# <u>Pavement Quality and Traffic Safety</u>

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**Introduction:**

Pavement quality is a matter that is widely discussed within and without the transportation engineering profession. Degradation in pavement can include issues such as rutting, loss of traction, and poor drainage. It is generally known that poor pavement is associated with higher maintenance costs for vehicles and lower safety. The purpose of this project is to identify and quantify any relationship between pavement quality and traffic safety. Although car crashes are stochastic events which cannot be predicted, this project will compare crash frequency and severity for roads with different levels of pavement quality.

**Literature:**

"Impact of pavement conditions on crash severity" by Li et al. studied correlations between car crash severities and pavement conditions at the crash sites. Texas DOT data from the 2008 and 2009 Crash Record Information System and Pavement Management Information System were used to conduct the study. No map projection was given in the report. The researchers used GIS to connect crash data with the pavement quality where the crash took place, after which they conducted statistical testing to establish correlations between crash severity and pavement quality.

"Impact of pavement surface condition on roadway departure crash risk in Iowa" by Alhasan et al. investigated pavement conditions, including rutting, skid number, and rut depth, and their relationship to roadway departure crashes. Crash data and pavement quality data were obtained from the Iowa traffic safety data service and pavement management system databases, respectively. As in the study conducted by Li et al., no projection information was included, and GIS was used to assign crashes to the highways on which they took place.

"Pavement condition and crashes" by Yokoo et al. conducted a study similar to the one conducted by Li et al., but instead data from Minnesota were used. Crash data and pavement quality on state highways from 2003 to 2014 were used, and AADT and truck percentage were included to add controls for the statistical analysis. No map projection was provided, and GIS was used again in this study to streamline the data analysis process.

**Project Location & Spatial Extent**

This project focuses on data provided for the state of Oregon and will encompass all major highways and interstates in the state. With available data, this project could be scaled up to a larger scope, but for the sake of simplicity this project will focus on roads in Oregon.

**Datasets**

The primary datasets used to conduct this project are all data publicly available through the Oregon Department of Transportation (ODOT). The first dataset is the 2019 crash data for the state of Oregon. This includes the location, date, and severity of all documented crashes in Oregon for 2019, as well as additional information such as crash causes and road conditions. The second dataset is the highway pavement condition data, which rates the pavement quality on a five-point Likert scale. The last data source is the AADT data, which estimates the number of vehicles using a given roadway on an average day. All three datasets use the NAD 1983 coordinate system, and all three sets are composed of vector data. The crash and AADT data use point geometry, while the pavement quality data use line and curve geometry. The three datasets are visualized below in Figures 1, 2, and 3.

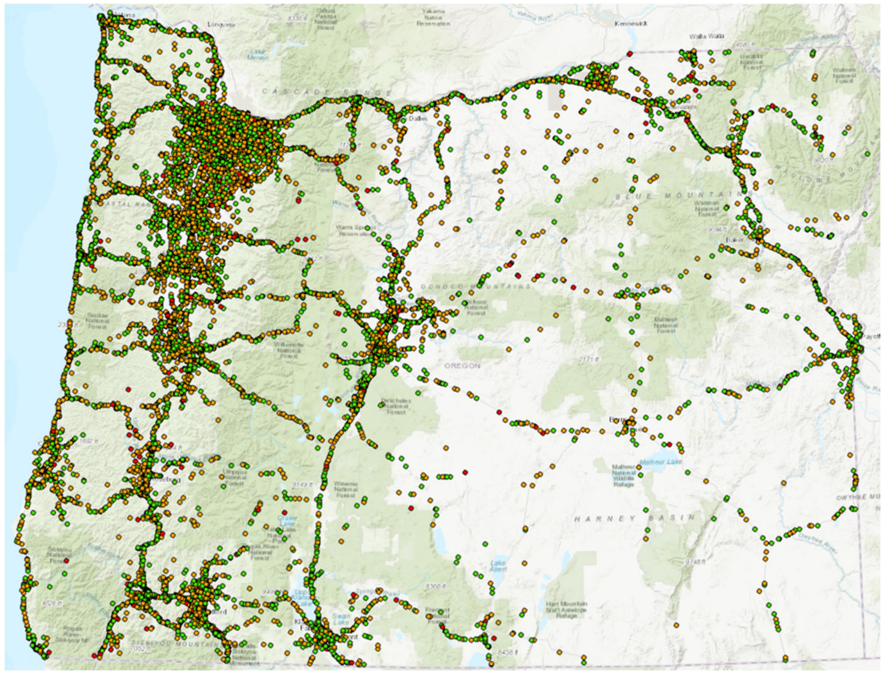

**Figure 1: Crashes in 2019 in Oregon**

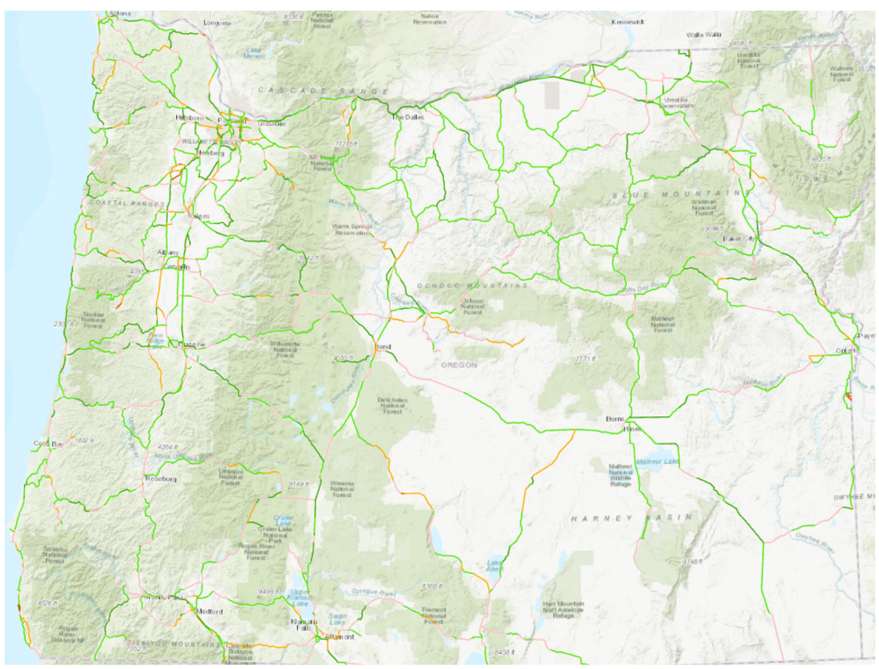

**Figure 2: Pavement Quality for Major Oregon Highways**

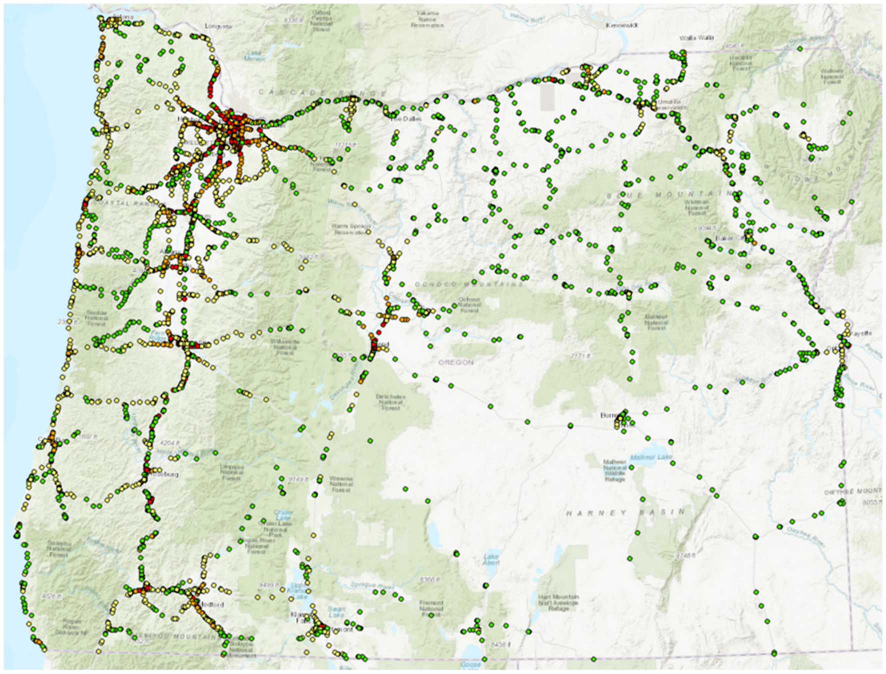

**Figure 3: AADT on Oregon Roads**

**Methodology**

Once the necessary data were loaded into ArcGIS, attributes from the pavement quality and AADT files needed to be transferred to the crash data. First, the AADT data were joined to the pavement quality data. This is illustrated in Figure 4, where the coloration of the state highways continues to be symbolized by color while the annual average daily traffic is symbolized by the weights applied to each road. Heavier weights indicate heavier daily traffic.

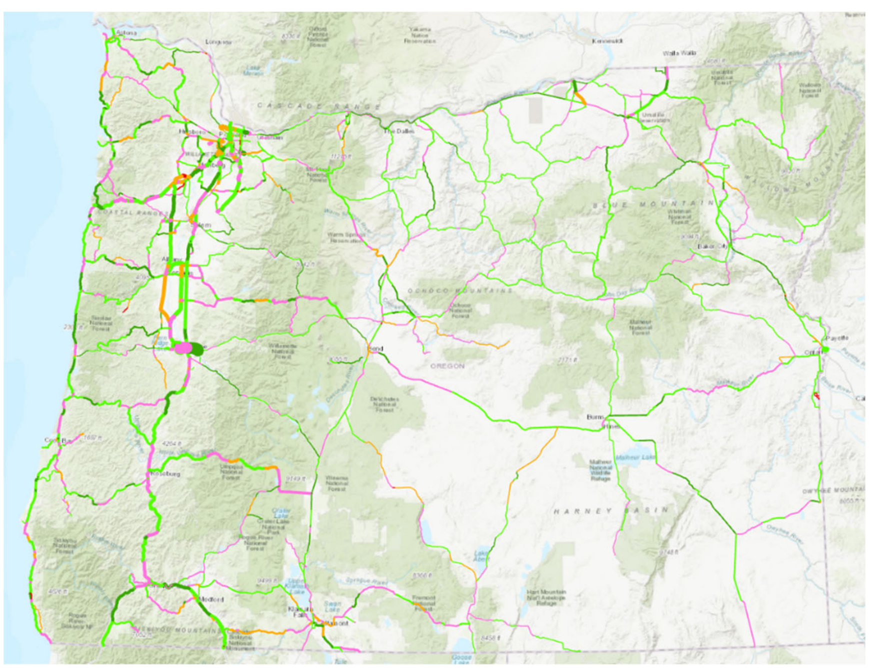

**Figure 4: Pavement Quality Weighted by AADT**

Next, crashes were snapped to state highways within a 0.1-mile radius. Since the pavement quality data only has information on state highways, crashes taking place on smaller local roads should not be included and the search radius for the snap function needed to be restricted. Once the crashes on state highways had been snapped into place, crashes which did not occur on state highways were removed using the Intersection geoprocessing command. The crashes which belong in the analysis dataset are shown overlaid on the state highway network in Figure 5.

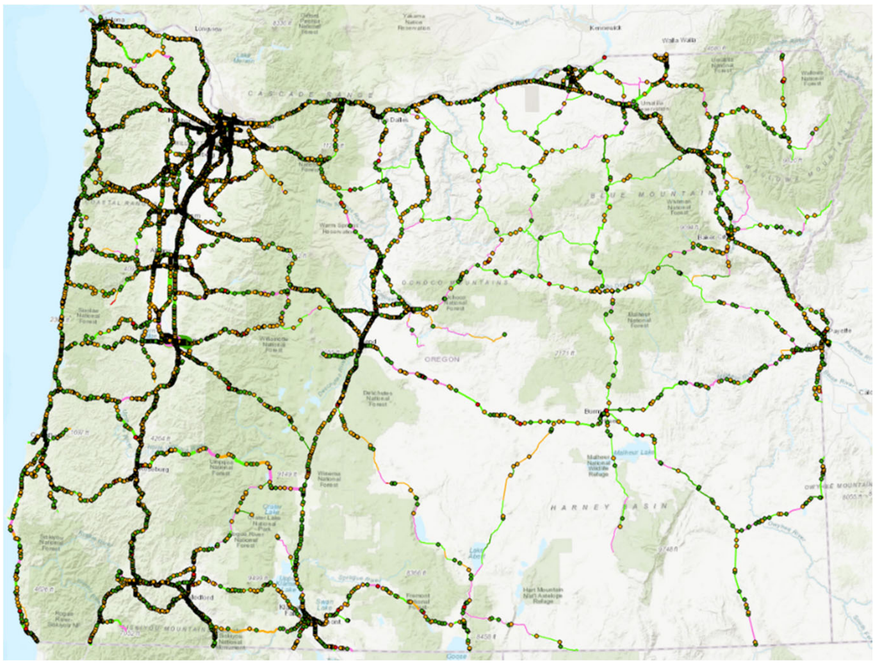

**Figure 5: Crashes on State Highways**

The crash data attributes were then added to their corresponding highways using the Spatial Join geoprocessing command. Next, a space time cube was generated for the road network based on the crash data for the state highway network. The time step interval for the space time cube was one week, and the distance interval was five miles. An emerging hotspot analysis indicated that there were no clear time-related trends for most of the state, including no cold spots. Much of the region from Portland down to Salem was composed of emerging hotspots, with some sporadic hotspots around the edges of the area. Several sporadic hotspots were also present on the Halsey-Sweet Home highway. Most of the persistent hotspots were in the vicinity of Salem. Based on an understanding of general population centers in Oregon, it makes sense that the hotspots are clustered around Portland and Salem, which are the two largest cities in the state and subsequently experience higher traffic and deal with heavier constraints for traffic management. There is no clear trend between the quality of the pavement and the crash hotspots, though the hotspot analysis requires refining to deal with regions where multiple highways could lead to inaccurate representations of point aggregations. The preliminary hotspot distribution is shown in Figure 6, which zooms in on the northwest portion of Oregon to show the areas where hotspots are prevalent.

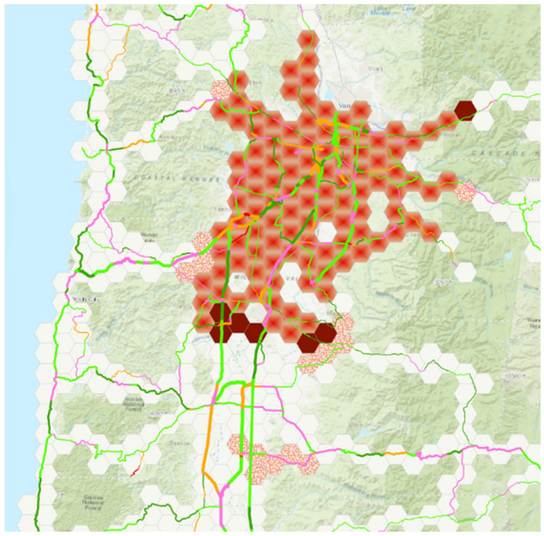

**Figure 6: Preliminary Hotspots**

In preparation for a spatial hotspot analysis, the cost of each crash was estimated. A fatal crash cost $4,008,900, a crash resulting in an incapacitating injury cost $216,000, a crash resulting in a serious non-incapacitating injury cost $79,000, and a crash resulting in a minor injury cost $44,900, based on the crash cost estimates produced by the Federal Highway Administration. The cost of crashes per vehicle-mile travelled on each highway segment was also calculated by summing the costs of all crashes on each stretch of highway, then dividing that value by the product of the annual average daily traffic and the length of the road. Figure 7 highlights highways which incur higher crash costs, while the pavement quality follows the color scheme used in previous maps.

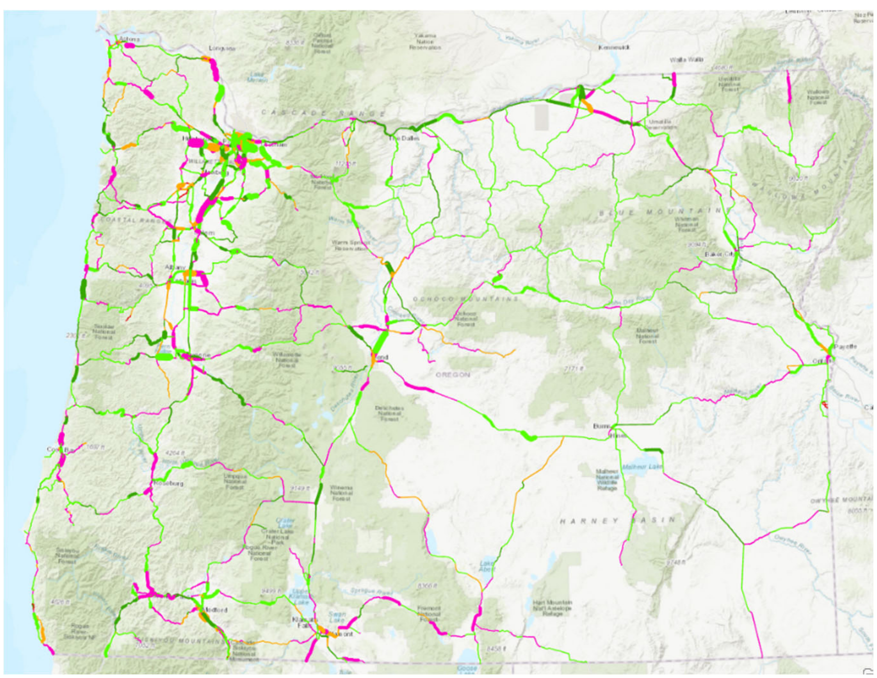

**Figure 7: Highways by Crash Costs and Pavement Quality**

Based on the total costs, higher crash severities appear to cluster on roads with “good” or “fair” pavement quality. While many of those crashes occur in the Portland metro area, others occur in less heavily-trafficked regions in the state. Figure 8 shows the roads which have higher crash costs per vehicle-mile travelled.

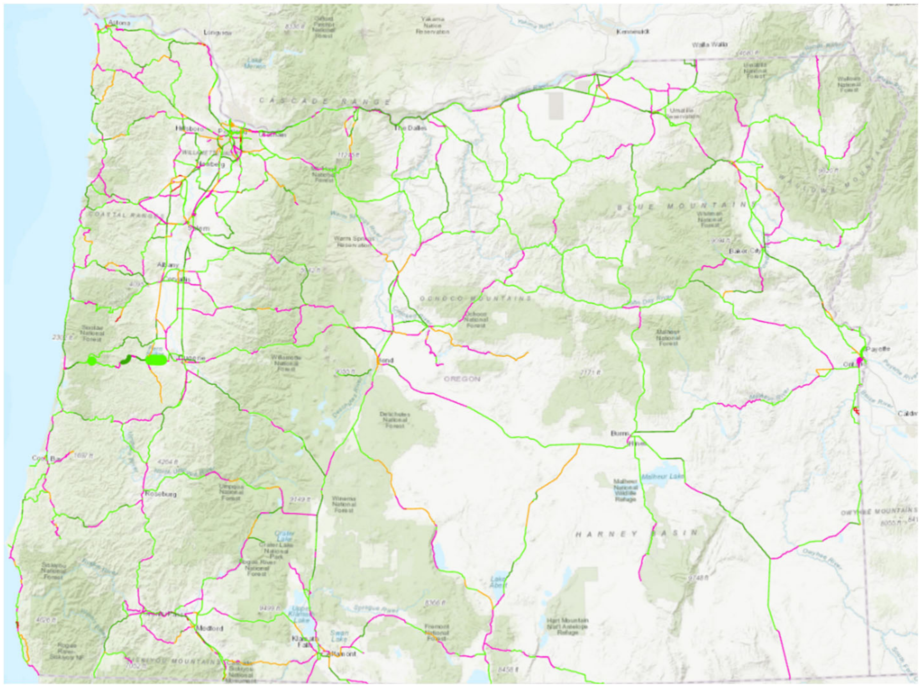

**Figure 8: Highways by Crash Cost per Vehicle-Miles Travelled**

Several stretches of highway west of Eugene show the highest crash cost per vehicle-mile travelled. Interestingly, these stretches have “good” or “very good” pavement quality. In other parts of the state, highways with the highest costs per vehicle-miles travelled have pavement conditions no worse than “fair.” Figure 9 shows an example of these crash hotspots west of Eugene.

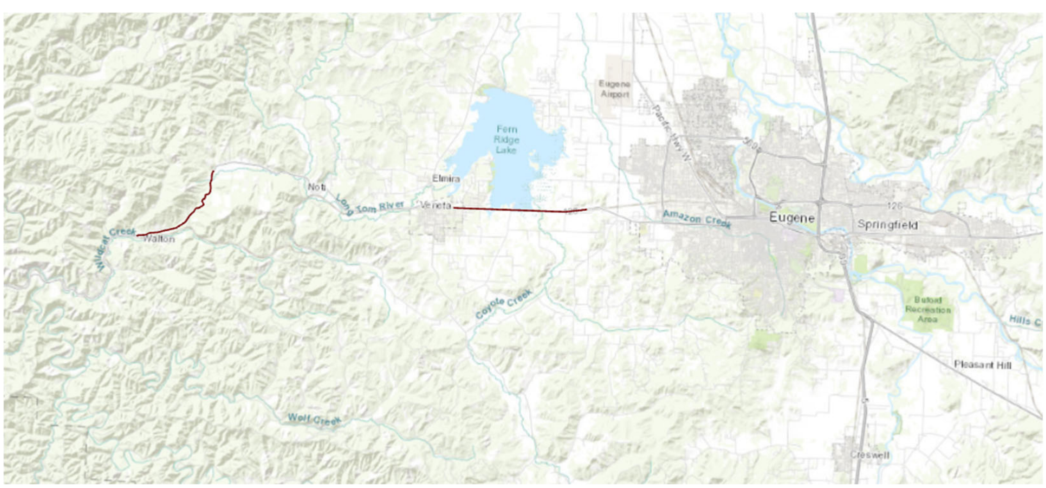


**Figure 9: Crash Hotspots**

The dark coloration of those highway segments indicates high statistical confidence that these regions have unusually high crash costs. As shown in Figure 10, when the hotspots are overlaid on the pavement quality layer, it is illustrated that the pavement quality is “good” to “very good,” while the stretches with poorer pavement quality experience lower costs.

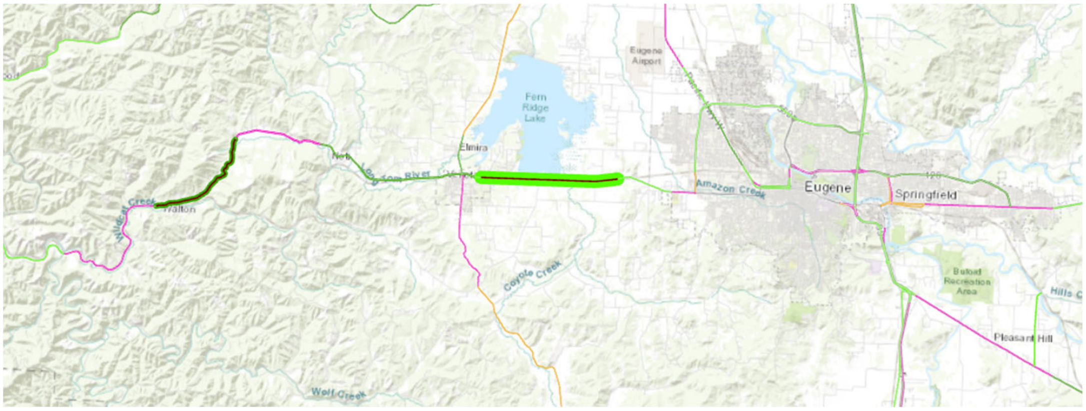


**Figure 10: Crash Hotspots and Pavement Quality**

Salem contains additional hotspots which take place on “fair” and “good” quality pavement, and the hotspots in Salem appear to be representative of the other hotspots around the state. The hotspots in Eugene appear to take place on relatively high-quality pavement, while most others take place on “fair” or “good” pavement. The only exception is in Astoria, where the hotspots take place on “poor” pavement. Figure 11 shows the hotspots in Salem.

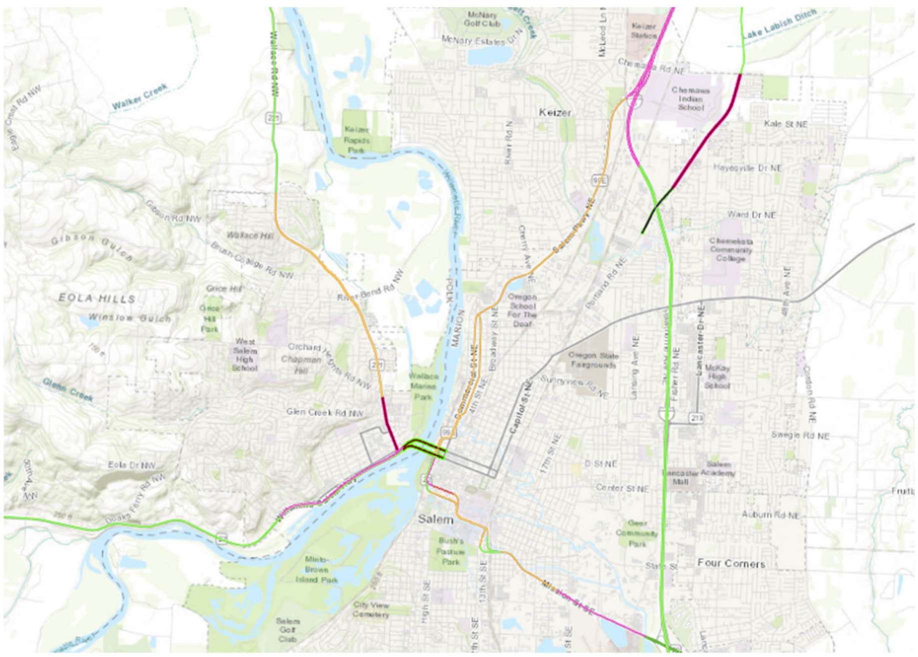


**Figure 11: Salem Hotspots**

## Conclusion

Overall, there does not appear to be a clear correlation between crash frequency and degradation in pavement quality, nor is there a clear connection between crash severity and degradation in pavement quality. It is possible that more dangerous crashes occur in areas with “fair” or “good” pavement quality, since drivers may be less inclined to drive carefully since the pavement conditions are not poor, but the pavement conditions are also not optimally safe.

**Sources**

Li, Y., Liu, C., & Ding, L. (2013). Impact of pavement conditions on crash severity. *Accident Analysis & Prevention*, *59*, 399–406. https://doi.org/10.1016/j.aap.2013.06.028

Alhasan, A., Nlenanya, I., Smadi, O., & MacKenzie, C. (2018). Impact of pavement surface condition on roadway departure crash risk in Iowa. *Infrastructures*, *3*(2), 14. https://doi.org/10.3390/infrastructures3020014

Levinson, D., Yokoo, T., & Marasteanu, M. (2018). Pavement condition and crashes. *Transport Findings*. https://doi.org/10.32866/5771