placed at the same height and use uniform lettering. City of Salem transportation staff should work with the planning department to enforce commercial sign codes and rewrite signage codes to eliminate unnecessary or distracting commercial signs around the intersection. The protected right-turn signal should be eliminated, as it adds to the clutter and can be perceived as contradictory, since a red ball and green arrow appear at the same time.

Figure 40: Traffic signals at intersection.

Recommendation

It is recommended that the countermeasures outlined in this report be further analyzed by the City of Salem for implementation and budgetary purposes. No single countermeasure stands out as being most effective at this point. Implementation of some or of all the countermeasures should be considered. Pedestrians must be considered high priority in order to increase safety at the intersection. Despite conditions not typically conducive to a pedestrian environment, many pedestrians were observed utilizing the facilities. There are opportunities to make livability improvements at this location for all users, especially for pedestrians, who will add to the vibrancy of the area.

Figure 41: Intersection of Summer Street and Marion Streets.

The Intersection of Marion and Summer Street Streets

The intersection of NE Summer Street and NE Marion Street is located in downtown Salem. There are several safety concerns with the current configuration of this intersection. Currently, the intersection has a dedicated right-turn lane and a through lane with a right-turn option. These two lanes are separated by a pedestrian refuge.

The current configuration of the intersection poses unnecessary risks to motorists, cyclists, and pedestrians. The intersection's unique geometry causes confusion among users. Unexpected turning movements by motorists at the intersection also pose a safety concern.

Findings

Seven crashes have occurred at the intersection between 2007 and 2010. The majority of crashes occurred between 4 and 9 PM. The proportion of wet and dry road conditions were found to be statistically equivalent with four accidents occurring under dry conditions and three occurring when wet. The proportions were the same for clear and rainy conditions. Of all the reported crashes, none were found to be related to drugs or alcohol; speed, however, was found to be a factor in one of the crashes.

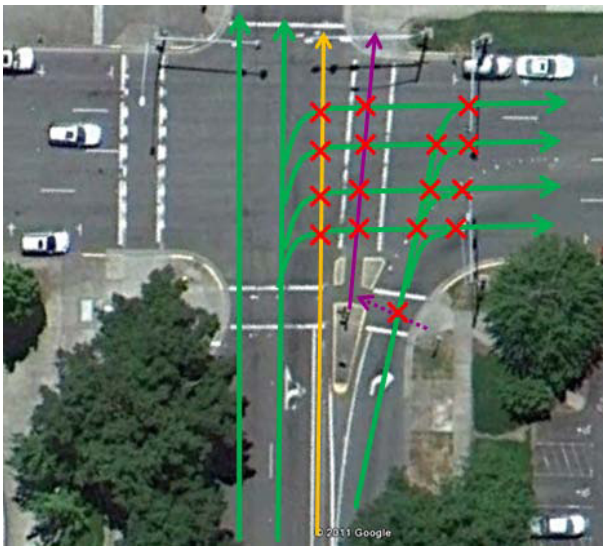


Figure 42: Conflict point analysis on Summer Street.

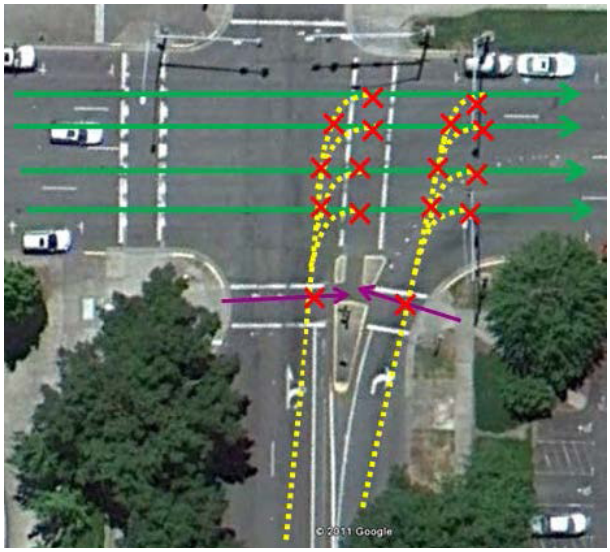


Figure 43: Conflict point analysis on Marion Street.

There are 16 potential conflicts when southbound traffic on Summer Street has a green light. When Marion Street westbound has a green light there are also 16 potential conflict points.

Conflict point analysis was conducted at the intersection. Results are shown in Figures 42 and 43. Arrow line colors are described as follows:

• Green lines indicate signal controlled vehicular through movements.

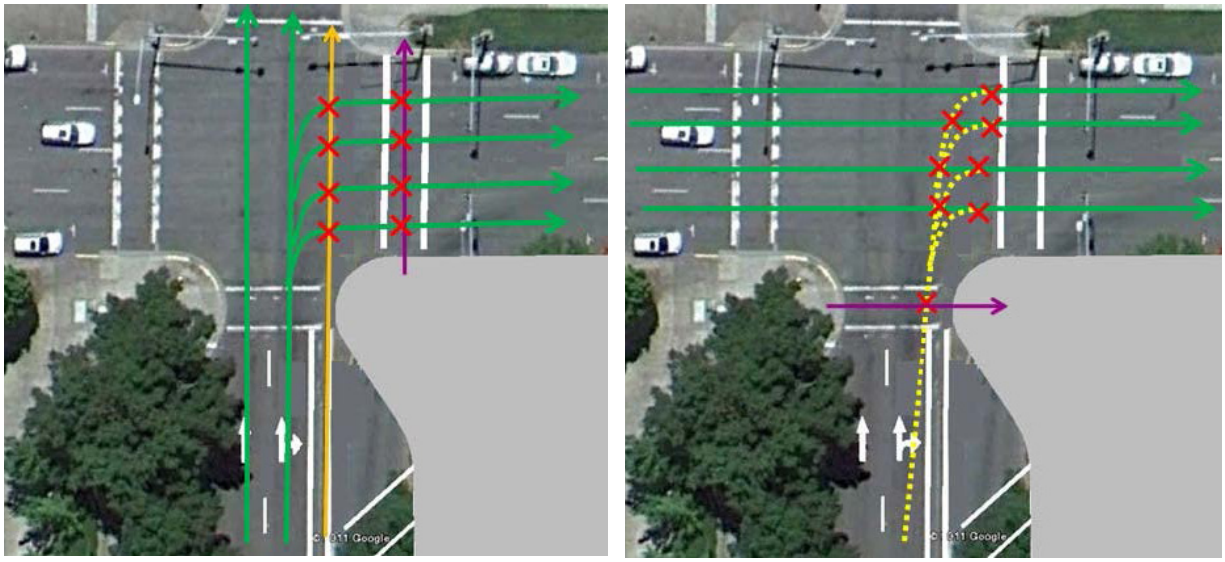
• Dashed yellow lines indicate yielded turning movements.

• Orange lines are potential bicycle movements.

• Purple solid and dashed lines indicate pedestrian movements, both allowed and yielded respectively.

Countermeasures

The current intersection configuration has 16 potential conflict points on each signalized green phase approach. In order to decrease the number of conflict points, the replacement of the far right turn lane with a curb extension on the northwest corner of the intersection could be used. The curb extension would eliminate the existing pedestrian refuge, allowing pedestrians to cross Marion Street directly in one signal phase. In addition to increasing the level of safety at the intersection, installing the curb extension would decrease the pedestrian crossing distance and could also allow for addition of on-street parking. Elimination of the right-turn lane would also remove a conflict point between



Figures 44 and 45: Conflict points on Summer Street with potential curb extension; Conflict points on Marion Street with potential curb extension. Both figures show potential new on-street parking at the lower right.

cyclists and cars moving into the right-turn lane north of the intersection on Summer Street. The curb extension configuration would reduce the number of conflicts from 16 to 8 for each of the green signal phase movements.

Incorporating a no turn on red policy at the intersection would eliminate eight additional conflict points that remain at the intersection when southbound traffic on Summer Street is permitted to turn right on red.

Recommendations

The project team recommends that the City of Salem remove the dedicated right-turn lane in conjunction with installation of a curb extension. The recommendations proposed in this report are intended to increase the level of safety to all users. This reduction will increase the level of safety at the intersection and will improve bike and pedestrian accessibility. Through the implementation of the recommended changes, safety can be improved by reducing the number of potential user conflict points.

Interstate 5 Intersections

Intersection of Market Street and Hawthorne Boulevard

The intersection of NE Market Street and NE Hawthorne Boulevard is a high-volume, four-leg signalized intersection located within the City of Salem. The intersection is located within a busy commercial area and is less than 500 feet from the approaches of a Single Point Urban Interchange (a type of highway interchange controlled by a single set of traffic signals) on Interstate 5.

Market Street is a four lane undivided arterial that runs in the east-west direction starting at Front Street Northeast and ending when it changes to Highway 213 shortly after intersecting NE Hawthorne Boulevard. Hawthorne Boulevard is primarily a four-lane undivided arterial that runs in the north-south direction in close proximity to Interstate 5 starting at Highway 99 East on the south end and ending as dead-end street by the Haysville Cemetery north of Salem.

Figure 46: Google satellite view of Market Street and Hawthorne Boulevard intersection.

The traffic on Hawthorne Boulevard approaches the intersection at a curve in the road. Each approach to the intersection has adequate space for queues. Sidewalks and curbs are included on every street. The intersection at Market Street has three westbound lanes, two protected left-turn lanes, and three eastbound lanes. The far right lane in the westbound direction merges left immediately west of the intersection, changing the width of Market Street with three westbound lanes, one protected left-turn lane, and three eastbound lanes. The posted speed limit on Market Street is 30 miles per hour.

Hawthorne Boulevard has the same configuration on both sides of the intersection with five lanes in both directions; one through and right-turn lane, one through lane, one left-turn lane, and two through lanes. The right lane of Hawthorne Boulevard in the southbound direction of traffic merges left after the intersection. The posted speed limit on Hawthorne Boulevard is 35 miles per hour.

The land use around the intersection is mainly commercial, although residential development does exist in the vicinity. The majority of the developments immediately adjacent to the intersection are hotels, restaurants, and shopping malls targeting Interstate 5 users as well as local residents. This land use pattern results in a high proportion of drivers who are unfamiliar with the area trying to understand and observe the intersection.

Another important component in the area is the Market Street Park-and-Ride located on the northwest corner of the intersection, which provides parking for 150 cars. This indicates heavy commuter traffic during rush hour.

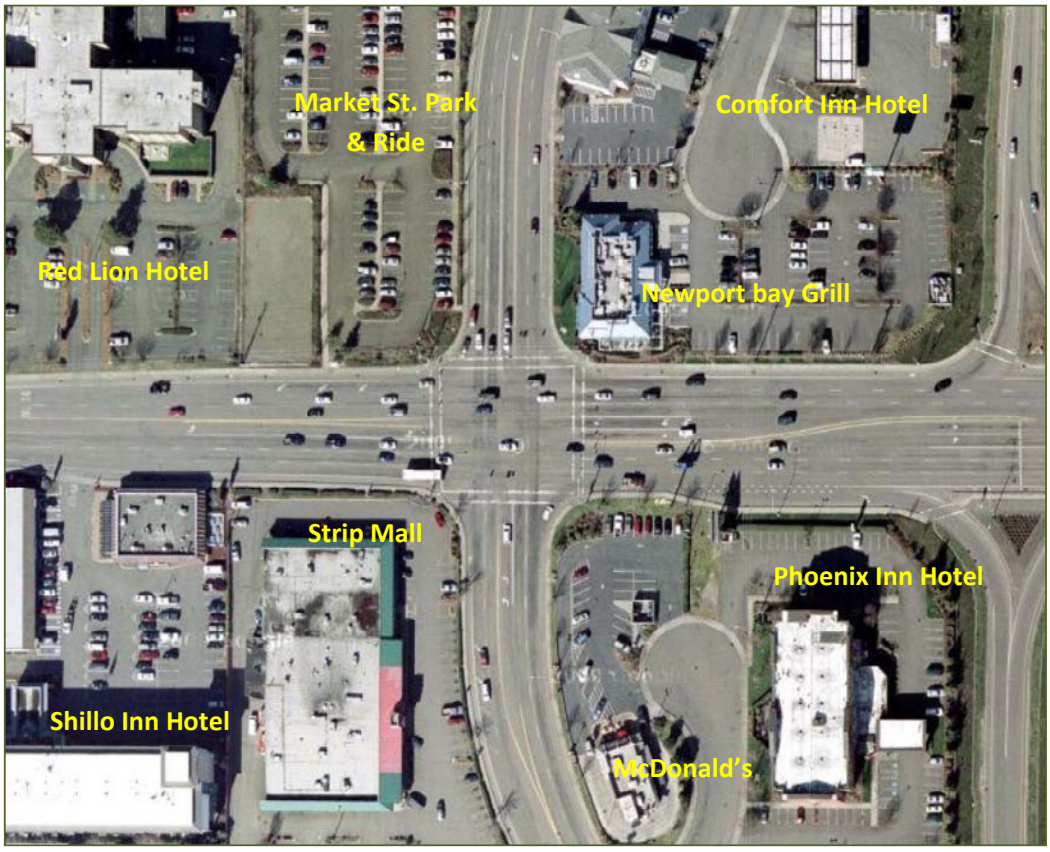


Figure 47: Land use around the intersection of Market Street and Hawthorne Boulevard.

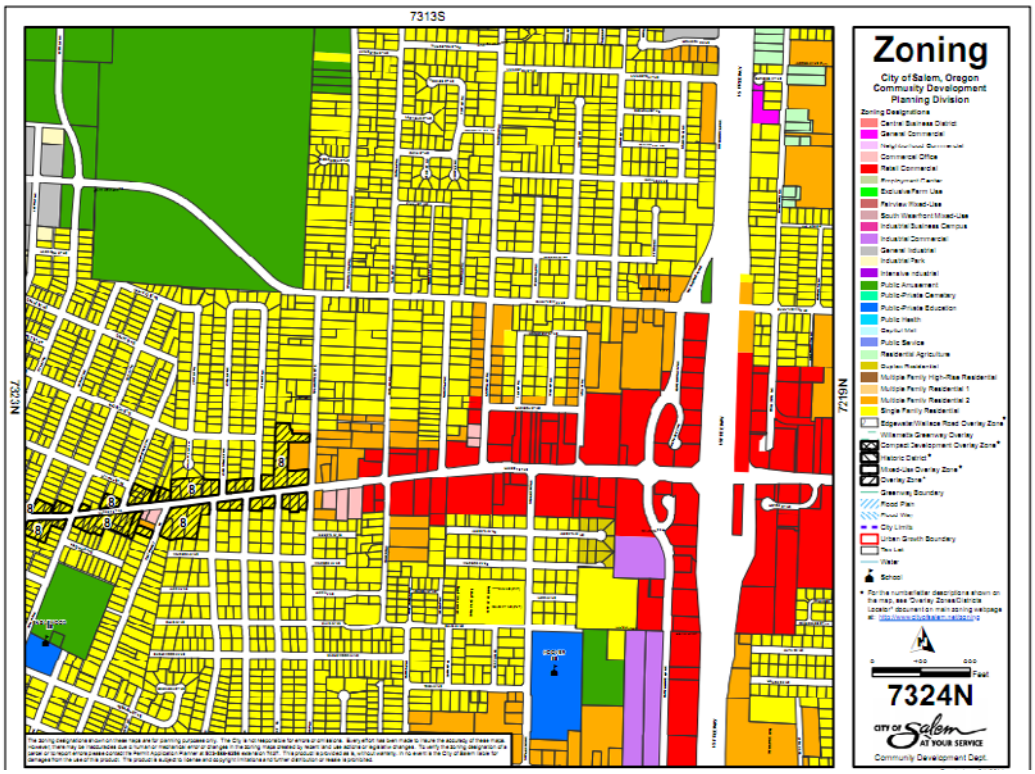


Figure 48: Zoning map of the intersection of Market Street and Hawthorne Boulevard.

Findings

A site investigation visit was conducted to identify traffic flow and potential conflicts. The sight distance lines are sufficient on Market Street; however, the sight distance may deteriorate when high volumes of vehicles and heavy trucks come into the intersection during rush hours due to the close proximity of Interstate 5 and land use trends in the area. Long vehicle queues develop during peak hours. Hawthorne Boulevard has poorer sight distance due to its curved geometry.

These observations point to the primary reason for the high number of rear-end crashes at the intersection.

Figure 49: Sight lines on Hawthorne Boulevard.

A conflict area was observed between vehicles turning right (east) from the unprotected right-turn lane on northbound Hawthorne Boulevard onto eastbound Market Street and vehicles traveling north on the same approach conflicting with vehicles turning left from southbound Hawthorne Boulevard onto eastbound Market Street.

Figure 50: Illustration of site visit observed conflict.

Figure 51: Illustration of site visit observed conflict.

Another observed conflict was between drivers turning left from westbound Market Street onto southbound Hawthorne Boulevard with oncoming traffic traveling east through the intersection on Market Street. This was mainly due to the undefined left-turn pathway pavement markings in the intersection and drivers turning left disregarding the signal because of short signal timing.

There was total number of 70 crashes in Market Street and Hawthorne Boulevard intersection reported from 2006 to 2010. After evaluating crash data, the result indicates that the total crash rate for this intersection is less than critical rate, and therefore not statistically significantly higher than crash rate of similar sites around the State.

Countermeasures

Installations of red-light cameras have proven to deter drivers from running red lights; however, there is a negative impact of increasing rear-end crashes. Only cameras watching the movements originating from the north and south of the intersection are feasible in this case. Red light cameras can be used to collect red light violations and late exit data for the through movement before and after implementation of the all-red clearance interval.

Driver confusion can exist in regard to choosing the proper turn path. This is especially relevant at Market Street and Hawthorne Boulevard intersection where the overall pavement area of the intersection is large. Delineation of turn paths is especially useful to drivers making simultaneous opposing left turns. Providing positive guidance to the driver in the form of pavement markings can help eliminate driver confusion and can eliminate vehicle conflict by “channeling” vehicles into their proper paths.

Changing the signal timing phase to make the right turn from northbound Hawthorne Boulevard a protected right turn would reduce the amount of conflicts with the traffic turning left from southbound Hawthorne Boulevard onto eastbound Market Street.

Lengthening the protected left-turn signal time on westbound Market Street and on northbound Hawthorne Boulevard would provide motorists a period of time where left turns can be made without encountering conflicting vehicular and pedestrian movements. Adjusting the signal timing on these approaches would reduce the number of cars that remain in the queue and would mitigate the urge of drivers to speed up to make it through the intersection.

Recommendations

It is recommended that an extensive signal timing study be conducted to determine an improved signal timing phase that includes the possibility of adding a right-turn phase, or adjusting the left-turn phase timing. Adding pavement markings and scribing path markings for multiple turn lanes are also recommended strategies.

Cordon Road Bridge Crossing

Cordon Road Bridge Crossing is located east of Interstate 5 and crosses over Highway 22. The bridge connects two residential districts on the outskirts of the city and acts as a thoroughfare to Lancaster Mall, a large commercial center. Cordon Road crossing is also close to Corban University. The current crossing facility features a striped shoulder that functions as a bike lane and a sidewalk. The width of the lane is inadequate for pedestrians and bicyclists to cross the bridge simultaneously.

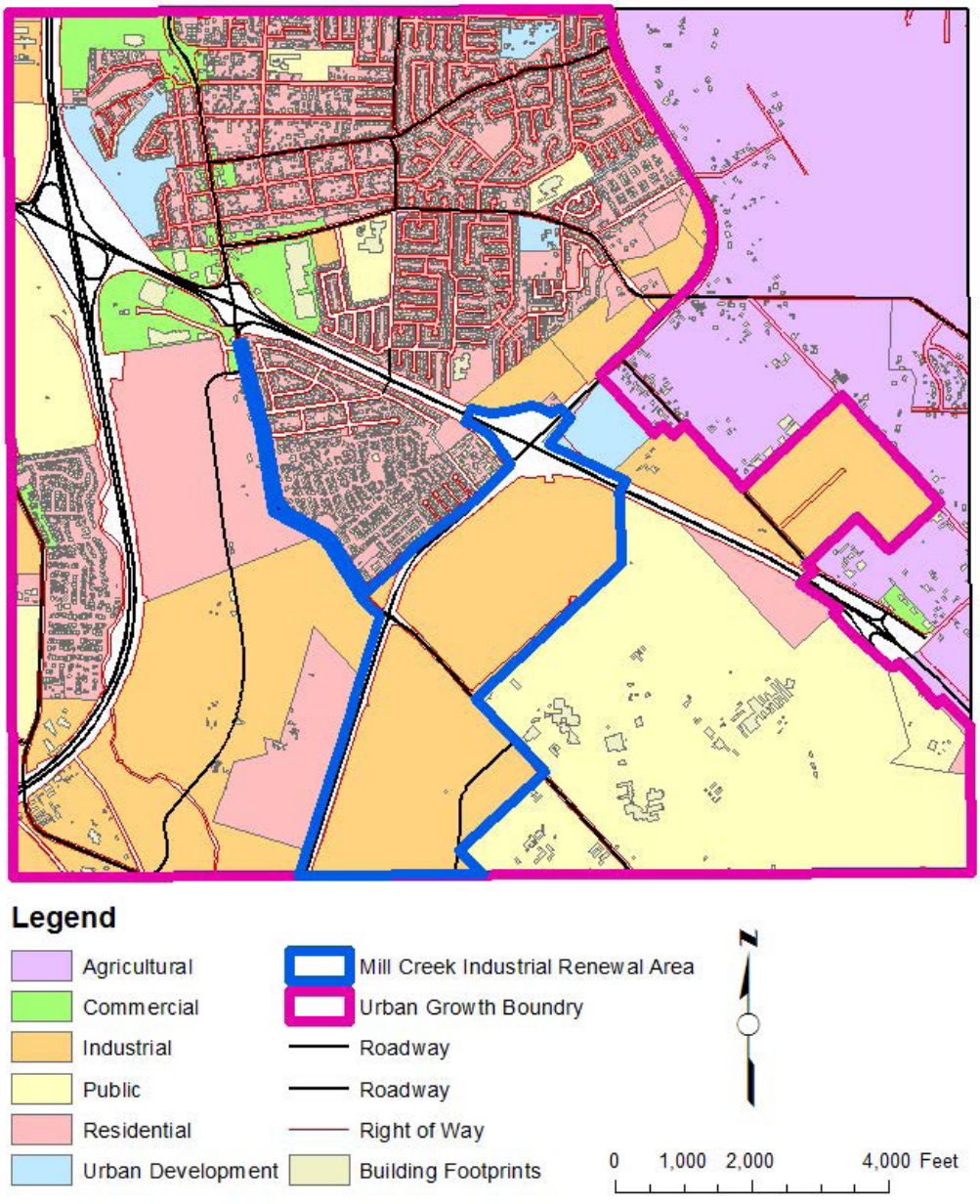


Figure 52: Land use map of Cordon Road crossing Santiam Highway.

The speed limit is 55 miles per hour on Cordon Road, which is not conducive to safe bicycling or walking. Recently, a pedestrian died after falling off of the bridge, potentially due to a low handrail and other factors. The bridge is also due for structural renovations in the coming decades.

Near the Cordon Road crossing, land use is mixed residential and commercial. An 828-acre area of land nearby is designated as the Mill Creek Corporate Center. This urban renewal area (URA) is estimated to bring 5,000 jobs to the Salem area over the next 15 to 20 years, encouraging residential growth and increasing trip-making activity in the area. This projected growth will increase traffic for all available modes on Cordon Road. While only 3 percent of the area's land may be allocated to retail-type services, an estimated 5,000 commuting trips to this URA are forecast to be attracted daily (Transportation Plan, 2007). As found in the URA plans for Mill Creek, the multi-use path extending along Cordon Road (with the exception of the North Santiam Highway crossing) fronts the new industrial roadways and extends the opportunity for bike commute trips. The anticipated growth would also increase demand on the Cordon Road crossing of the Santiam Highway for vehicles, pedestrians and cycling traffic.

Findings

Currently, Cordon Road has bicycle lanes, but they narrow down to two feet in width on the portion of the bridge that crosses Highway 22. According to the City of Salem Transportation Plan, bicycle lanes should vary in width from four to six feet. Bicycles require 40 inches of operating width due to normal sideways movement that occurs while cycling as a result of such factors as instability, wind, and cycling proficiency.

Cordon Road is classified as a parkway under the City of Salem Transportation Plan. A parkway is a "high capacity, high speed, roadway that primarily serves regional and intra-city travel;" lowering the 55 miles per hour speed limit on Cordon Road is therefore unlikely.

Figure 53 illustrates a typical parkway cross-section, which includes an 8-foot bike lane and two 12-foot travel lanes in each direction. There is also a 16-foot

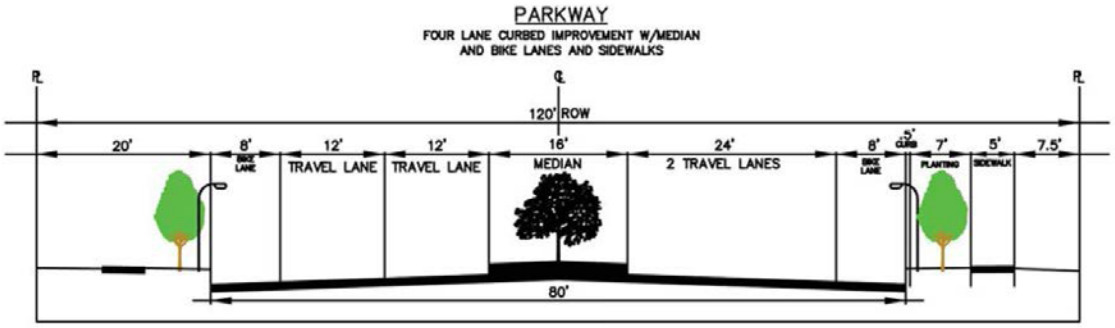
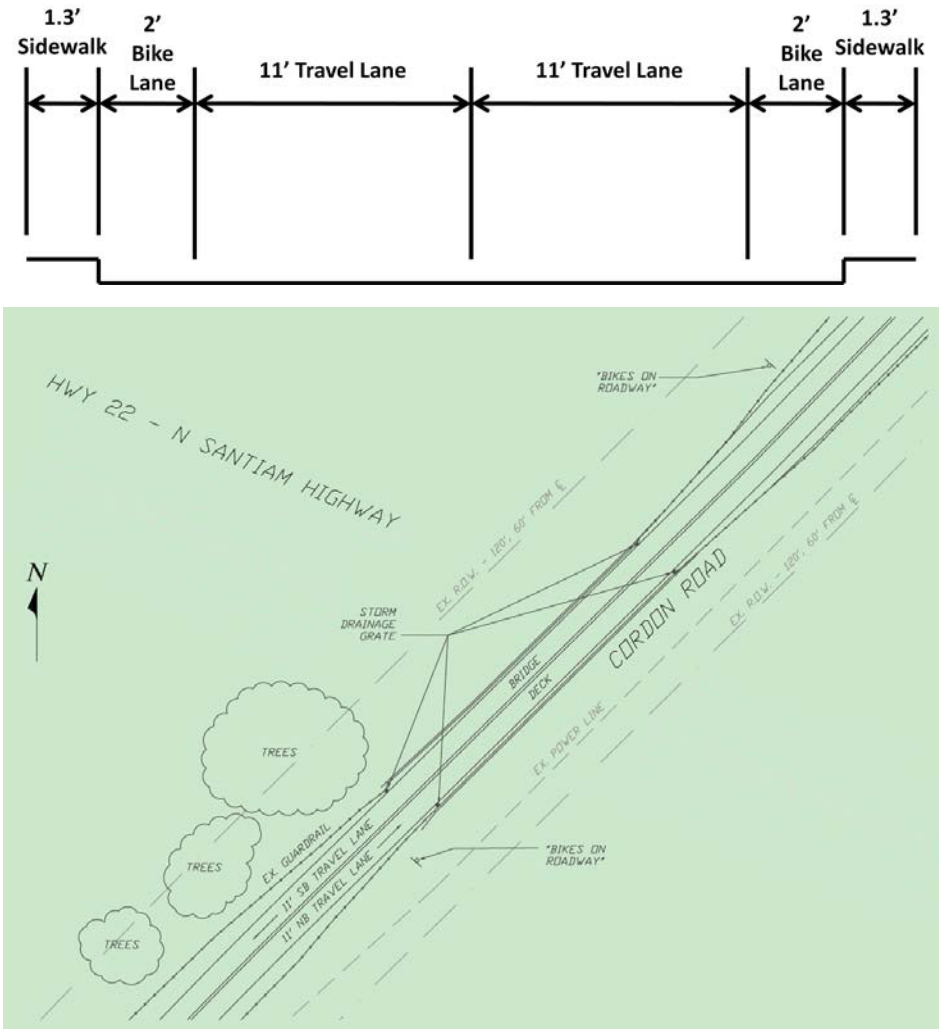


Figure 53: A standard parkway cross-section.



Figures 54 and 55: Cross-sectional view of existing bridge; Existing conditions plan view of Cordon Road crossing.

raised median, landscaping, and sidewalk (Transportation Plan, 2007). Cordon Road currently does not meet these standards.

At Cordon Road, differences in speed between vehicles, bicycles, and pedestrians is very dangerous and has been shown to increase the crash severity between users (Klop & Khattak, 2003). When travel speed prior to impact is greater than 50 miles per hour, the probability of a fatal crash result increases sixteen-fold (Kim et al., 2007).

The Salem Bicycle Club uses the Cordon Crossing approximately twice a month for events such as the Peach Event. This cycling advocacy club calls the bridge a “wing and prayer crossing” because of the existing safety risks.

During a four-year period, there was only one recorded crash at the study location. No bikes or pedestrians were involved. A driver headed in one direction

crossed the center lane attempting to overtake a vehicle and sideswiped the vehicle being passed, resulting in property damage only.

Countermeasures

Restriping travel lanes and reallocating widths could accommodate various users. This can be done by narrowing the 11 foot vehicle travel lanes to 10 feet, combining both two-foot wide bike lanes into one dual-direction bike facility, and installing a row of plastic bollards between the roadway and the two-way bike facility on the north side of the bridge. Further, extending the shared use, dual-direction facility on the north side of the bridge to the closest intersections on Cordon Road would significantly improve bicycle and pedestrian amenities.

Another option would be constructing a separated mixed-use bridge spanning Highway 22 on the north side of Cordon Road. The placement of a bicycle and pedestrian bridge along Cordon Road has great potential to increase cyclist activity in this area and throughout Salem's bicycle network by increasing access and safety. First, there are few paved mixed-use trails in the Salem metropolitan area. When traveling toward the outskirts of town, rural roads typically feature narrow bike lanes that make cycling unpleasant due to close proximity to passing motorists.

The best way to keep cyclists safe is to completely remove them from cars by creating a separated, paved mixed-use path. This bicycle treatment has been used successfully in places like Portland, Minneapolis, and St. Paul, where the path runs along the rural highway. Given the 120 foot right-of-way owned by the City of Salem along Cordon Road, there is ample space to construct a mixed-use path.

Cordon Road runs along the exterior eastern and southern edges of Salem. Installing a mixed-use path in this project's study area would provide a foundation for future expansion of a mixed-use path along the Southeast city boundary.

To complete this design, improvements are needed at the intersections to the west and east of the Cordon Road Bridge. Signage indicating the correct placement of non-motorized users on the roadway is necessary to ensure safe crossing of the bridge.

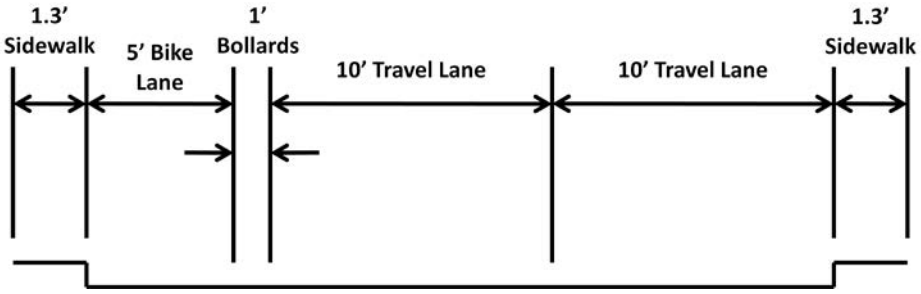


Figure 56: Cross-sectional view of reallocated lane widths.

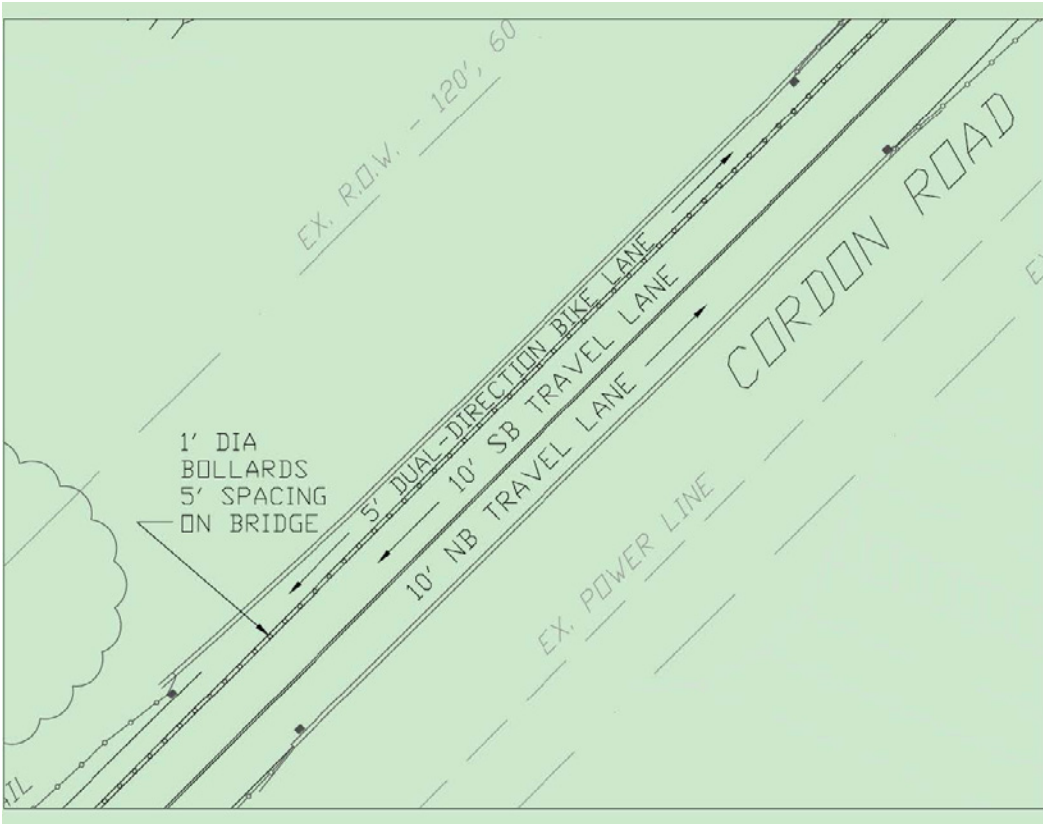


Figure 57: Plan view of reallocated lane widths.

A more conservative option would be to add simple safety improvement features at a minimum to address basic pedestrian and bicyclist dangers.

Installing a higher handrail or fence on each side of the bridge structure would increase safety, both actual and perceived. Currently, there is very little pedestrian protection from falling over the ledge onto Highway 22. A fence would make pedestrians and cyclists feel safer while they are on the bridge.

The other main concern with pedestrians and cyclists feeling safe on the bridge are the high speeds of the vehicular traffic. Implementing traffic calming devices or lowering the speed limit of the facility around the bridge would lower the speed differential between vehicles and cyclists, which would increase safety. Although this is a controversial recommendation considering Cordon Road's parkway classification, safety for pedestrians and cyclists would be improved.

Recommendations

It is recommended that a separate multi-use bridge be constructed north of the existing Cordon Road crossing. Although this alternative is likely the most expensive choice, it makes the largest safety improvement. Unlike the other proposed designs, the multi-use bridge meets standards for the City of Salem

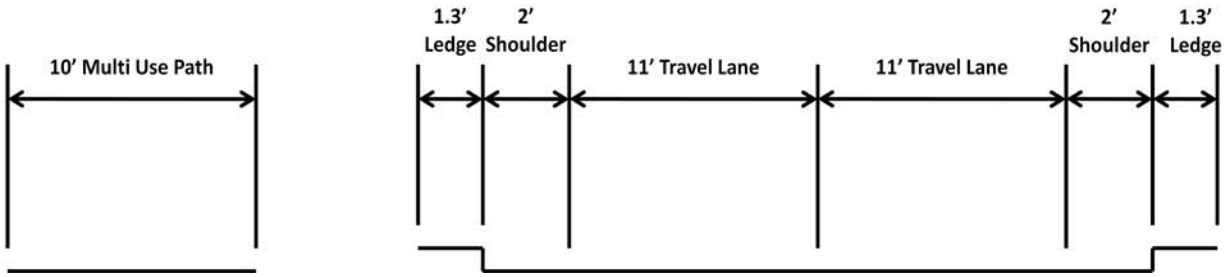


Figure 58: Cross-sectional view for mixed-use path alternative.

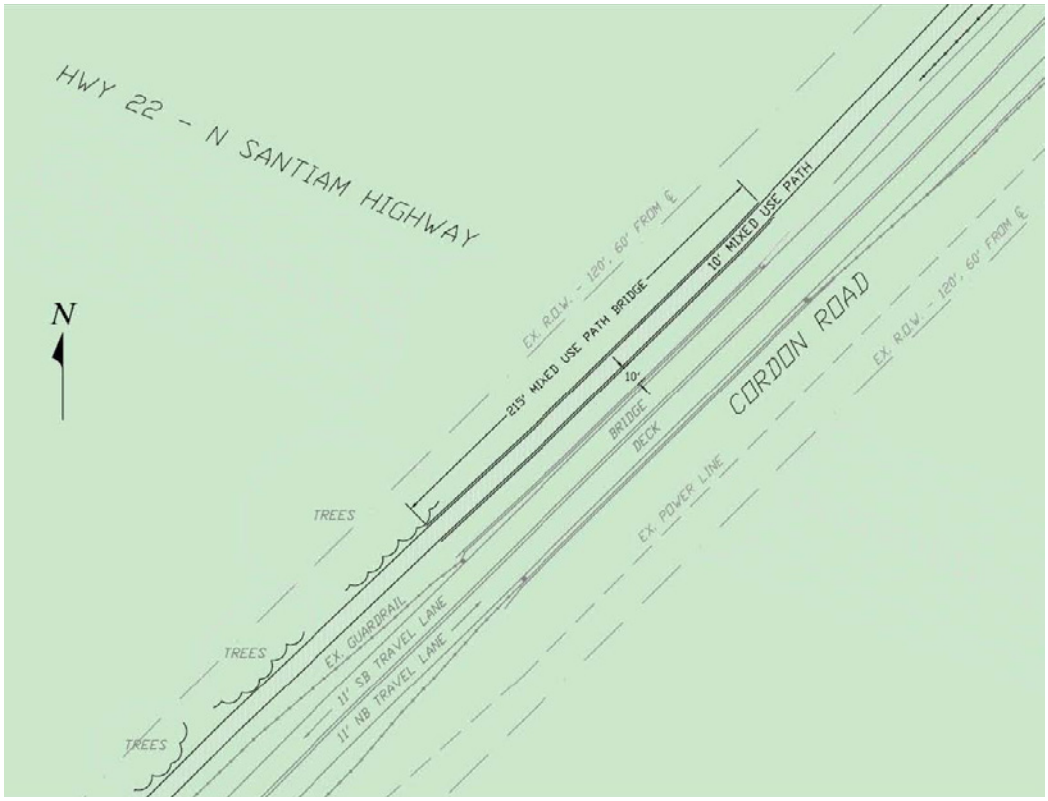


Figure 59: Plan view of separate multi-use bridge.

and the Oregon Department of Transportation. Design options to retain the existing bridge structure are considered unsafe for pedestrians and cyclists.

The only way for the City of Salem to safely meet their goals of improving pedestrian and bicycle facilities and encouraging active transportation is to construct a separate multi-use bridge. This alternative removes pedestrians and bicyclists from vehicular traffic traveling at high speeds, accommodates surrounding land uses, and will be unaffected by a planned interchange at this site. This increases the life span of the multi-use bridge, making it more cost effective over time.

Interstate 5 Ramps in Salem

This study covers two possible projects; improvements to the existing Kuebler Boulevard on- and off-ramps, and the possible development of a new off-ramp at Commercial Street.

The Kuebler Boulevard intersection at the I-5 southbound off-ramp is located at the south end of Salem. The intersection has two lanes of through travel in the westbound and eastbound directions on Kuebler Boulevard. The eastbound traffic has a left-turn only lane that connects to I-5 south. Both directions of travel have existing bike lanes.

Presently, two lanes of through travel exist in the east and west direction. The existing westbound right lane allows drivers to continue west through the intersection or to turn onto the recently built Interstate 5 north on-ramp. The right lane in the east direction provides a diverging right-turn only lane that connects to Interstate 5 north. Bike lanes exist in both directions of travel.

Findings

The Kuebler Boulevard off-ramp experiences significant delays between 4 and 6 PM. Most traffic from the off-ramp turns right onto Kuebler Boulevard toward south Salem. Drivers accustomed to the high speeds of the freeway sometimes have to suddenly stop halfway down the off-ramp because of the backups.

The crash data for the connection on Interstate 5 southbound Kuebler Boulevard off-ramp was obtained from the Whale Communications Intelligent Application Gateway (Keiko). The crash data showed that there were 10 crashes on the off-ramp. The crashes were dominated by rear end crashes. Ninety percent of the crashes were rear-end and ten percent of the crashes were turning crashes. The rear-end crashes were scattered from the intersection down the ramp to about 0.2 miles back from the intersection.

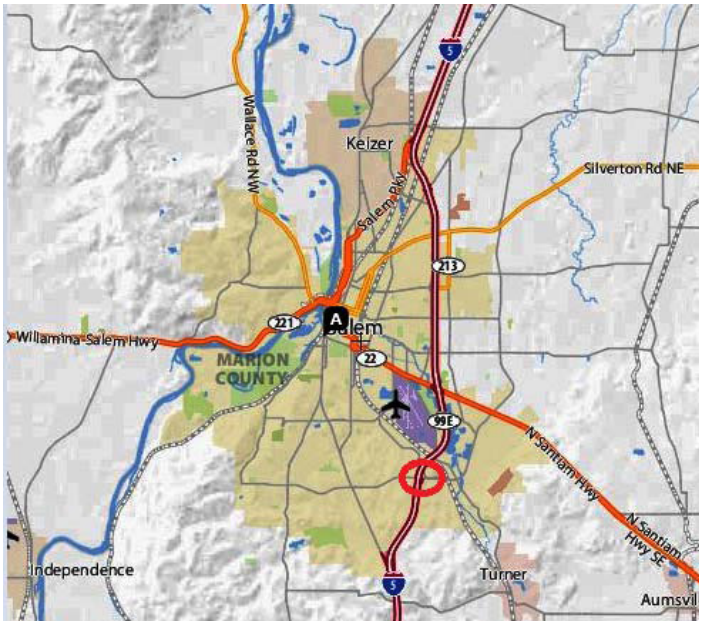


Figure 60: Map of Salem with the location of the site. Source: Organize Oregon.

Due to the increased amount of residential development between Interstate 5 and Commercial Street, demand is growing for access to Commercial Street. Currently, drivers are exiting off of southbound Interstate 5 on Kuebler Boulevard in order to connect to Commercial Street. The next closest exit is Delaney Road, south of Kuebler

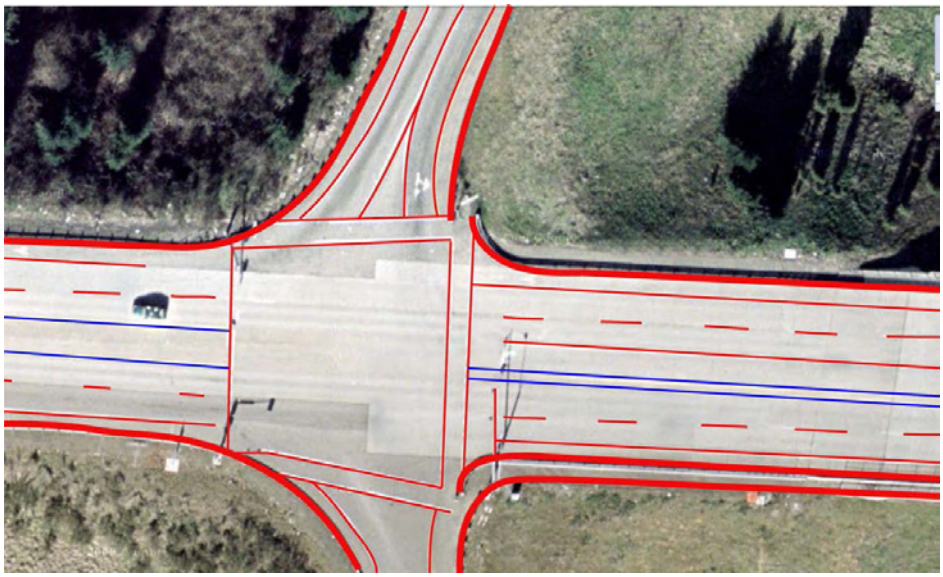


Figure 61: Kuebler Boulevard off-ramp existing conditions.

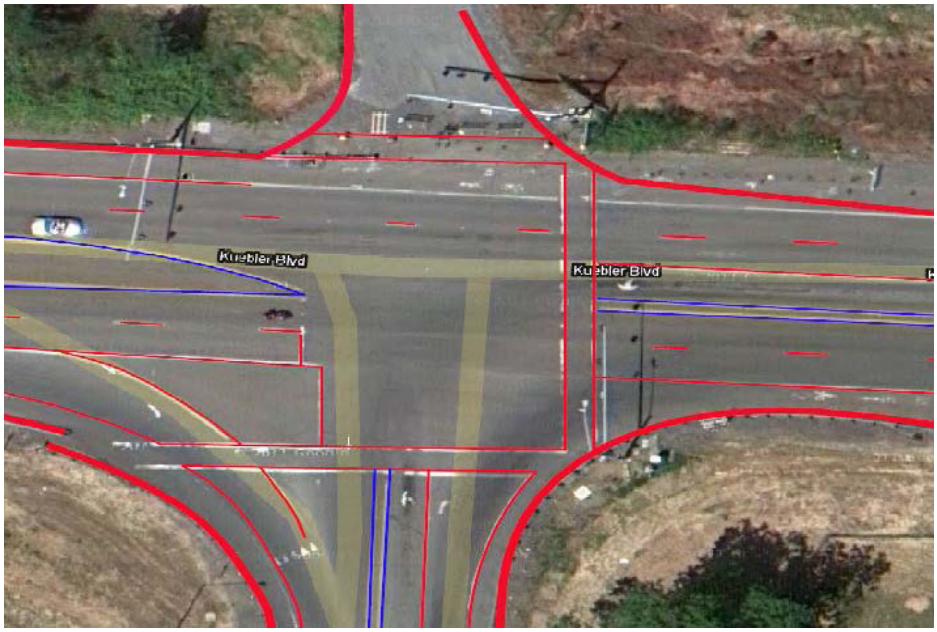
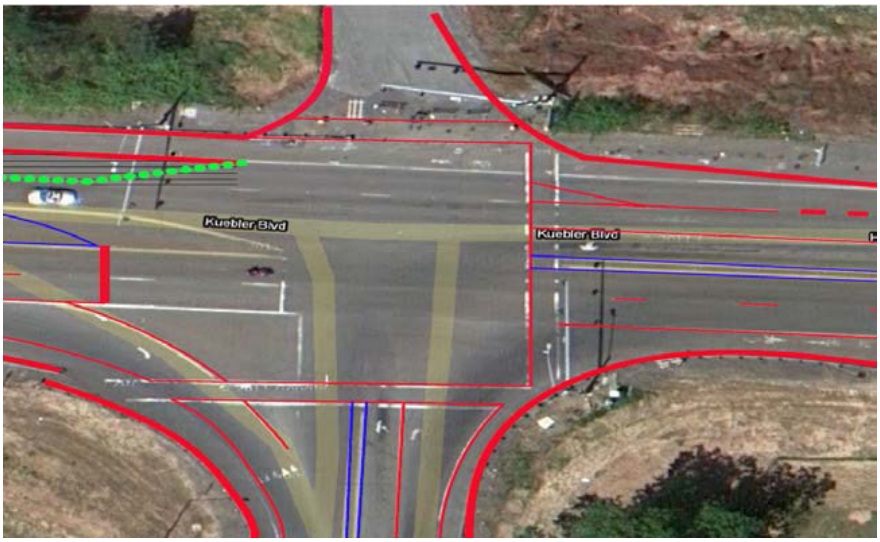


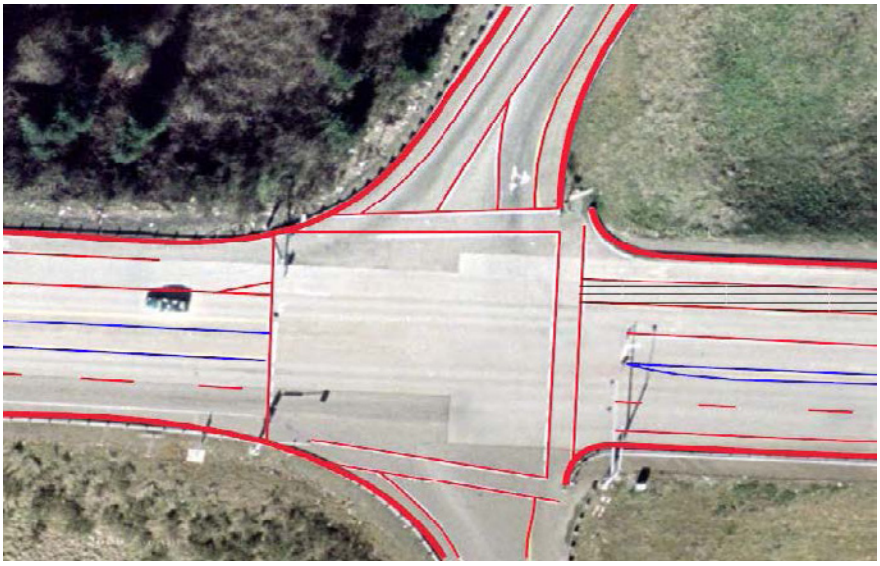
Figure 62: Kuebler Boulevard on-ramp existing conditions.

Boulevard. Using the Delaney exit is a less convenient and longer distance option for drivers.

The design proposed for the possible Commercial Street off-ramp is in a heavily forested triangular area with steep gradients, especially at the southern portion. The feasibility of an off-ramp will depend on the sharpness of both the horizontal curve and the vertical curve.

The off-ramp consists of two curves with a transition in between, as well as the connection directly off Interstate 5 and the connection to Commercial Street.





Figures 63 and 64: Kuebler Boulevard on-ramp design; Kuebler Boulevard off-ramp design.

The first curve has a radius of 303 feet or 19 degrees. The second curve has a radius of 572 feet or 10 degrees. According to ODOT's Highway Design Manual, for an off-ramp on a freeway of 65 mph the minimum design speed is 35 miles per hour. A 35 miles per hour ramp has a maximum degree of curvature of 19 degrees, while a 45 miles per hour ramp has a maximum degree of 10.5 degrees. Both curves are within allowable limits. The 45 miles per hour design speed for the second curve transitions to a lane that joins Commercial Street, which has a posted speed limit of 45 miles per hour.

The extra superelevation that is needed to be built into the landscape is minimal. The same is true for the second curve. The ascending vertical grade

is allowed to be 6 percent for a 35 to 40 mile per hour design speed and the descending grade is the same for a 45 to 50 mile per hour design speed. The sites for both curves have an approximate maximum slope of 7 percent. There are flatter sections north of the hill, however, that can be used to reduce the grade.

Countermeasures

Possible improvements to the intersections include the conversion of the existing right lane in the west direction to a right-turn only lane. A white right-turn only regulatory sign would need to be installed 200 feet prior to the beginning of the existing Interstate 5 north on-ramp at the intersection and on the existing traffic light cross arm. Right-turn only pavement arrows would also be painted on the approach to the northbound on-ramp. The continuing westbound right through lane (after the intersection) would be sectioned off by hatching lines to represent a no travel lane. White delineator poles would be installed at the beginning of the hatched area starting from the northeast corner. The initial angle of the delineator poles will provide drivers a refuge area in the event that they mistakenly travel through the intersection from the right-turn only lane. The existing stop bar and double yellow line, at-grade median area in the eastbound direction would be moved back in the west direction. The moved stop bar will provide large semi-trucks traveling from the northbound off-ramp a smoother turn so as to not infringe on the stanchion area.

A redesign of the existing guardrail with a larger turning radius would also improve conditions. The guardrail feature is suggested because students observed vehicles exiting the off-ramp making right turns onto westbound Kuebler Boulevard at high speeds. These higher speeds often led to turning vehicles intruding into the left through travel lane in the westbound direction. Reflective, raised pavement markers could also be installed on the left edge of the westbound right travel lane along with a painted, solid white line.

Recommendations

It is recommended that the city adopt the proposed changes to the Kuebler Boulevard Interstate 5 intersections described above.

The site appears to be well-suited for an off-ramp from Interstate 5 to Commercial Street. The preliminary design analysis shows the possibility of an off-ramp located at the proposed site. The sharpest curve is built into the side of a hill and uses the natural slope for superelevation. The steep climb would serve to slow exiting freeway traffic. This would lead into a softer curve with a downward slope, allowing vehicles to reach the posted speed of 45 miles per hour for Commercial Street. The connection from the ramp to Commercial Street would include adding a lane to Commercial Street's one-lane setup. There is ample space on the right-hand side of the road to do so. The added lane would only exist for a few hundred feet before it met with the existing two lane layout at the next intersection.

Figure 65: Topology map of Commercial Street off-ramp site.

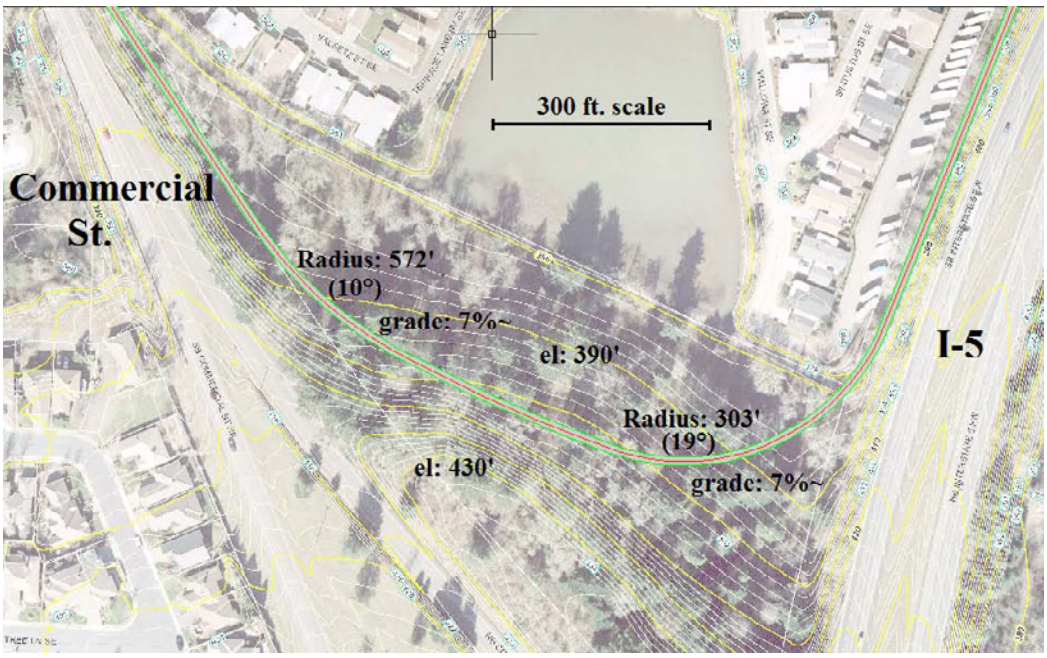


Figure 66: Proposed design for Commercial Street off-ramp.

Conclusion

Improving traffic safety for all users in Salem was the focus of this Portland State University civil engineering study in traffic safety engineering. A number of traffic problem areas in Salem were evaluated by engineering students using site visits, interviews, crash data, and modeling. Countermeasures were suggested and refined to create the best possible safety outcomes.

Many of the recommended improvements to intersections include relatively low cost solutions, such as improving pedestrian crossings with striping, the addition of curb extensions, and the removal of some parking. Other recommended intersection improvements include removing distractions such as overgrown landscaping and controlling distracting commercial business signs near intersections with signals.

The use of chicanes as both a traffic calming device and a method of improving access for emergency vehicles in Salem's neighborhoods was also recommended.

Increasing safe routes for pedestrians and bikes was emphasized. Students recommended improved pedestrian crossings at Judson High School with more marked cross walks, along with a stronger procedural method at the high school to mitigate peak school traffic.

Several studies suggested that roundabouts at intersections be further considered, but roundabouts were not often included in the final recommendations because of the public's unfamiliarity of roundabouts and the initial cost of construction.

It was recommended that a new off-ramp at Commercial Street and Interstate 5 be further investigated after a preliminary study in this report suggested the feasibility of such a ramp.

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