

Rough Roads Ahead 2

Economic Implications of Deteriorating Highway Conditions



February 2017 -

Acknowledgements

Technical Advisory Committee

ODOT wishes to thank the members of the Rough Roads Ahead 2 Technical Advisory Committee, who provided valuable oversight and guidance for this project, meeting July 2016 through January 2017:

Emily Ackland, *Association of Oregon Counties*

Craig Campbell, *AAA Oregon/Idaho*

Mike Eliason, *Association of Oregon Counties*

Karmen Fore, *Governor's Office*

Craig Honeyman, *League of Oregon Cities*

Susie Lahsene, *Port of Portland*

Susan Morgan, *Association of Oregon Counties*

Chris Rall, *T4America*

Bob Russell, *Oregon Trucking Associations*

A project of this scope and complexity required a team of experts to work in collaboration over the course of a year.

ODOT Staff

Travis Brouwer, *Assistant Director*

Paul Mather, P.E., *Highway Division Administrator*

Jerri Bohard, *Transportation Development Administrator*

Brian Dunn, P.E., *Transportation Planning Analysis Unit Manager*

Bruce Johnson, P.E., *Bridge Unit Manager*

Bert Hartman, P.E., *Bridge Program Managing Engineer*

Liz Hunt, P.E., *Bridge Planner*

Corey Withroe, *Bridge Data Analyst*

John Coplantz, P.E., *Pavement Management Engineer*

Alex Bettinardi, P.E., *Senior Integrated Analysis Engineer*

Dejan Dudich, *Transportation Analyst/Modeler*

Becky Knudson, *Senior Transportation Economist*

Shelley Snow, *Strategic Communication Coordinator*

Cathy Sattergren, *Graphic Designer*

Consultant Staff

Rick Donnelly, PhD, *WSP Parsons Brinkerhoff*

Greg MacFarlane, P.E., PhD, *WSP Parsons Brinkerhoff*

Joel Freedman, *RSG, Inc.*

Ben Stabler, *RSG, Inc.*

Nagendra Dhakar, PhD., *RSG, Inc.*

Table of Contents

Acknowledgements.....	2
Introduction.....	5
Background: Transportation Disinvestment	5
Methodology.....	6
Scenario Descriptions.....	11
Analysis Tools	22
Findings	22
Conclusions	34
Appendix	37
Disinvestment Definitions	37
Fix-It Priority Corridors	37
Enhancement Investment Examples	39
Scenario Budgets	39
Revenue Source Assumptions for “What If” Scenarios 3 and 4	40
Bridge Model.....	41
Oregon Statewide Integrated Model.....	42
Current Pavement Program Strategy	45
Pavement Roughness Vehicle Operation Costs Data.....	48
International Roughness Index.....	49



Rough Roads Ahead 2: Economic Implications of Deteriorating Highway Conditions

Executive Summary

Oregon's Economy Depends on a Good Transportation System

Oregon highways and roads are important for the movement of people and freight. Oregon is home to over 4 million residents and a labor force of 2 million workers. People use highways to get to work and school, shop, recreate, access transit and rail, ride bicycles and walk. Freight moves to and from Oregon via multiple modes as well, but commercial trucking dominates. In 2015, 139 million tons (80 percent) of commodities originating in Oregon moved by truck and 137 million tons (75 percent) arrived in the state by truck. These commodities represent \$260 billion in value. Thus, the highway transportation system is critical to Oregon businesses and households.

In order to be competitive in global markets, Oregon firms need an efficient transportation system to move their goods and services quickly and affordably. Oregon is a trade-dependent state, relying heavily on exports from our farms, forests and factories to create jobs. The state's transportation system is vital to Oregon's economy: one in five jobs in Oregon is transportation- and trade-related.

Road Conditions Will Deteriorate

The current 20-year forecast budget for the state highway system is insufficient to preserve and maintain current conditions of pavement and bridges going forward. As a result, highway conditions will deteriorate over time. Over half of the 2,736 state highway bridges were built before 1970. Most of these bridges have reached or exceeded their 50 year design life and were not built to withstand a major seismic event; they require replacement or major repair in the near future. The current ODOT bridge budget is able to fund an average of three bridge replacements a year. At this rate it would take over 900 years to replace Oregon's state bridges. Nearly one third of state highway bridges are forecast to be in poor condition by 2036, with about 370 bridges projected to be weight restricted, forcing heavy trucks to detour. Similarly, the ODOT pavement budget is insufficient to preserve and maintain the 8,032 miles of state highways. Without additional investment, by 2036 nearly half of state highway pavement will be in poor condition.

Pay Now or Pay Later

The transportation system has many competing needs, requiring strategic investment and disinvestment decisions now that impact the economic future of Oregon. Deteriorating roads and bridges have significant negative impacts on job creation in Oregon. As bridges deteriorate, they must eventually be closed to heavy trucks, creating detours that increase expenses for businesses and cause unexpected impacts to detour routes. Similarly, rough pavements lead to greater wear and tear on vehicles, slow traffic and create safety hazards. Like aging bridges, deteriorating pavement increases transportation costs and negatively impacts Oregon businesses, residents and visitors. Ultimately, without maintenance, Oregon will forfeit jobs, lose businesses and reduce gross state product.

It is more affordable to keep up with infrastructure maintenance than to let conditions deteriorate. Maintaining bridges and pavement to today's conditions would cost an additional \$2.6 billion over the next 20 years. If conditions are allowed to deteriorate under the current forecast funding level, it will cost about twice as much to return deteriorated bridges and pavement to existing conditions.

Study Methodology

This study evaluates potential economic impacts of investing in the transportation system and not investing in the transportation system, with the focus on the economic impacts of bridges restricted to weights below 80,000 pounds. Information prepared for this study is designed to evaluate investment trade-offs and options when investment needs exceed available resources. This study uses a scenario modeling approach building upon the analysis and information presented in “Rough Roads Ahead: The Cost of Poor Highway Conditions to Oregon’s Economy, 2014.”

This analysis uses two primary forecast models: the ODOT Bridge model forecasts bridge conditions under the four scenario budgets, while the Oregon Statewide Integrated Model forecasts the impact of bridge weight restrictions on job growth and gross domestic product over a 20-year period.

The analysis compares three hypothetical budgets/improvement scenarios to the current ODOT forecast budget for highways. The four scenarios evaluated are illustrated in Figure 1, which include:

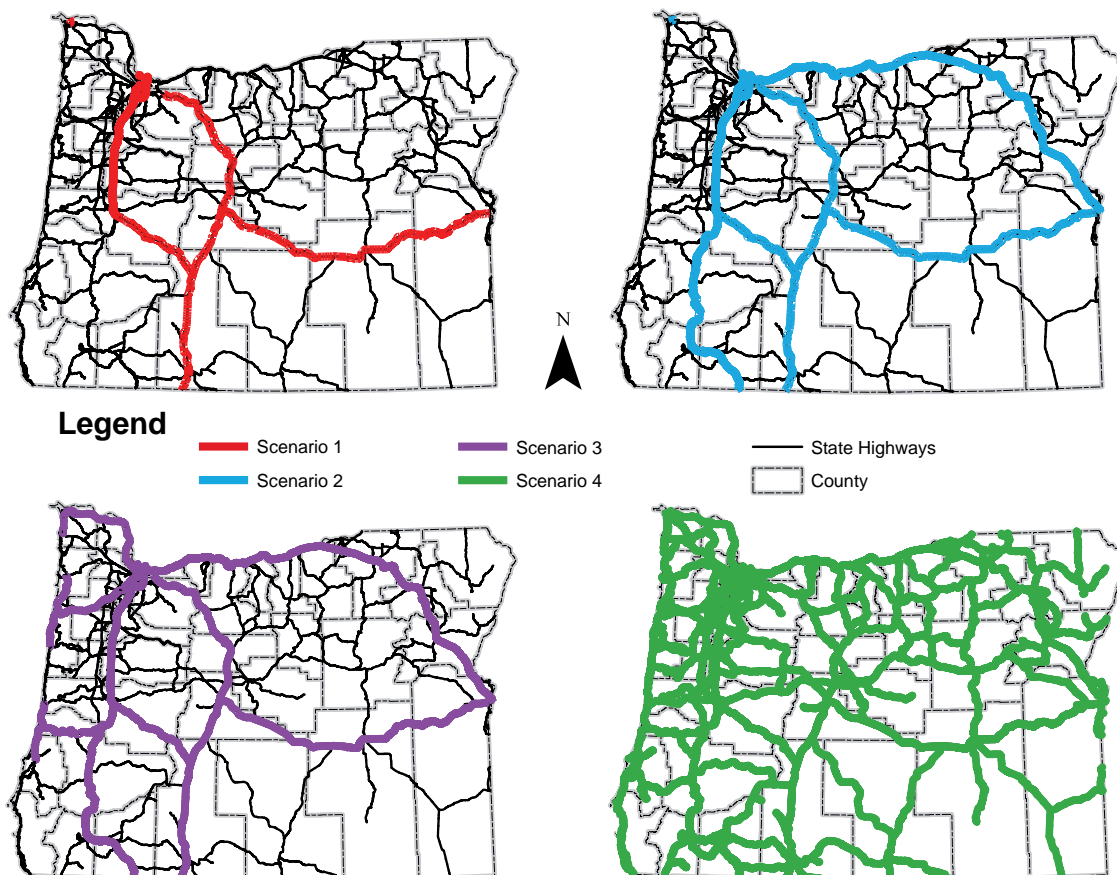
Scenario 1: Current ODOT forecast budget for the state system.

Scenario 2: Limited expansion of current investment; adds the remainder of Interstate 5 and Interstate 84 to the limited network that can be addressed under the current budget.

Scenario 3: Hypothetical “What Would It Take” to preserve and repair the entire network of high-priority state highways, known as the Fix-It priority routes.

Scenario 4: Hypothetical “What Would it Take” to maintain current bridge and pavement conditions for the entire state-owned and operated system, including seismic preparation.

Figure 1. Scenario Investment Priority Routes



The scenario budgets show the trade-offs between maintaining and preserving an aging transportation system in light of growing demands on existing capacity. For this analysis, highway projects that expand capacity of the transportation system (such as building new lanes) are postponed as funding shifts to cover rising maintenance needs associated with aging infrastructure. As a result, congestion is expected to increase, increasing costs for businesses whose products and workers get stuck in traffic. Outcomes of the various scenarios are summarized in Table 1.

Table 1. Scenario Analysis Summary of Results

	Scenario 1 Current Funding	Scenario 2 Limited Highway Corridors	Scenario 3 Preserve Priority Corridors	Scenario 4 Meet Needs
Economic Impacts				
Forfeit Jobs	75,000 - 120,000	70,000 - 90,000	50,000 - 60,000	0
Lost GDP, billions	\$155 - \$605	\$144 - \$355	\$88 - \$156	0
State Infrastructure Condition				
Bridges Repaired	130	355	482	1179
Bridges Weight Restricted	370	317	272	0
Pavement % Fair or Better	53%	68%	76%	90%
20 Year Budget,* billions	\$8.7	\$14.7	\$17.7	\$25.5
Bridge Backlog, billions (disinvestment)	\$7.4	\$5.7	\$4.3	\$0.0
Pavement Backlog, billions (disinvestment)	\$4.6	\$2.5	\$1.7	\$0.0
* See scenario descriptions for detailed list of assumptions. Increased budgets are for 20-year core highway budget categories only: Maintenance, Pavement, Bridge, Seismic, Enhance and Other, not entire ODOT budget; dollars are expressed as 2016 values.				

Economic Impacts of Deteriorating Roads

The analysis delivers a number of key findings:

- **Jobs and production will be lost.** Given current funding levels, forecasted bridge weight restrictions on heavy trucks will increase business costs, making Oregon firms less competitive. This is likely to reduce Oregon job growth by at least 75,000 jobs by 2036, and substantially more when accounting for the likely deterioration of city and county roads. It is also likely to result in over \$150 billion in cumulative lost gross domestic product over the 20-year period, and substantially more when accounting for the impacts of deteriorating city and county infrastructure.
- **Local road conditions matter.** Roads off the highway system play an integral role accommodating detoured trucks when state bridges are weight-restricted. However, like the state highway system, county and city roads and bridges are expected to deteriorate over time, and detouring heavy vehicles will cause accelerated deterioration to local roads and impact public safety. Using rough estimates of the impacts of local infrastructure deterioration, this study estimates the statewide economic impacts would be much larger in scale if the local system deteriorates because detour options will be limited. Local system deterioration could increase job losses as much as 50 percent compared to assuming local roads remain in good condition, with lost cumulative gross domestic product nearly quadrupling.

- **Vehicle repair and operating costs will increase.** Rough pavement increases vehicle user costs, impacting household budgets and business costs. Vehicle fuel efficiency drops, while tire wear, oil use and repair costs rise. If 20 percent of vehicle-miles-traveled occurred on rough pavement in the future, statewide vehicle operating costs are expected to rise 2 percent. This translates into over \$300 million of additional spending on vehicle repairs and maintenance per year. This impacts household budgets, where transportation spending is second only to housing as the largest budget category. Rising transportation costs make Oregon firms less competitive in the global marketplace, where trucking firms track costs-per-mile to the penny.
- **Infrastructure repair costs will increase.** The cost of rehabilitating deteriorated bridges and pavement later is much greater than keeping them in good condition through proper preservation moving forward. At the end of 20 years of operating at currently forecast funding levels, the state would need to spend an estimated \$4 – \$5.5 billion to return degraded pavement to today’s conditions — much higher than the \$2.6 billion in additional funding needed in the near future to preserve them in good condition.
- **Investing in transportation produces a good return.** Any additional investment provides a good return on the dollar, as each additional increment of investment reduces the economic losses associated with deteriorating roads.



Rough Roads Ahead 2: Economic Implications of Deteriorating Highway Conditions

Introduction

This study evaluates the potential impacts of delaying key investments in Oregon’s transportation system. Information prepared for this study is designed to evaluate investment trade-offs and possible options when investment needs exceed available resources.

This study does not evaluate specific project solutions; rather it provides information that can be used when developing strategies to implement ODOT objectives, such as seismic preparedness, emergency preparation, public safety, and economic opportunity. This study uses a scenario modeling approach that builds on the information presented in “Rough Roads Ahead: The Cost of Poor Highway Conditions to Oregon’s Economy 2014”.¹

Oregon’s economy depends on a well-functioning transportation system. Traded industries rely on transportation to ship goods to customers outside of the state, which generates revenue and creates jobs within the state. A Port of Portland study estimated 1 in 5 jobs in the state of Oregon is transportation reliant or transportation related.²

Right now, the Oregon economy is very strong. The state has been adding jobs faster than the U.S. since 2013. Recently Oregon added more jobs in 12 months than over any 12-month period since 1990, while the unemployment rate was the lowest in 40 years.³ Average wages are on the rise due to the strong job growth, tight labor market and low inflation. Oregon’s export dependent economy fluctuates with business cycles,⁴ but an agile economy relies on an efficient and reliable transportation system to support quick recovery and avoid permanent losses in employment and revenue, especially for key export industries of computer and electronic products, agricultural products, timber, machinery, chemicals and transportation equipment.

Oregon highways and roads are important for the movement of people and freight. Oregon is home to over 4 million residents and a labor force of 2 million workers. People use the highways to get to work and school, shop, recreate, access transit and rail, ride bicycles and walk. Freight moves to and from Oregon via multiple modes as well, but commercial trucking dominates. In the year 2015, 139 million tons (80 percent) of commodities originating in Oregon moved by truck and 137 million tons (75 percent) arrived in the state by truck. These commodities represent \$260 billion in value. Thus, the transportation system is important to all Oregonians, both businesses and households.

Background: Transportation Disinvestment

Transportation system deterioration occurs gradually over time. Historically, transportation funding has been spent on a mixture of expansion, enhancement, preservation and maintenance. Recently, expenditures have shifted away from expansion and enhancement to preservation and maintenance as facilities, such as bridges, approach the end of their design life and the cost to maintain and replace these large assets become a larger proportion of required work. Current funding levels are insufficient to maintain current condition levels. If funding remains the same,

¹ Report is available here: <https://www.oregon.gov/ODOT/Planning/Documents/Rough-Roads-Ahead-1.pdf>

² https://cdn.portofportland.com/pdfs/Trade_Trans_Studies_CostHwy_ExecSmry.pdf

³ <https://www.qualityinfo.org/>

⁴ <https://oregoneconomicanalysis.com/2015/04/08/oregon-exports-trade-and-growth/>

infrastructure will fall below standards defined by the USDOT as “minimum tolerable conditions” for roads and bridges. This pattern holds true across the nation, and especially so for Oregon bridges, because the majority of bridges on state highways have reached or are approaching the end of their expected life.

The American Society of Civil Engineers (ASCE) conducted extensive research on the topic of national infrastructure needs recently in its report “Failure to Act: Closing the Infrastructure Investment Gap for America’s Economic Future”.⁵ The study states: “Although recent funding efforts have been sufficient to avoid the imminent failure of key facilities, continued deterioration leaves a significant and mounting burden on the U.S. economy.” Deteriorating road conditions impose costs on households and businesses in the form of higher vehicle operating costs, maintenance and repairs. Traffic congestion is rising and impacting reliability, which reduces on-time arrivals, impacts freight costs, and increases environmental and safety costs. The ASCE estimates deficiencies in U.S. surface transportation systems cost households and businesses nearly \$147 billion in 2015.

Because this demand for a high quality transportation system outpaces the funds to provide it, Oregon must make tactical choices by examining strategic use of transportation dollars as well as evaluating the most efficient use of transportation facilities in preparation for investment and disinvestment over time.⁶

Oregon is ahead of many states in this area, having completed several strategic planning efforts over the last 15 years. The 2003 “Economic and Bridge Options Report”⁷ estimated the impacts to the Oregon economy of weight restricting bridges. This analysis led to development of the Oregon Transportation Investment Act (OTIA) III program, which prioritized investment in the state system by corridors chosen to minimize the economic impacts of weight restricting bridges. The Oregon Lifelines Study⁸ developed a strategic approach to supporting emergency response and recovery efforts by providing the best strategy for connecting infrastructure and support for community and regional economic recovery after a disaster event. From this came the Oregon Seismic Lifeline Routes, a document developed by considering a major Cascadia Subduction Zone earthquake, which would likely include related events such as a tsunami, landslides, soil liquefaction and bridge failures. This work was used to develop the Oregon Highways Seismic Plus Report⁹, which identified a strategic approach to repairing seismically deficient bridges and unstable slopes in phases of retrofitting. ODOT recently completed “Rough Roads Ahead: The Cost of Poor Highway Conditions to Oregon’s Economy 2014”¹⁰, which evaluated the potential economic impacts of deteriorating transportation infrastructure on the state.

Methodology

The methodology used for this study uses forecast scenarios based on three different hypothetical budget increases in comparison to the current ODOT forecast budget for core highway asset spending categories: Maintenance, Pavement, Bridge, Enhance, Seismic and Other investment. The four scenarios evaluated include:

Scenario 1: Current ODOT Forecast Budget for the state system.

Scenario 2: Expanded current investment required to keep Interstate 5 and Interstate 84 open to trucks.

⁵ <https://www.asce.org/failuretoact/>

⁶ For this analysis the definition of disinvestment is consistent with NCHRP Synthesis 480; for details see the [Appendix](#)

⁷ <https://www.oregon.gov/ODOT/Planning/Documents/Economic-Bridge-Options-Report.pdf>

⁸ <https://www.oregon.gov/ODOT/Planning/Documents/Seismic-Lifelines-Evaluation-Vulnerability-Synthese-Identification.pdf>

⁹ https://www.oregon.gov/ODOT/Bridge/Docs_Seismic/Seismic-Plus-Report_2014.pdf

¹⁰ Report is available online here: <https://www.oregon.gov/ODOT/Planning/Documents/Rough-Roads-Ahead-1.pdf>

Scenario 3: Hypothetical “What Would It Take” to preserve and repair the entire network of high-priority state highways, known as the Fix-It priority routes.

Scenario 4: Hypothetical “What Would it Take” to maintain current bridge and pavement conditions for the entire state-owned and operated system.

The scenario budgets identify the equivalent additional fuel tax required to generate revenue to increase the ODOT budget for core highway budget categories. This provides a sense of the benefits associated with higher highway use taxes. The focus of each scenario budget is on the trade-offs between maintaining and preserving an aging transportation system in light of growing demands on existing capacity. Projects that expand capacity of the transportation system, referred to as “Enhance” projects, will be postponed as funding shifts to cover rising maintenance needs.

This analysis looks at how aging and deteriorating bridges impact Oregon’s trade-based economy, which relies on the transportation system to move goods from forests, farms and factories to markets. It also looks at the economic impacts of bridges restricted to weights below 80,000 pounds. The majority of trucks carrying freight on Oregon highways weigh 80,000 pounds or more. Bridges restricted to lighter loads will force heavy trucks to detour or require companies to break up heavier loads into multiple trips, increasing transportation costs and impacting businesses’ access to markets. Bridge weight restrictions impact the cost of transporting goods to businesses reaching their final markets.

Like bridge weight restrictions, poor highway conditions translate into higher transportation costs to businesses and households. Higher costs reduce connectivity and accessibility of businesses to goods and labor markets, workers to jobs and affordable housing. Depending on the number of bridges restricted and alternative routes available, the impact on accessibility varies by region and industry. Industries relying on heavy goods are most affected.

Forecast models such as the Oregon Statewide Model (SWIM) can be used to compare hypothetical scenarios side-by-side in order to evaluate potential impacts of specific changes. For these hypothetical scenarios, a simplified approach to highway investment is used to evaluate high level policy options and investment trade-offs. These scenarios do not represent specific investment plans or programs; instead, they are based on priorities identified through the ODOT Statewide Transportation Improvement Program (STIP) Fix-It program¹¹ and the Seismic Plus Report¹².

The Fix-It program includes projects that preserve the existing transportation system, including bridge repair and replacement and paving. Fix-It currently receives 76 percent of the statewide funding for the STIP.¹³

The Seismic Plus approach to bridge investment is to retrofit seismically vulnerable bridges on key lifeline routes to allow for rescue and recovery following a major earthquake in a way that incorporates fixes to complementary bridges, a more cost effective approach. This analysis focuses on Fix-It route bridges that have been identified as requiring work within the next 20-year period.

This study includes the following features and assumptions:

- The ODOT Bridge Model¹⁴ is used to forecast future state-owned bridge investment needs and deterioration under different investment budgets.

¹¹ <https://www.oregon.gov/ODOT/STIP/>

¹² See footnote 5

¹³ Figure comes from the adopted 2015-2018 STIP.

¹⁴ See *Appendix* for a detailed description of the Bridge Model

- Within the next 20 years, four critical bridges spanning the Columbia River are identified as requiring significant repair. This analysis designates these four bridges as too important to become load restricted: US 101 Astoria-Megler Bridge over the Columbia River, both I-5 bridges over the Columbia River and the I-205 Glenn Jackson Bridge over the Columbia River. Scenario budgets include maintenance levels sufficient to keep these four bridges in full operation over the 20-year period, which is estimated to be about 10 percent of the total replacement cost. None of the budgets represented in the four analysis scenarios assume replacement of these large and expensive bridges. Additional funds would be required beyond the proposed budgets in this report to fully update and replace all or any of these four significant bridges.
- The Oregon Statewide Integrated Model (SWIM),¹⁵ which integrates transportation, land use and economic activity, is used to forecast impacts of bridge weight restrictions to the state and regional economies.
- The modeled highway network is used to evaluate potential impacts of weight restricting bridges on the state-owned highway system. The modeled highway network does not include all highways and streets; most state highways are included along with a subset of local highways. If a state highway bridge is weight restricted, vehicles will be shifted to the next-best route, which may be a city or county road. However, in reality these alternative routes may not be practical or allow heavy trucks. Detailed information on city and county roads is necessary to represent local infrastructure to this level of accuracy, which is not currently available. This also means the disruption and safety implications of trucks routing through small cities and onto county roads are not accounted for in this analysis. While it is theoretically possible to represent how traffic patterns would play out in the real world, the data collection costs and labor hours associated with this level of detailed simulation would be cost-prohibitive. Representation of traffic patterns for this analysis is detailed enough to evaluate high-level comparative investment scenarios and report statewide results.
- Scenarios focus on state-owned bridge conditions under different funding levels. Impacts to local government-owned bridges (city/county) are not adequately represented, which means estimated economic impacts partially measure the full statewide impacts as traffic shifts to/from local infrastructure; under actual conditions, many county and city bridges are likely to be weight restricted, impacting detour options for truck movement statewide.
- The modeled highway network does not represent a detailed simulation model of specific highway projects. A generalized corridor prioritization approach is used consistently across all scenarios to allow comparative economic impact analysis appropriate for high-level, long-range strategic planning.
- This analysis focuses on statewide economic patterns associated with bridge weight restrictions on truck movement and overall transportation costs. Thus, for this analysis, SWIM was not set up to simulate the evolution of business locations over time based on what is observed today at a detailed level, such as tax lots or city blocks. Economic activity is simulated at the regional level, and aggregate patterns represent overall activity observed for cities and counties.
- Seismic investment was identified for each scenario and allocated to priority corridors. All new bridges are designed to withstand a 1000-year seismic event, which is consistent with the standard level of design nationwide. Additionally, new bridges located west of US 97 are designed to remain functional after a Cascadia Scenario event, which is an Oregon-specific hazard. Therefore, any bridge identified as a replacement will be built to be seismically resilient. Because of this, there are assumed seismic upgrades to bridges across all funding scenarios, even in the lowest funding scenarios with little to no budget for seismic investment.

¹⁵ See [Appendix](#) for a detailed description of the Oregon Statewide Integrated Model

- Impacts of Enhance projects, which are defined as investments that improve mobility of people and goods by expanding transportation system capacity, are not included or represented in this modeling analysis. Congestion impacts have been evaluated and reported in several recent studies.¹⁶ Including congestion impacts in the modeling would significantly increase the scope of this study. To manage study cost and timelines, this modeling analysis focused on bridge condition impacts only. Clearly, congestion will further add to the economic impacts Oregon expects in the future. The increasing potential for truck detours illustrated in this study will compound congestion and likely increase the number and severity of freight bottlenecks in Oregon.
- The impact of deteriorating pavement condition on jobs and production is not modeled in this analysis, but the potential impact to highway user costs is evaluated using the characteristics of currently registered vehicles in Oregon.
- This study includes the impacts of construction inflation by using the inflation forecast included in the IHS Global Insight national forecast, which ranges between 2.1 and 3.1 percent per year over the 20-year study period.
- The economic forecast is consistent with the official Department of Administrative Services, Office of Economic Analysis state revenue forecast, which incorporated the IHS Global Insight national forecast data. This data assumes Oregon’s population will grow and age, consumption will increase with the increase in population, workforce productivity will remain competitive and trade will increase.
- Forecast vehicle-miles-traveled continues to rise, but at a slower rate than observed in the past. In addition, vehicles are expected to become more fuel efficient in the future, which reduces revenue generated from fuel sales. Thus, there is uncertainty related to future funding levels that were not addressed in this analysis. This analysis assumes the net impact of rising statewide total VMT and rising vehicle fuel efficiency is null, consistent with the December 2016 ODOT revenue forecast.
- A one cent increase in highway use tax generates about \$28 million in net annual revenue – \$17.7 million from fuel tax and \$10.3 million from the heavy vehicle weight-mile tax. Any increase in revenue is apportioned between ODOT and Oregon’s counties and cities, of which approximately 50 percent is apportioned to ODOT, 30 percent to counties and 20 percent to cities. Individual counties receive funds based on the number of vehicle registrations within their jurisdiction, while cities apportion these funds based on population.

Corridor Prioritization

To preserve movement of freight and economic activity, ODOT employs a “corridor approach” that prioritizes resources to keep key freight corridors open to truck traffic. ODOT has designated the main routes of the state highway system connecting most of the state’s communities and carrying most freight and automobile traffic as “Fix-It priority corridors” and focuses scarce resources on maintaining bridge and pavement conditions on these routes. Bridge investment priorities in this analysis are based on Fix-It priority corridors, with the addition of I-205. **Figure 1** illustrates the Fix-It priority routes. **Figure 2** illustrates the Oregon State Highway Freight System, of which the Fix-It routes are a subset. See the [Appendix](#) for more detailed description of the prioritization approach.

¹⁶ “Economic Impacts of Congestion in Oregon, Final Report” February 2014 <https://portlandalliance.com/advocacy/economic-reports.html> and “The Cost of Highway Limitations and Traffic Delay to Oregon’s Economy” March 2007 <https://www.edrgroup.com/pdf/oregon-exec-summary.pdf>

Figure 1. Fix-It Priority Routes

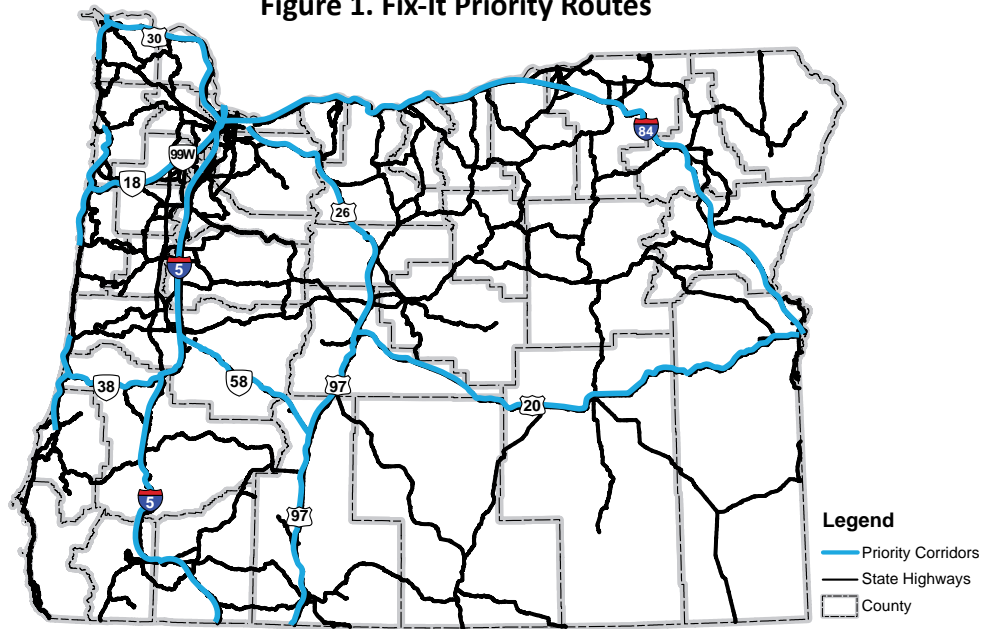
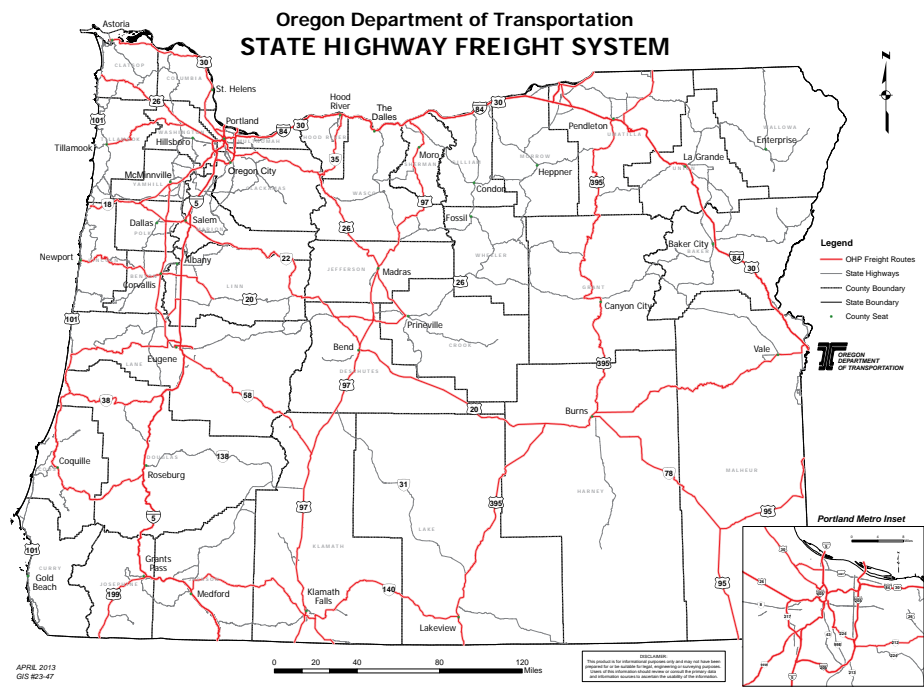


Figure 2. Oregon State Highway Freight System

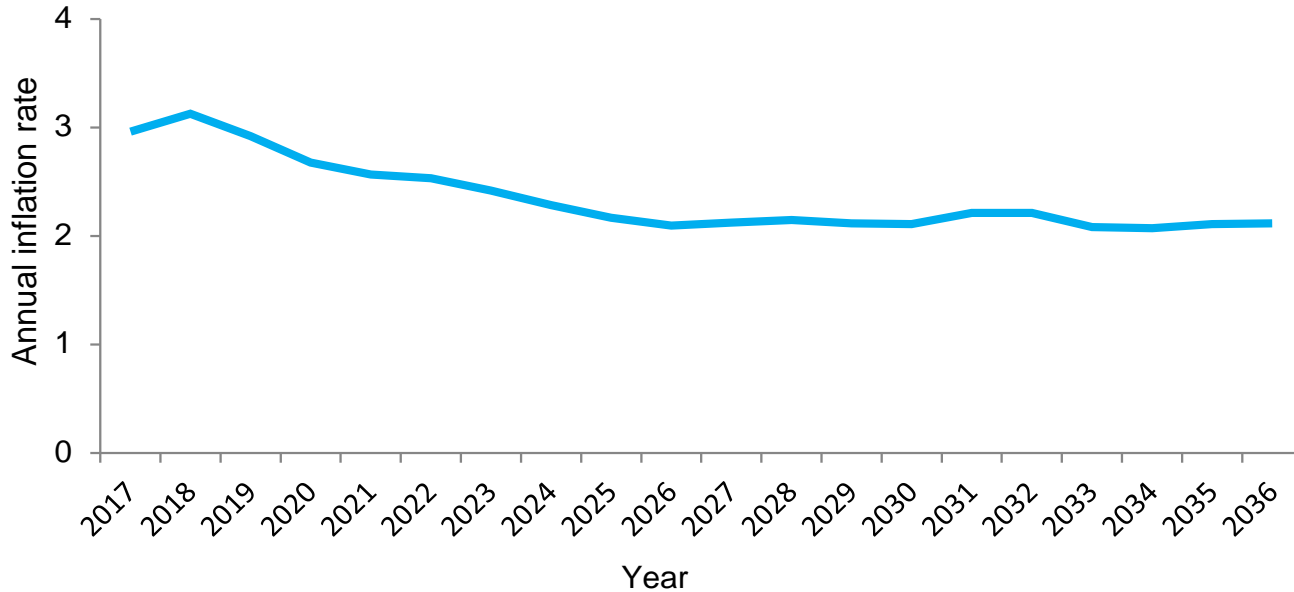


Inflation Adjustment

Inflation will have a significant impact on the purchasing power of highway fund dollars over the next 20 years. For this analysis, the IHS Global Insight forecast “Price Deflators for Government Purchases: State and Local Construction”¹⁷ is used to represent inflationary impacts, which are illustrated in **Figure 3**. The current ODOT unadjusted “nominal” budget is \$10.9 billion over the twenty-year period. Inflation reduces purchasing power over time, reducing the twenty-year budget to \$8.7 billion in 2016 adjusted “real” dollars. Thus, real purchasing power over the twenty-year period is expected to be reduced by 20 percent. IHS Global Insight forecasts an average inflation rate of 2.4 percent a year, ranging between 2.1 and 3.1 percent over the twenty-year period.

¹⁷ The State of Oregon subscribes to IHS Global Insight for economic forecast data.

Figure 3. Forecast Inflation Rate: State & Local Construction



Source: IHS Global Insight Aug 2015 Forecast

Scenario Descriptions

For this study four scenarios are developed to better understand four different levels of investment and disinvestment in the system. For these hypothetical scenarios, a simplified prioritization approach to corridor highway investment is used in order to evaluate high level policy options and investment trade-offs. These scenarios do not represent specific investment plans or programs. Instead, they are meant to approximate planning-level investment plans and strategies; they are based on priorities identified through the ODOT Statewide Transportation Improvement Program (STIP) *Fix-It program* and the *Seismic Plus Report*. This analysis focuses on Fix-It route bridges that have been identified as requiring work within the next 20 years. The impacts of investment in other ODOT programs are not modeled in this analysis, such as future STIP projects or safety projects.

Bridges were identified for work based first on route prioritization and then on the Remaining Service Life (RSL) reported out of the ODOT Bridge Model. A detailed description of the model is provided in the [Appendix](#). For this analysis, culvert work was not included.

The bridge investment levels evaluated include:

- Scenario 1: 20-year budget at the current bridge program funding level with bridges prioritized to provide one north-south and one east-west route across the state. This scenario includes I-205 through Portland, but not I-5 north of the I-205 interchange. Outside of Portland, the I-5 corridor from I-205 to OR 58 (Eugene) is addressed, along with US 26/US 97 from the Portland metro region to the California border, OR 58, and US 20 from Bend to Ontario.
- Scenario 2: 20-year forecast budget based on the cost to ensure that all of I-5, and I-84 could be addressed in addition to the routes identified in Scenario 1: I-205, US 26/US 97 from the Portland metro region to the California border, OR 58, and US 20 from Bend to Ontario.
- Scenario 3: 20-year forecast budget based on the total cost to address all bridge needs on the entire Fix-It priority corridors and I-205.
- Scenario 4: 20-year forecast budget based on the total cost to address all of the 20-year bridge needs on the entire state-owned and operated highway system.

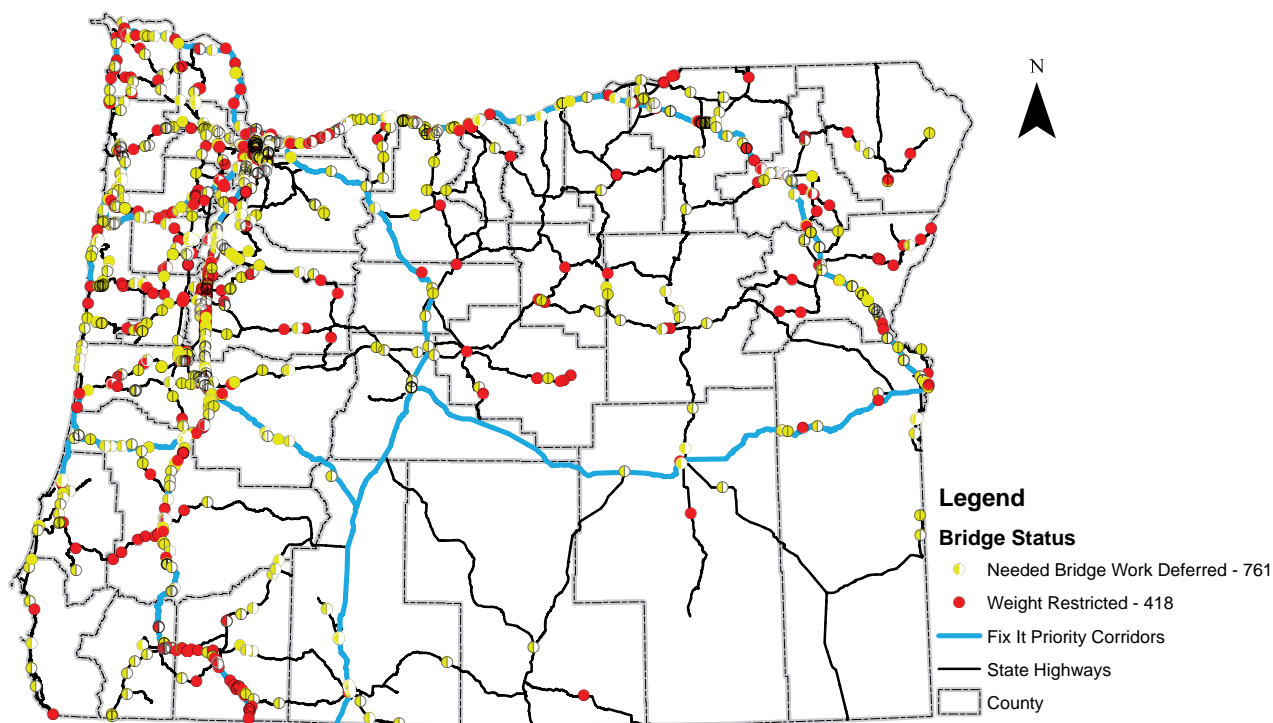
Final revisions were made to the initial bridge list generated by the ODOT Bridge Model using engineering judgement and supplemental data from other ODOT sources. The projected bridge work by scenario is shown in **Table 1** below.

Table 1: Bridge Investment for Each 20-year Scenario

Scenario	Forecast Bridge Rehabilitations	Forecast Bridge Replacements	Total Bridges Forecast Addressed	Total Bridges Deferred Maintenance	Total Bridges Weight Restricted
1	69	61	130	679	370
2	195	160	355	507	317
3	271	211	482	425	272
4	807	372	1179	0	0

The total bridge need for all of these scenarios combined is 1,179 bridges. This value represents the number of bridges on the state-owned and operated system identified as needing significant rehabilitation or replacement within the next 20 years. Of that number, 418 bridges are expected to be weight restricted to vehicles below 80,000 pounds within the next 20 years if they do not receive work. **Figure 4** illustrates the overall bridge needs for the state-owned and operated system. It is important to note all of the 1,179 bridges would eventually be weight restricted, but only 35 percent of these bridges are expected to be weight restricted within the 20-year planning horizon.

Figure 4. Overall Bridge Needs for the State System by Year 2036



The number of bridges identified for work may be fewer than what would actually be programmed because the model selects bridges based on overall need versus critical needs. In reality, with limited funding, the scope of work for many bridges would be adjusted to address only the critical needs so the state could address more bridges. It is important to note that bridges are inspected

every two years; bridges deteriorate at a rate that may be slightly greater or less than the predicted rate of deterioration. Before any bridge projects are programmed, the most recent inspection and inventory data is used to determine the correct scope of the project.

Scenario 1

Scenario 1 represents the expected 20-year forecast budget for highway spending for the *core highway asset* categories of Maintenance, Pavement, Bridge, Enhance, Seismic and Other. As assets age, they require major preservation investment. When preservation investment does not occur, maintenance costs begin to increase. This creates a need to shift resources and make disinvestment trade-off decisions. The scenario budget reflects this by shifting funding out of the Enhance budget and into the Maintenance budget. The annual Maintenance budget in this scenario increases by 3 percent each year by moving funds from the Enhance budget until the Enhance budget reaches zero by 2026. The purpose of this shift in budget is to show the engineering priority of preserving existing assets over enhancing existing assets.

Figures 5 and 6 present the budget assumptions for Scenario 1. Over the 20-year period the average annual nominal budget is \$545 million. After accounting for inflation, purchasing power declines to an average annual real budget of \$436 million. Thus, the 20-year program budget of \$10.9 billion is expected to be reduced in purchasing power to \$8.7 billion, about a 20 percent reduction.

Figure 5
Scenario 1 Budget

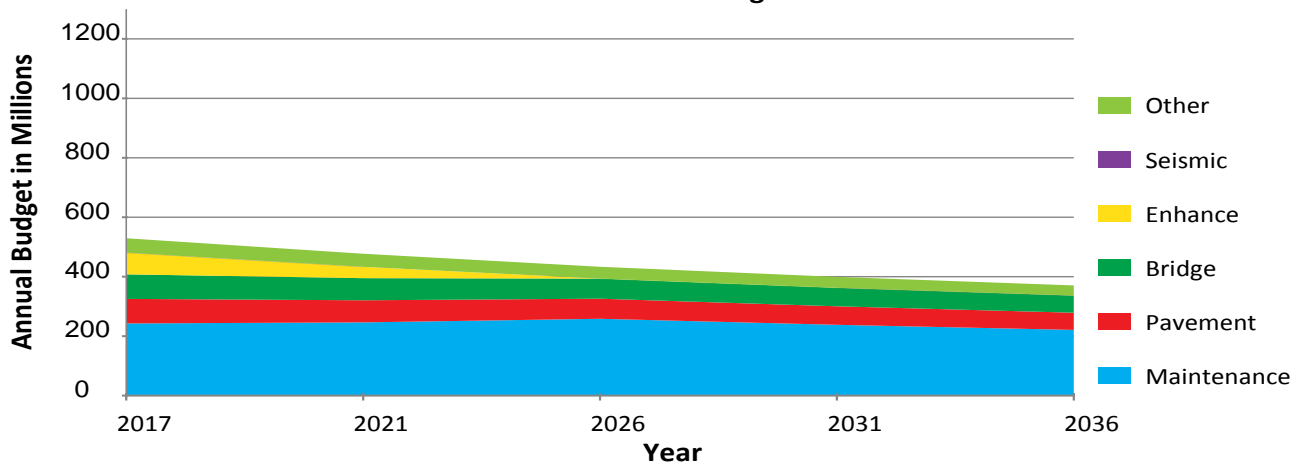


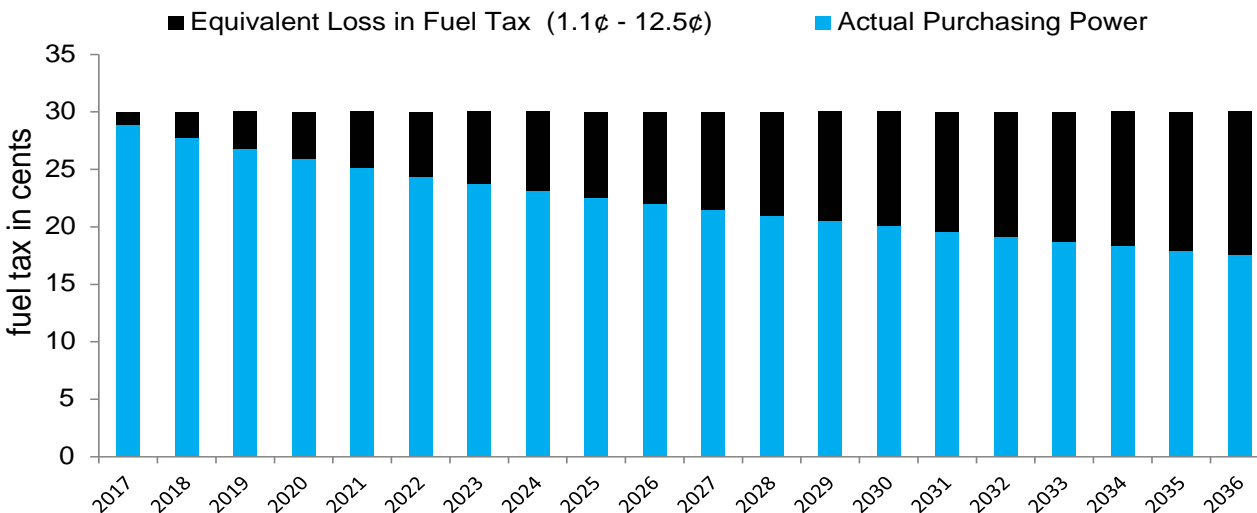
Figure 6

Scenario 1 Budget Assumptions	Maintenance	Pavement	Bridge	Enhance	Seismic	Other	Annual Total	20-Year Budget
Average Annual Budget for 20-Year Period in millions nominal dollars	\$306	\$85	\$85	\$19	\$0	\$50	\$545	\$10.9 billion
Average Annual Budget Adjusted for Inflation for 20-Year Period	\$243	\$68	\$68	\$17	\$0	\$40	\$436	\$ 8.7 billion

Inflation reduces the real revenue generated for highway investment. By year 2036 the 30 cent per gallon state fuel tax purchasing power is reduced to an effective rate of 17.5 cents per gallon. Figure 7 illustrates the loss of purchasing power expressed in terms of lost fuel tax purchasing power for the 20-year period.

Figure 7

Scenario 1 Loss in Purchasing Power Over Time



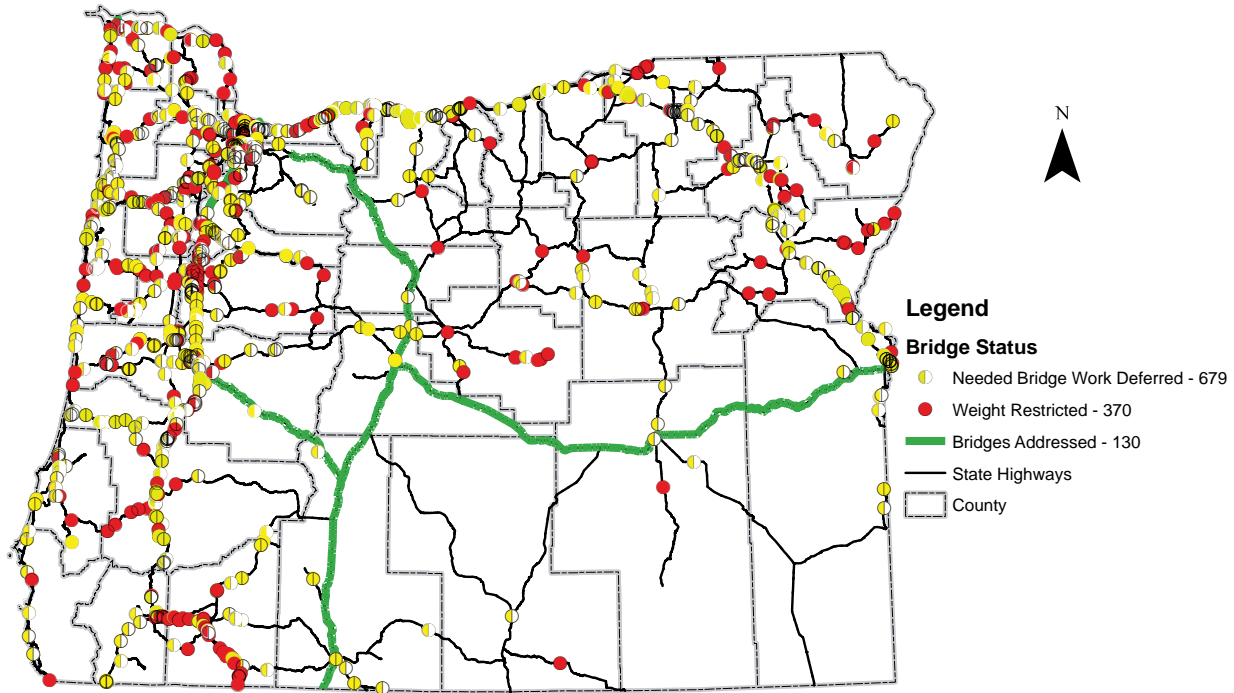
Scenario 1 investments focus on the I-5 corridor from Portland to Eugene, I-205, US 26/US97 from the Portland metro region to the California border, OR 58, and US 20 from Bend to Ontario. These corridors connect most urban areas and provide east-west and north-south connectivity.

For Scenario 1 the 20-year bridge budget of \$1.36 billion preserves or replaces 130 bridges on the Fix-It routes, as illustrated in **Figure 8**. **Figure 8** also illustrates the 370 bridges expected to be weight limited to vehicles below 80,000 pounds. Of these, 98 are on the Fix-It priority corridors and 272 are on other state highways. In addition to the weight restricted bridges, bridge work is deferred for 679 bridges, including 254 bridges on Fix-It routes and an additional 425 bridges where work is deferred on other state highways. This represents a \$7.3 billion backlog of bridge projects by the end of the 20-year period under Scenario 1. This backlog of bridge costs is anticipated to rise due to inflation and worsening bridge conditions as they further age without repair. Thus, the total bridge backlog is anticipated to be greater than \$7.3 billion after 20 years.

Current pavement investment needs are estimated to be \$200 million a year. Scenario 1 assumes an average annual budget of \$68 million, creating a \$2.6 billion deficit over the 20-year period. After 20 years operating with the Scenario 1 pavement budget, the state would have to spend an estimated \$4 billion to \$5.5 billion in additional funds to return pavement condition to current levels. Delaying needed pavement maintenance over the next 20 years forces the state to pay more than double what it would have cost if investment occurred according to pavement management best practices.

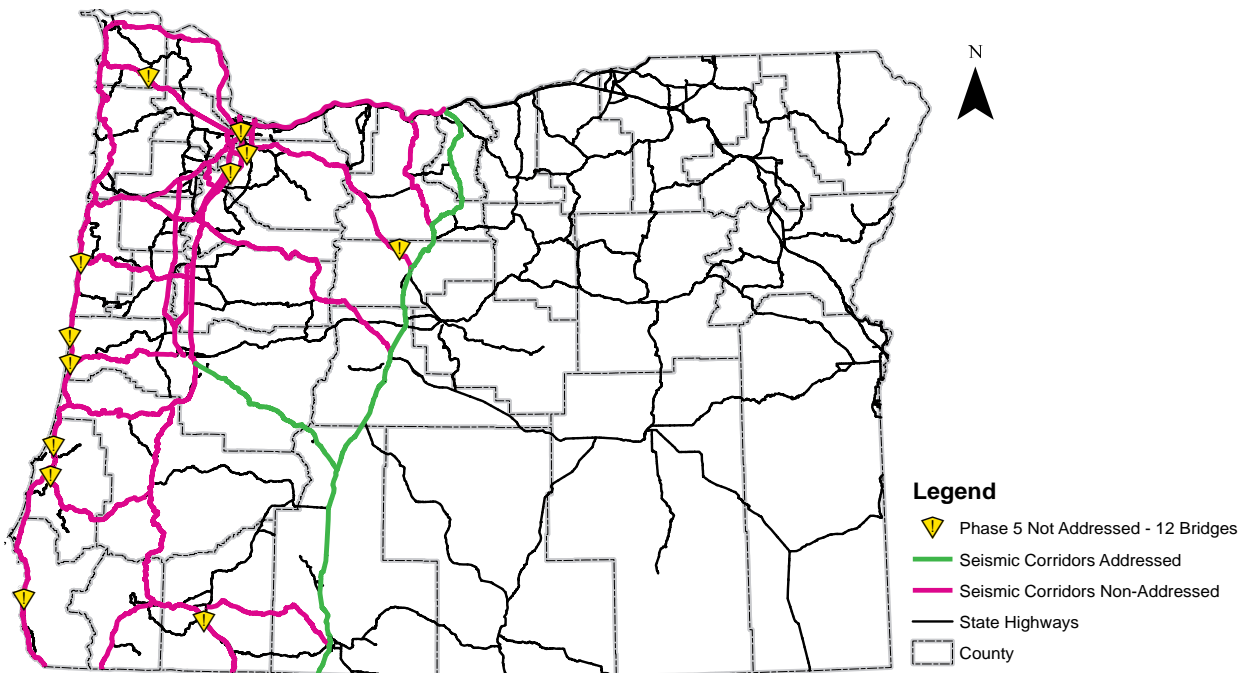
Overall, the need backlog for state bridge and pavement projects over the 20-year period under Scenario 1 is anticipated to be greater than \$12 billion. This backlog is likely lower than the actual need, because it only includes state-owned facilities, does not account for repair costs of bridges not maintained, and does not include costs associated with culverts, landslides, and extreme events.

Figure 8



For this scenario the Seismic budget is \$0. However, there are 39 bridges in this scenario that are made seismically resilient due to the rehabilitation and replacement work represented in this scenario.¹⁸ While seismic projects are not prioritized in Scenario 1, the work conducted on bridges for other structural reasons results in US 97 and OR 58 to be completed from the seismic preparedness perspective. **Figure 9** illustrates the corridors that become seismically resilient under Scenario 1.

Figure 9



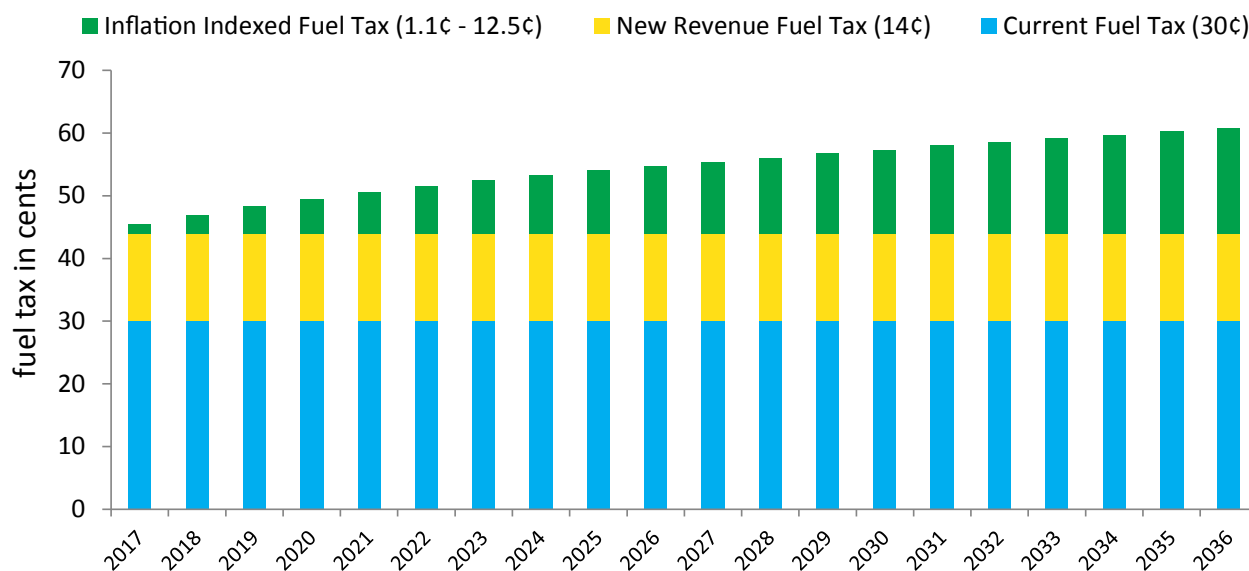
¹⁸ Only 39 of the 61 bridges replaced in this scenario are on the Seismic Plus list, the other 22 bridges were not identified as at risk of seismic impacts.

Scenario 2

Scenario 2 represents an expanded investment budget based on keeping I-5 and I-84 open to trucks. It represents a 35 percent increase in the budget for core highway assets. Such an increase would require a 14 cent increase in the state fuel tax and an equivalent increase in the weight-mile tax, of which half goes toward state spending and the other half to cities and counties. This scenario assumes purchasing power is maintained over time. **Figure 10** illustrates the level of equivalent fuel tax and weight-mile tax required to generate the increased budget and maintain purchasing power over time. Inflation has a cumulative impact; every year purchasing power declines by 2 percent to 3 percent (see Figure 3) and can be counteracted by an equivalent increase in revenue.

Figure 10

Scenario 2 Revenue Source Assumptions



To reflect the disinvestment trade-offs needed to address aging infrastructure, the Maintenance budget is increased 2 percent a year by shifting budget out of Enhance, until the Enhance budget reaches zero by year 2034. **Figure 11** presents the budget assumptions for Scenario 2. The 20-year budget is \$14.7 billion, with an average annual budget of \$735 million expressed as 2016 dollars.

Figure 11

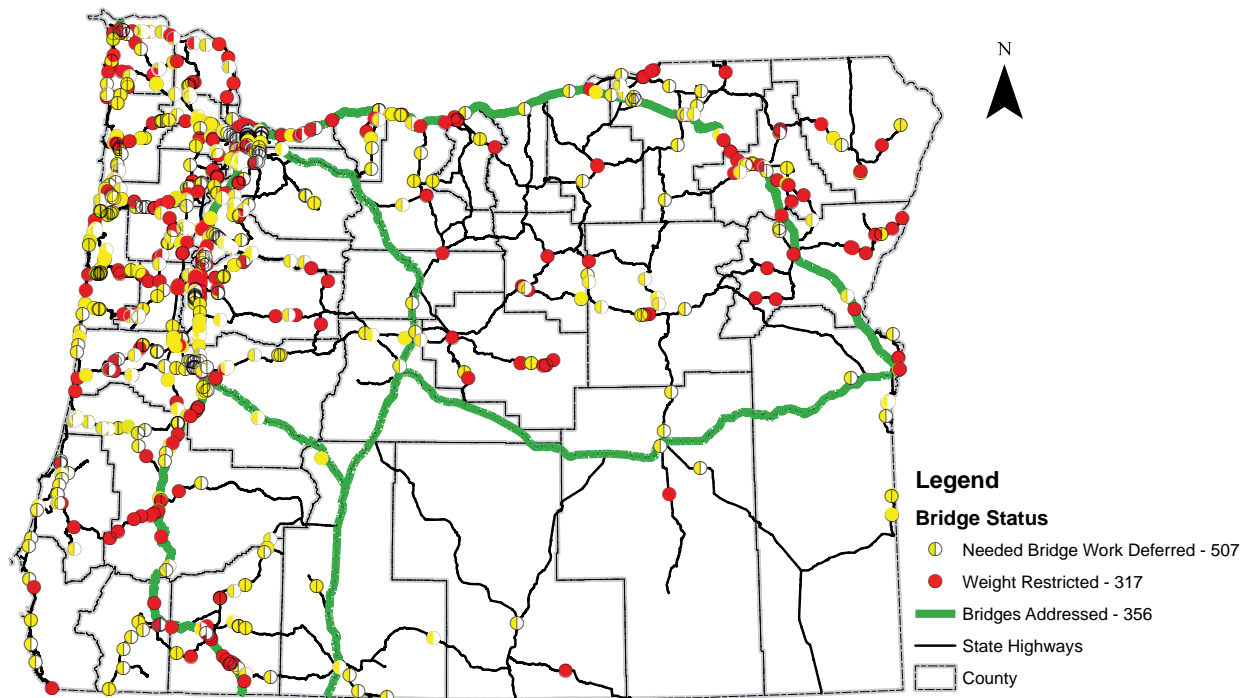
Scenario 2 Budget Assumptions	Maintenance	Pavement	Bridge	Enhance	Seismic	Other	Annual Total	20-Year Budget
Average Annual Budget for 20-Year Period in millions	\$302	\$127	\$150	\$43	\$49	\$64	\$735	\$14.7 billion

For Scenario 2, the 20-year bridge budget of \$3 billion preserves or replaces 355 bridges on the Fix-It routes, as illustrated in **Figure 12**. **Figure 12** also illustrates the 317 bridges expected to be weight restricted to vehicles below 80,000 pounds, of which 45 bridges are on Fix-It priority routes and 272 are off Fix-It priority routes. In addition to the weight restricted bridges, needed bridge work is being deferred for 507 bridges, 82 bridges on Fix-It routes and an additional 425 bridges where work is deferred on other state highways. This represents a \$5.7 billion backlog of bridge projects by the end of the 20-year period under Scenario 2. This backlog of bridge costs is anticipated to rise due to inflation and worsening bridge conditions as they further age without repair. Thus, the total bridge backlog is anticipated to be greater than \$5.7 billion after 20 years.

Current pavement investment needs are estimated today to be \$200 million per year. Scenario 2 assumes an average annual budget of \$127 million, creating a \$1.5 billion dollar deficit over the 20-year period. After 20 years at the Scenario 2 pavement budget, the state would have to spend an estimated \$2 billion to \$3.1 billion in additional investment to return pavement conditions to current levels. Delaying needed pavement maintenance over the next 20 years forces the state to pay up to double what it would have cost if investment occurred according to pavement management best practices.

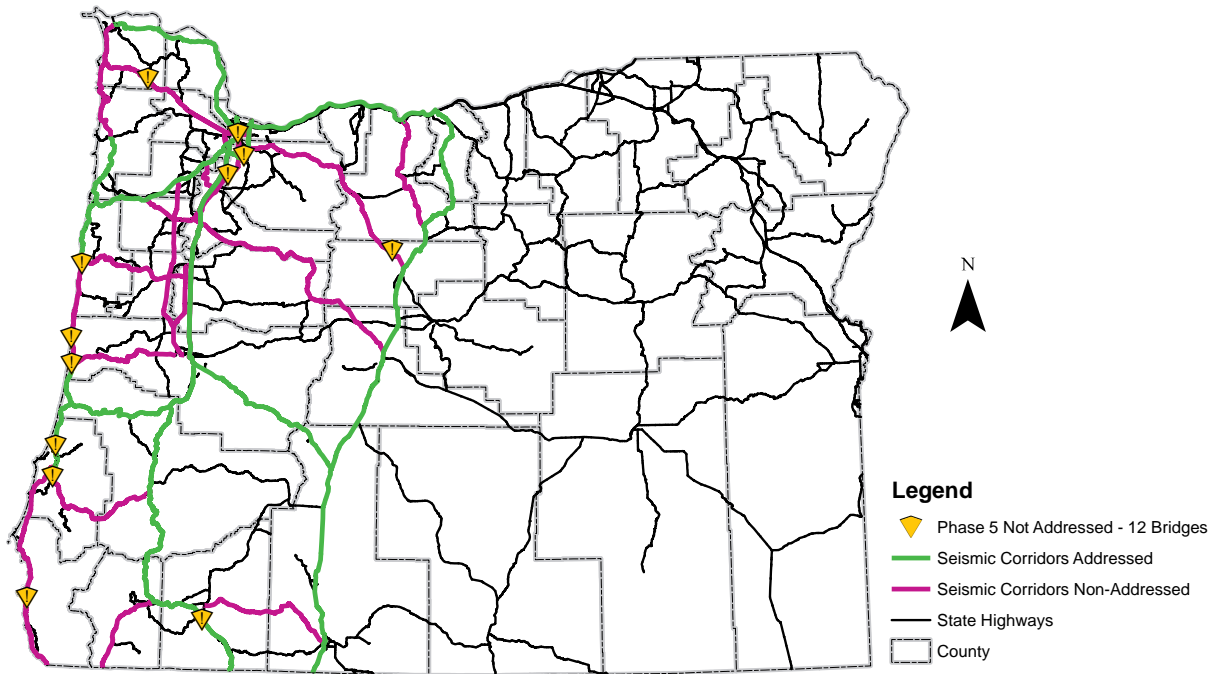
Overall, the need backlog for bridge and pavement projects over the 20-year period under Scenario 2 is anticipated to be greater than \$8.2 billion. This backlog is likely lower than the actual need, because it only includes state-owned facilities, does not account for repair costs of bridges not maintained, and does not include costs associated with culverts, landslides, and extreme events.

Figure 12



The 20-year Seismic bridge budget of \$980 million, combined with bridge replacements funded under the bridge program, completes seismic retrofits and reconstructions identified as Phase 1 and 2 of the Seismic Plus Program, illustrated in **Figure 13**.

Figure 13



Scenarios 3 & 4

Two hypothetical scenarios are presented here in order to evaluate the level of investment needed to preserve and maintain the highway system at levels closer to meeting actual need. These two scenarios include assumptions of higher budgets across all categories of core highway assets, representing hypothetical “What Would It Take” scenarios. They provide a sense of the levels of investment needed to meet the maintenance and preservation needs of Oregon highways and bridges.

Scenario 3

Scenario 3 illustrates the hypothetical “What Would It Take” to preserve and repair the entire state Fix-It system. Such an increase would require a 24 cent increase in the state fuel tax and equivalent weight-mile tax, of which half would go toward state-owned facilities. This scenario also assumes purchasing power is maintained over time and represented in the same manner presented for Scenario 2 and illustrated in the [Appendix](#). To reflect the disinvestment trade-offs required to address aging infrastructure – and given the full state system is underfunded for this scenario, – the Maintenance budget is increased 1 percent a year by shifting budget out of Enhance. Scenario 3 budget assumptions are presented in **Figure 14**.

Figure 14

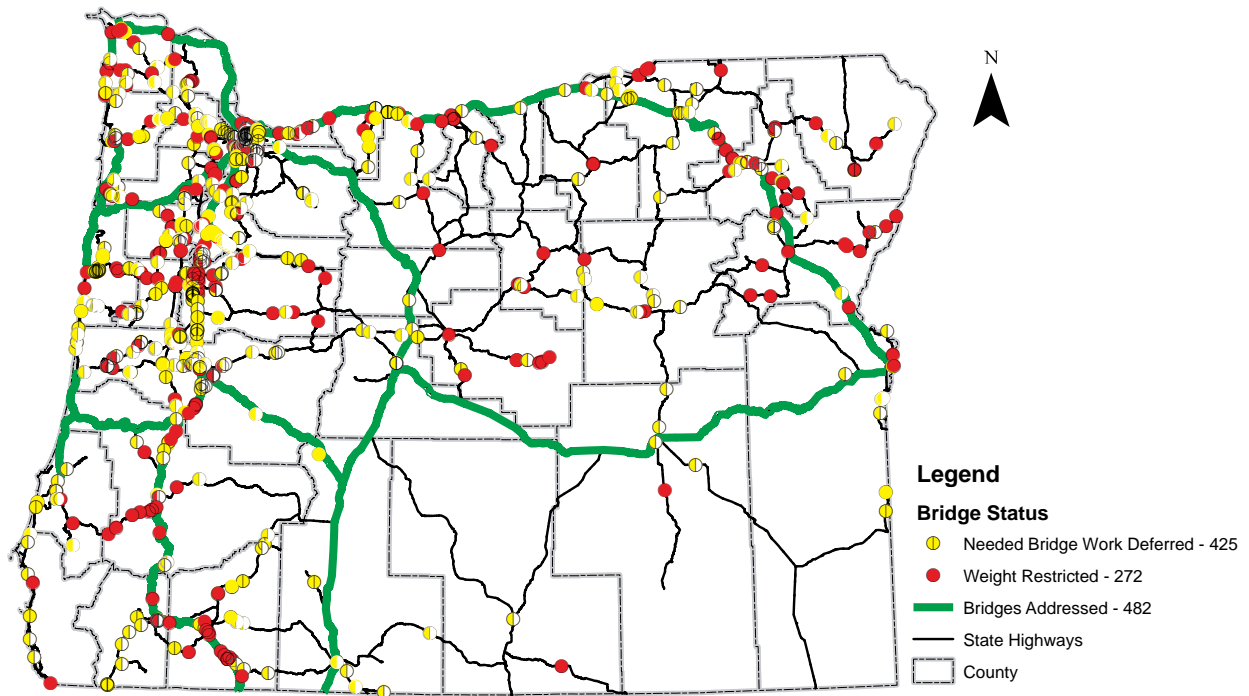
Scenario 3 Budget Assumptions	Maintenance	Pavement	Bridge	Enhance	Seismic	Other	Annual Total	20-Year Budget
Average Annual Budget for 20-Year Period in millions	\$275	\$154	\$220	\$90	\$70	\$77	\$887	\$17.7 billion

For Scenario 3, the 20-year bridge budget of \$4.4 billion preserves or replaces 482 bridges on the Fix-It priority corridors, as illustrated in **Figure 15**. This completes all of the Fix-It priority corridor bridge work. **Figure 15** also illustrates the 272 bridges expected to be weight restricted to vehicles below 80,000 pounds and an additional 425 bridges where work is deferred on other state highways. This represents a \$4.3 billion backlog of bridge projects by the end of the 20-year period under Scenario 3. This backlog of bridge costs is anticipated to rise due to inflation and worsening bridge conditions as they further age without repair. Thus, the total bridge backlog is anticipated to be greater than \$4.3 billion after 20 years.

Current pavement investment needs are estimated to be \$200 million a year. Scenario 3 assumes an average annual budget of \$154 million, creating a \$0.9 billion deficit over the 20 year time period. After 20 years operating with the Scenario 3 pavement budget, the state would have to spend an additional \$1.3 billion to \$2 billion to return pavement condition to current levels. Delaying needed pavement maintenance over the next 20 years forces the state to pay up to double what it would have cost if investment occurred according to pavement management best practices.

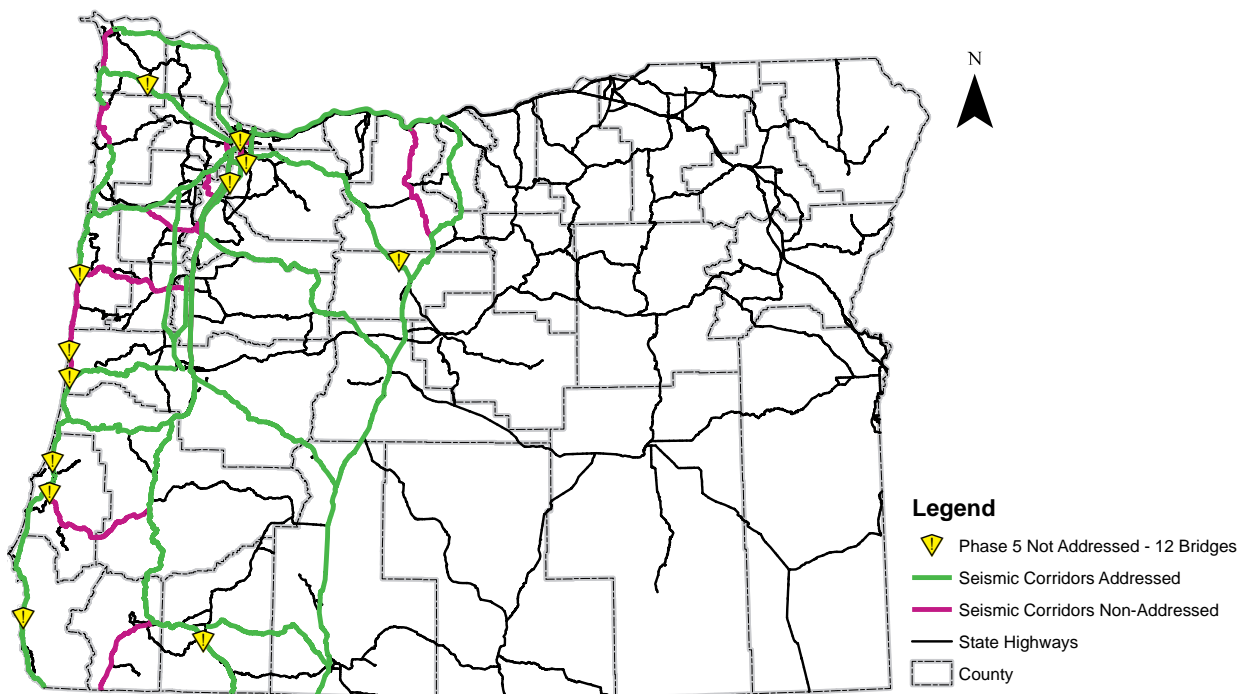
Overall, the need backlog for bridge and pavement projects over the 20-year period under Scenario 3 is anticipated to be greater than \$6 billion. This estimated backlog is likely lower than the actual need, because it only includes state-owned facilities, does not account for repair costs of bridges not maintained, and does not include costs associated with culverts, landslides, and extreme events.

Figure 15



The assumed 20-year Seismic bridge budget of \$1.4 billion completes seismic retrofits and reconstructions identified for Phase 3, in addition to Phases 1 and 2 of the Seismic Plus Program, illustrated in **Figure 16**.

Figure 16



Scenario 4

Scenario 4 illustrates the hypothetical “What Would It Take” to maintain current bridge and pavement conditions for the state system. Such an increase would require a 52 cent increase in the state fuel tax or equivalent weight-mile tax, of which half would go toward state-owned facilities and half to local governments. In this scenario, all budget categories are stable and funded at levels needed to sustain the system efficiently and avoid weight restrictions, presented in **Figure 17**.¹⁹ This scenario also assumes purchasing power is maintained over time and represented in the same manner as previous scenarios, illustrated in the *Appendix*.

Figure 17

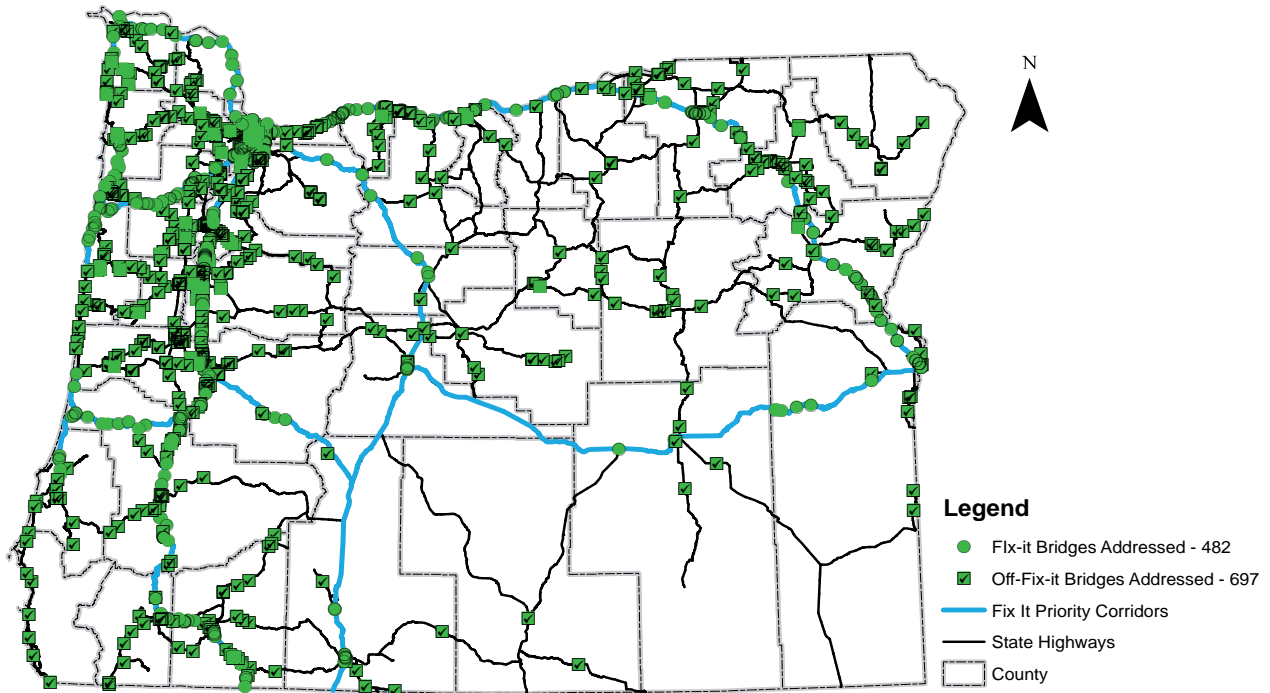
Scenario 4 Budget Assumptions	Maintenance	Pavement	Bridge	Enhance	Seismic	Other	Annual Total	20-Year Budget
Average Annual Budget for 20-Year Period in millions	\$300	\$200	\$435	\$150	\$90	\$100	\$1,275	\$25.5 billion

For Scenario 4, the 20-year bridge budget of \$8.7 billion completes all needed bridge work, including 482 bridges on Fix-It route priority corridors and 697 bridges on other state highways as illustrated in **Figure 18**. An important exception to note here are four major bridges crossing the Columbia River mentioned earlier in this report: US 101 Astoria-Megler Bridge, both I-5 bridges and the I-205 Glenn Jackson Bridge. These are bridges of statewide significance, which involve budget uncertainty.

¹⁹ Further detail on the budget assumptions for all four scenarios side-by-side are provided in the *Appendix*

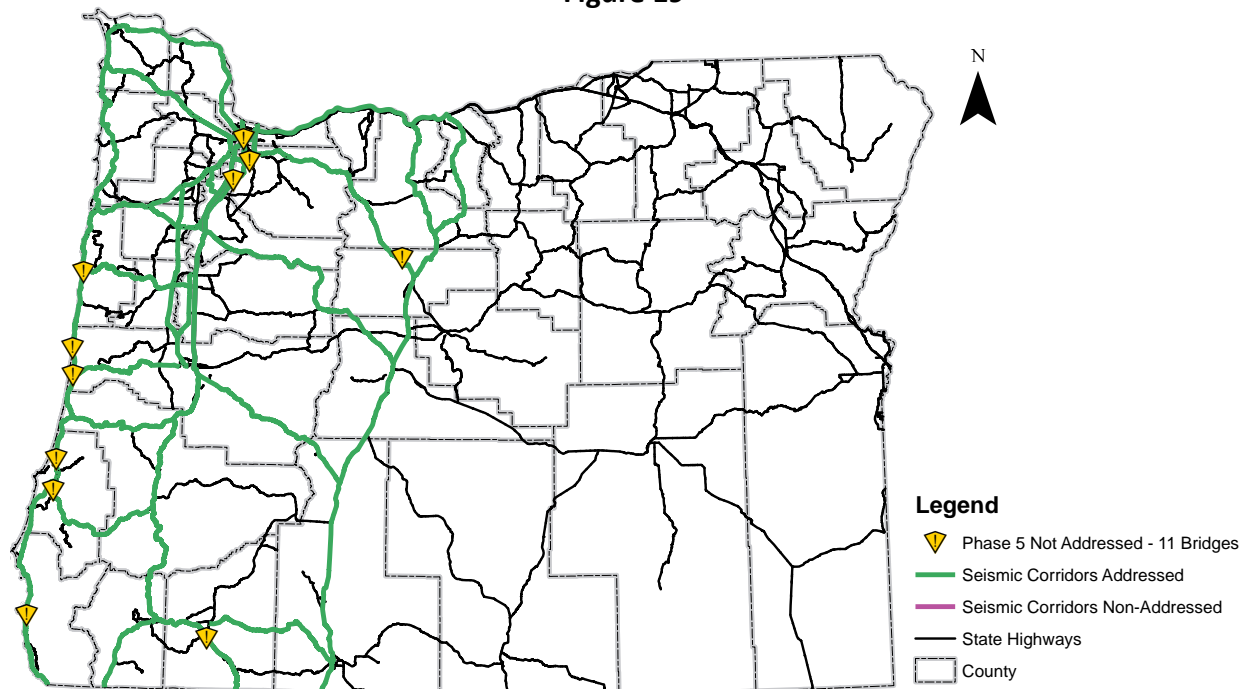
The 20-year need associated with these bridges for this analysis was assumed to be fixed maintenance costs captured in the scenario budgets. The cost of addressing these four bridges at the end of the 20-year period were not included in the backlog estimates for any of the scenarios.

Figure 18



The 20-year Seismic bridge budget of \$1.8 billion completes seismic retrofits and reconstructions identified in Phases 1, 2, 3 and 4 of the Seismic Plus Program, illustrated in **Figure 19**. Note that one bridge from Seismic Plus Phase 5 was addressed as part of Scenario 4 preservation work.

Figure 19



Analysis Tools

Bridge Model

Bridge conditions were forecast using the ODOT Bridge Model, developed by using bridge inspection and load rating data. ODOT statewide bridge inspection program captures over 100 data points per bridge per inspection. Data collected includes location, age, design type, size, traffic, component (deck, superstructure, and substructure) and the associated element conditions, among others. The Bridge Program is responsible for load rating, which determines allowable load capacity for 20 truck categories. Over thirty years of bridge inspection and load rating data were used as the basis to determine bridge aging trends within the ODOT Bridge Model. These trends were then used to estimate future needs. More information describing the ODOT Bridge model is provided in the [Appendix](#).

Bridge conditions were analyzed under four funding scenarios. The ODOT Bridge Section identified the bridges that would receive work prioritized by Fix-It Route and bridge remaining service life (RSL). To compare the outcome of the four scenarios after 20 years, the number of good, fair and poor bridges was projected.

Statewide Integrated Model

Forecast bridge weight restrictions are entered into the Oregon Statewide Integrated Model (SWIM) in order to estimate the impacts to the economy. SWIM is a data-driven forecast model designed to represent the Oregon economy with respect to land-use and transportation by simulating the activity and market exchanges made by people and businesses. Household and business location decisions are simulated, including travel generated by activities, such as commuting to work, purchasing commodities for industrial production and transporting final goods to markets within Oregon and outside of the state. The design of SWIM has been guided and vetted by an internationally recognized peer review panel of experts since inception and was designed to suit the unique planning needs of Oregon. More information on the history, development and characteristics of SWIM is provided in the [Appendix](#).

Findings

The findings section reports on the four scenarios for the following areas:

- Statewide economic impacts to jobs and gross domestic product.
- Impacts to bridge conditions.
- Impacts to pavement conditions.
- Impacts of rough pavement on vehicle operating costs.

Statewide Economic Impacts

This study builds on analysis completed for the 2014 Rough Roads Ahead report in several ways. For this update, ODOT evaluated dozens of model simulations representing varying conditions to understand potential outcomes given the uncertainty of future conditions. This approach resulted in findings consistent with the 2014 analysis. This analysis provides a broader evaluation of statewide future implications and options for investment decisions due to several updates, including:

- Improved Statewide Integrated Model, better representation of freight flows and industry patterns.

- ODOT Bridge Model, a new tool used to forecast future bridge conditions under different funding levels.
- Improved development of budget and investment assumptions.

A key finding of this study came about while evaluating the traffic simulation patterns within the modeling tools, revealing the importance of city and county-owned facilities as alternative routes when state bridges are weight restricted. The analysis scenarios were run using several techniques to represent how non-state facilities may deteriorate as traffic is shifted from state routes to local routes. Currently, there is very little data available to represent local infrastructure inventory and condition at the level of detail required for the tools used in this analysis. However, the study evaluates the broad implications of local infrastructure deterioration on statewide economic impacts. Thus, the results for impacts on employment and state production are presented with and without representation of local system deterioration in order to reveal the range of potential impacts.

Figure 20 illustrates the potential for job losses associated with rising transportation costs caused by bridge weight restrictions for the four scenarios, with job losses in Scenarios 1-3 compared to Scenario 4 in which bridges are preserved in good condition across the entire state highway system and thus do not cause any job losses. Several patterns stand out:

- Failure to address the full state system bridge needs is likely to result in a loss of about 75,000 jobs and up to 120,000 jobs if local infrastructure deteriorates similarly to state patterns.
- Additional investment in the Fix It Priority routes results in benefits to the system, reducing potential job losses as system condition rises, due to the reduction in transportation costs imposed on businesses by bridges restricted to heavy trucks.
- The condition and operations of the local transportation system matters to the Oregon economy. When state highway bridges are closed to trucks weighing 80,000 pounds or more, they are rerouted onto local roads in the model simulation. Consequently, when the modeled local transportation system does not account for deterioration, heavy trucks can use these detours without creating economic impacts. However, given that age and condition of local bridges mirror the state highway system, this is not a realistic assumption. There is insufficient information regarding the inventory and condition of local infrastructure to integrate it into the SWIM. A rough estimate of the potential impacts was constructed by using a deterioration rate for the local system similar to deterioration observed on the state highway system. Including local system condition and deterioration results in larger job losses due to higher transport costs caused by fewer alternative routes and businesses facing higher costs to get their goods to market.

Figure 20

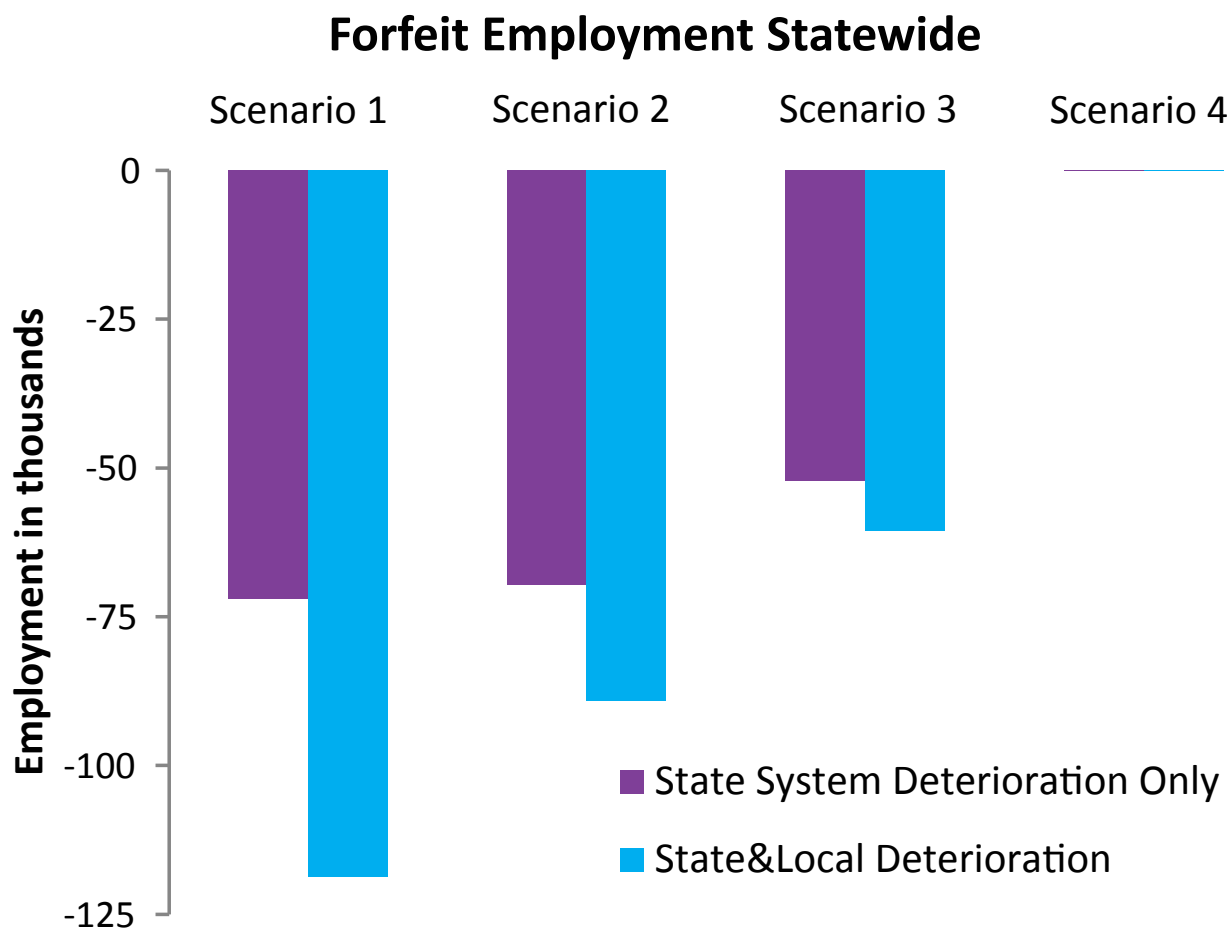
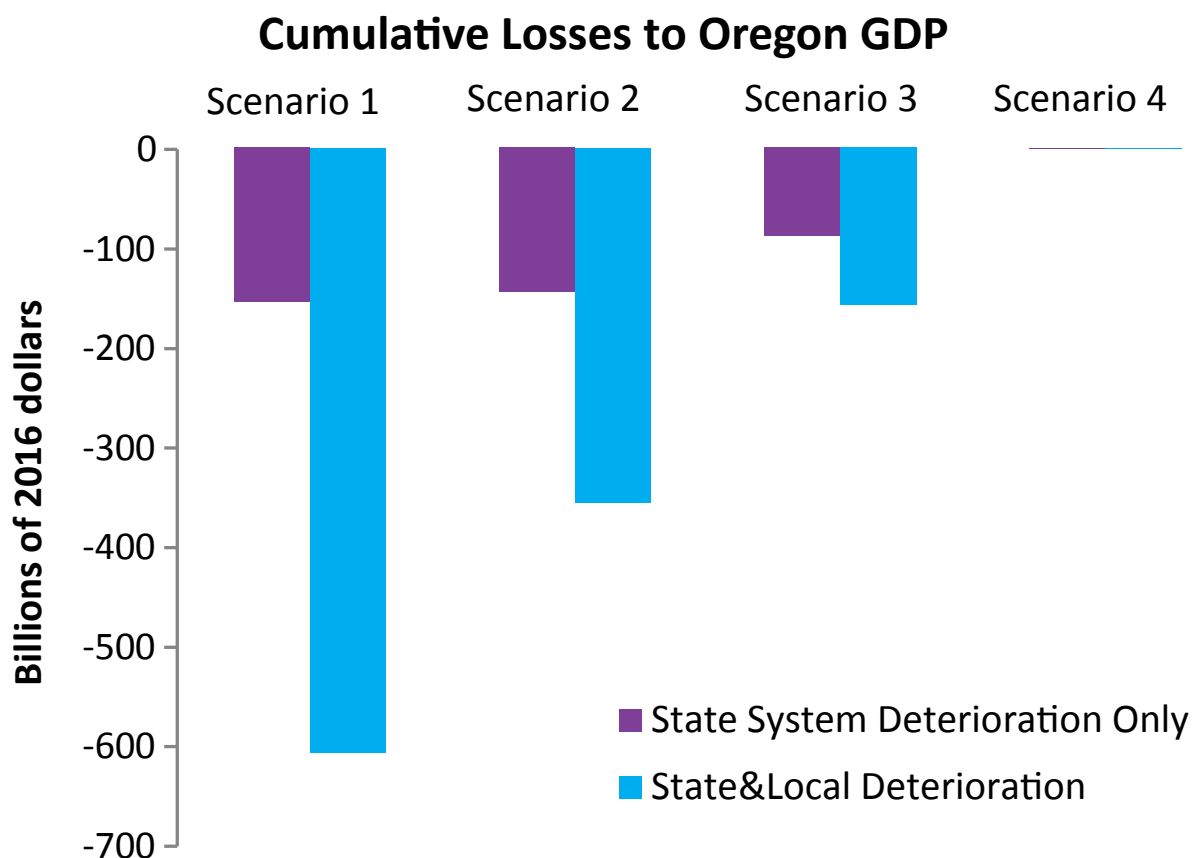


Figure 21 illustrates the potential for cumulative losses in gross state product over the 20-year period. The patterns here are similar, with significant production losses due to deterioration of the system and significant benefits with each additional increment of investment that enables more of the state highway system to remain open to heavy trucks. The implications of local system deterioration caused by truck traffic shifting from restricted state facilities to local facilities stand out even more than observed for employment impacts. Scenario 1 losses to gross state product over the 20-year period total over \$150 billion and nearly quadruples when representing local system deterioration. Scenario 2 losses are about 7 percent lower than Scenario 1 when only state system deterioration is modeled. However, losses are 60 percent lower in Scenario 2 when deterioration for state and local systems is included. Scenario 3 level of investment reduces gross state product losses by about 55 percent of Scenario 1 losses when accounting for state system deterioration only. Losses are reduced about 75 percent in Scenario 3 when including the impacts of local system deterioration.

Figure 21



Again, these results illustrate the importance of local city and county transportation infrastructure to the Oregon economy. About 15 percent of Oregon lane miles are owned by the state and carry about 60 percent of vehicle-miles-traveled and 80 percent of truck traffic, while the remaining 85 percent of lane miles are owned and maintained by city and county jurisdictions and carry about 40 percent of vehicle-miles-traveled. Oregon roads and highways together, regardless of ownership, operate as a system with redundancy and alternative routes available in the short run. However, major closures and long term heavy-vehicle detours would impact conditions on alternative routes, especially on facilities that were not designed for heavy trucks and increased use a detour may generate. If the local system is expected to provide redundancy for the state system, appropriate investment must be made to support this need in the future.

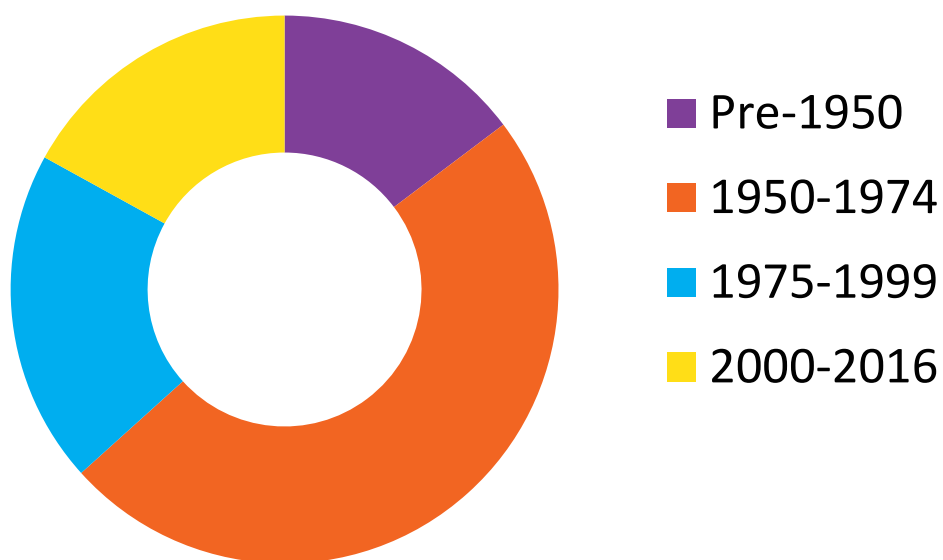
Impacts to Bridge Conditions

Effect on Interstate-Era Bridge Population

About half of ODOT’s bridges were built during the Interstate-Era of the 1950s and into the 1970s as illustrated in Figure 22. Many of these bridges were designed for loads smaller than originally allowed by state law. Preserving them is not cost effective because of their design details. Bridges with so-called “poor details” have higher incidences of cracking that may grow rapidly, holes in thin bridge decks developing without warning, load capacity issues and instability during earthquakes.

Figure 22

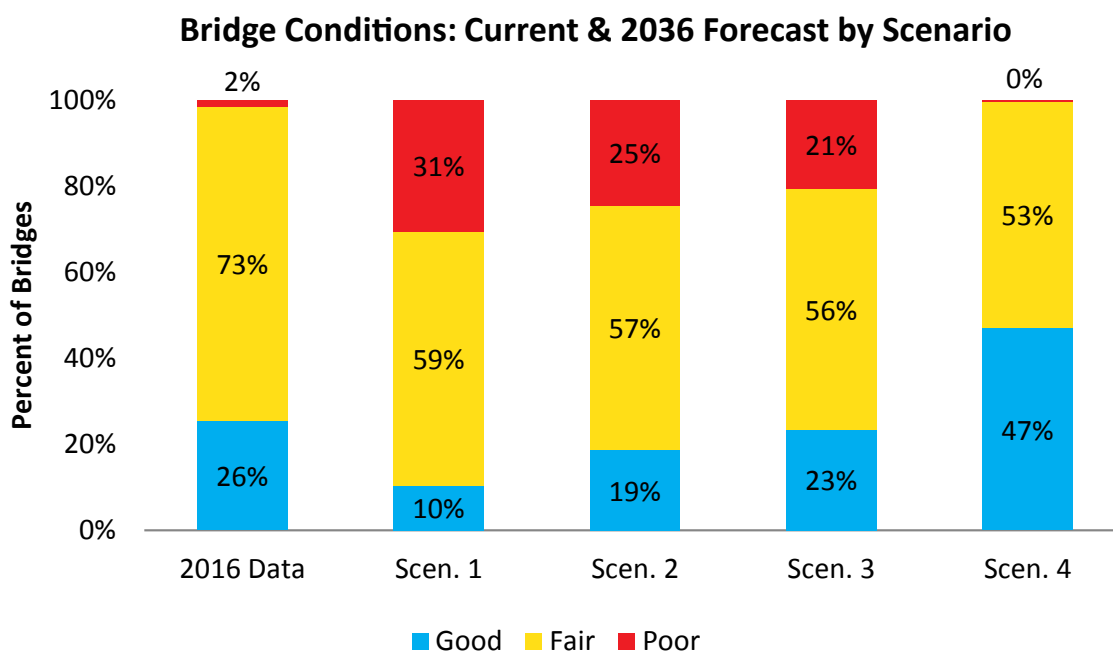
AGE OF OREGON'S BRIDGES



Increased investments in Scenarios 2-4 result in a reduced number of Interstate-Era and older bridges. Replacing these bridges in a planned manner will reduce the risk of widespread load restrictions and emergency repairs, and reduce the costs associated with disruptions to the system. It will also avoid the alternative of having to replace an unreasonably large number of bridges in a short timeframe as they eventually deteriorate to the point where replacement is the only option.

Figure 23 illustrates bridge conditions at the end of the 20-year period for all scenarios. Good/Fair/Poor percentages were calculated based on the projected improved National Bridge Institute ratings and the projected deteriorated conditions for those bridges that did not get work.

Figure 23

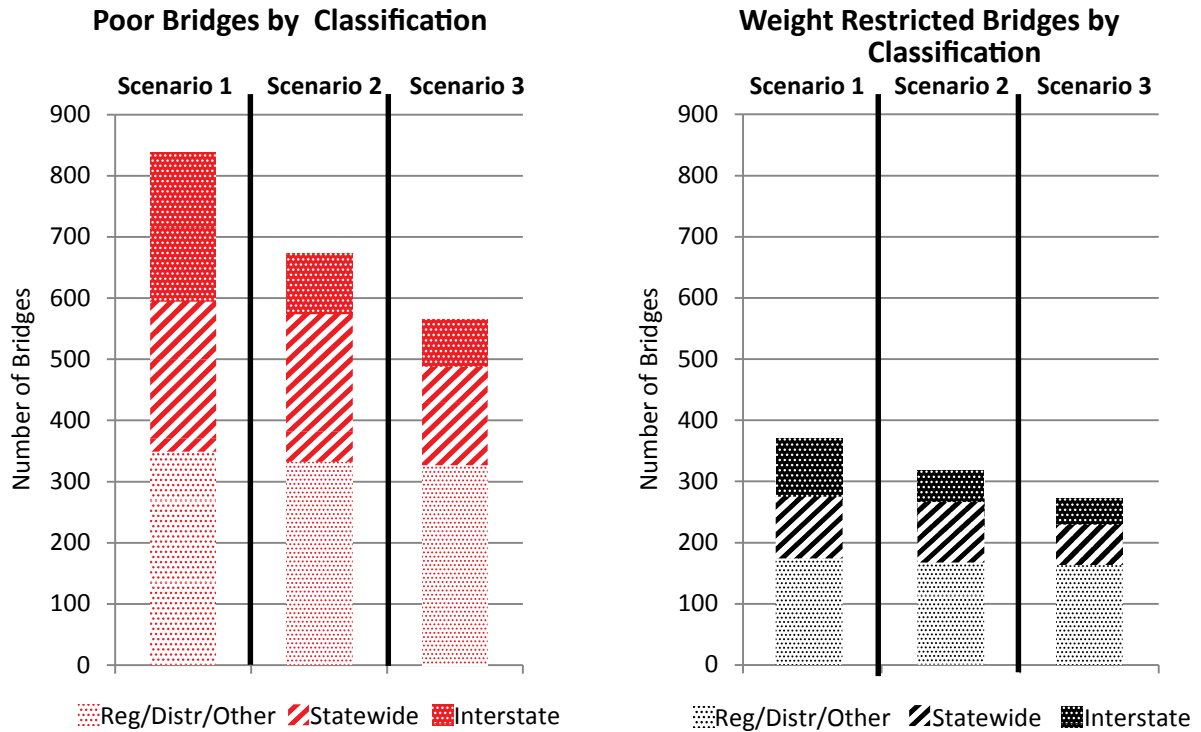


With increasing levels of funding, the percentage of poor bridges decreases. Poor bridges may have weight restrictions. While poor bridges may still be safe for travel, maintenance needs and distresses may trigger the need for replacement.

Weight-restricted bridges affect more than just the heavy trucks that need to use detours to deliver their loads. When trucks are detoured from state highways to city streets, they may encounter streets that are too narrow and corners that are too sharp to allow for necessary turns. In addition to freight, fire trucks and other emergency vehicles are affected, as are school buses. Detours can increase the response time to an incident, or complicate getting students to and from school. However, if a company chooses to divide loads so it can use a weight-restricted bridge, it creates more trucks on the roads to deliver the same goods, and the higher shipping costs would likely be passed on to consumers.

A breakdown of poor and weight-restricted bridges by classification and scenario is shown in **Figure 24** and discussed below.

Figure 24. Number of Poor and Weight-Restricted Bridges by Classification



Although Oregon bridges are considered safe (if load restriction signs are obeyed), there are a large number of bridges with critical and near-critical conditions whose service lives have been extended beyond a normal time period because of long-standing inadequate funding for bridges. Those bridges demand vigilance and dedication by inspectors and maintenance personnel to maintain safe conditions.

At lower funding level scenarios, there is considerable risk that critical and near-critical conditions will rise at an increasing rate until a point in the near future when ODOT will be unable to address serious issues in a timely manner especially on lower priority Region/District/Other routes. At that point unpredictable failures become a rising possibility, resulting in safety issues, delays, detours and high-cost emergency repairs.

Impact to Pavement Conditions

The goal of the ODOT pavement preservation program is to keep state highways in the best condition possible, for the lowest cost within a limited budget, by taking a life-cycle cost approach to preservation and maintenance. The most cost-effective strategy is applying preservation treatments on highways while they are still in “fair or better” condition, which extends pavement life at a reduced resurfacing cost. If not properly maintained, roads will deteriorate to very poor condition and require complete reconstruction to fix them. **Figure 25** illustrates the importance of performing the right treatment to the right road at the right time. **Figure 26** provides illustrated examples of pavement condition.

Figure 25

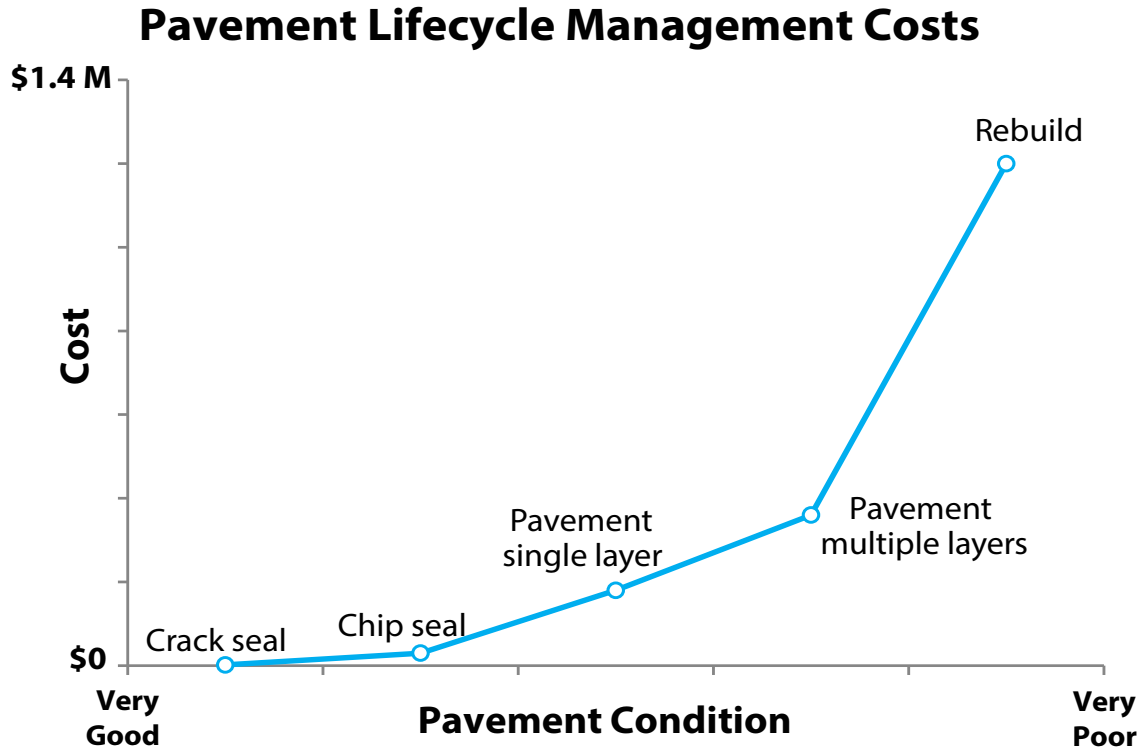
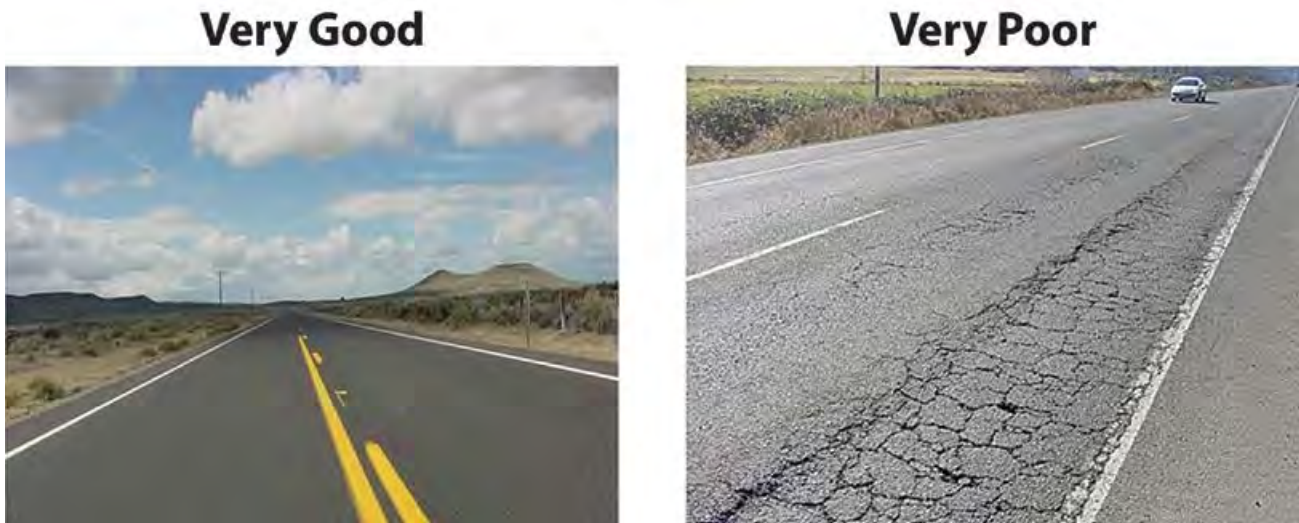


Figure 26



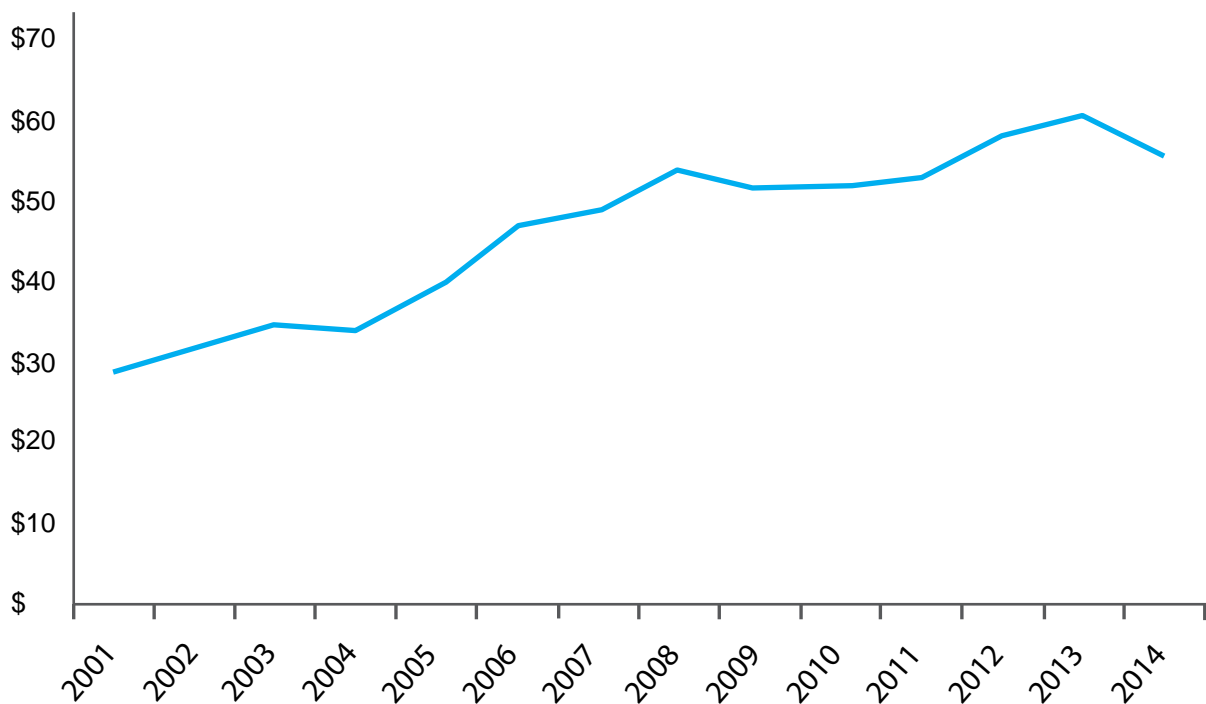
In the later stages of a pavement’s service life, deterioration occurs at an increasing rate, making it critically important not to defer preservation treatment much longer. If a preservation treatment can be applied before a pavement reaches poor condition, the service life can be extended for a fraction of the cost of reconstruction. Deferring maintenance just a few years will cost much more in the long run. According to the American Association of State Highway and Transportation Officials (AASHTO), every dollar spent on road maintenance avoids \$6 to \$14 needed later to rebuild a road that has irreparably deteriorated²⁰.

²⁰ National Center for Pavement Preservation, Preservation Awareness Toolkit, Media Fact Sheet: <https://www.tsp2.org/files/2012/01/News-release-template-4.pdf>

An estimated \$200 million per year in current dollars for the next 20 years is sufficient to repair the backlog of high cost poor and very poor highways, while keeping the remaining state highways in “fair or better” condition. This funding level would support major repairs needed on routes with the worst pavement conditions, while providing for timely preventive preservation and maintenance on roads in fair to good condition.

The current ODOT budget of \$85 million per year for pavement preservation and repair work provides less than one-half of the actual need for pavement preservation and major repairs. Declining purchasing power (construction costs inflation) makes the business case even worse. Because construction costs rise over time, today’s pavement budget paves little more than half what could be paved 15 years ago. **Figure 27** illustrates the change in nominal asphalt costs since 2001²¹.

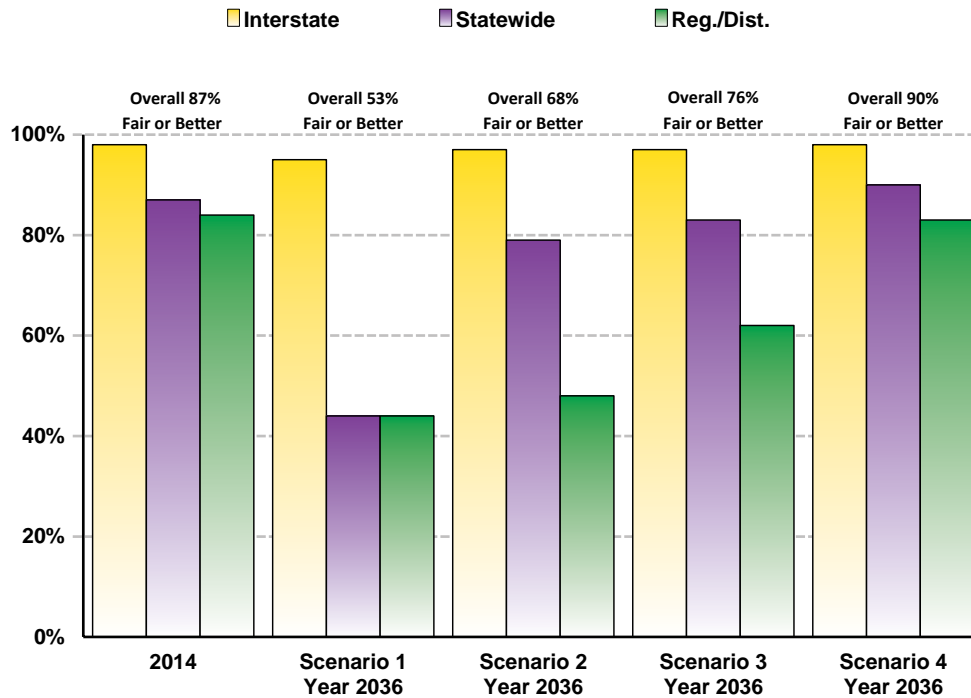
Figure 27. Change in Nominal Asphalt Costs Over Time



After 20 years of funding at current forecast levels represented in Scenario 1, pavement conditions will decline across the system. The greatest declines will be on urban roads and lower volume roads. To keep state highways in their current good condition, ODOT needs to pave about 400 miles each year. However, future funding levels only allow for paving about 170 miles each year, so road conditions will decline over time. Current and forecast pavement conditions by functional class for all four scenarios are illustrated side-by-side in **Figure 28**.

²¹ ODOT Office of Project Letting, nominal values not adjusted for inflation

Figure 28. Pavement Condition - Current and Future by Scenario Forecasts by Facility Type



Because the Interstate System is a critical transportation system that carries heavy volumes of traffic and freight at high speeds, preservation investments will focus on interstates. Under current funding (Scenario 1), by 2036 many segments will have reached the end of their structural life and these segments will need major rehabilitation or reconstruction to carry projected traffic. The condition on the statewide system of primary routes and the region and district level routes will decline dramatically. Routes east of US 97 will mostly receive just patching and chip seals and virtually no paving projects. This strategy will work initially, but will fail over the long term. Also, a chip seal strategy is not a viable option for most primary routes west of the Cascades so crack sealing and patching become the only viable alternative to paving. State highways in local communities that require higher-cost projects will likely receive only patching.

Declining pavement conditions will shift the burden to ODOT maintenance crews to keep poor highways in a safe condition for travel. Maintenance budget demands for reactive maintenance activities, such as pothole patching and rut filling, will increase. It is estimated that the Maintenance budget will need to increase so much that the budget for highway capacity expansion (Enhance) will eventually be totally consumed by increased pavement and bridge maintenance needs. Under current funding projections it is estimated to take 10 years for the Maintenance budget to bring the highway capacity budget to zero. Even with extra funding shifting from the Enhance budget to the Maintenance budget, there will still be substantial consequences to underfunding pavement preservation.

Despite extra spending towards maintenance, after 20 years of funding at current levels, there will be substantially more miles of poor and very poor roads than there are today. **Figure 29** illustrates examples where pavement deterioration has reached an advanced state requiring complete reconstruction or major rehabilitation. It is estimated the number of roads in this condition will double or triple within the next 20 years at current funding levels.

Figure 29



Over time, as road conditions deteriorate, thicker paving and/or complete replacement will become necessary at a higher cost. If significant deterioration occurs, pavement surface becomes rougher, vehicle operating costs rise and safety impacts occur. Beyond the 20-year horizon, poor pavement condition on some lower functional class roads will require reductions in posted speed to maintain safe travel and reduce chances of vehicle damage. Many of the lower functional class roads will be in poor condition and further deteriorate to very poor if maintenance funding is unavailable.

Impact of Rough Pavement on Vehicle Operating Costs

Preserving pavement condition at current levels would avoid higher user costs for private autos, commercial vehicles and heavy trucks. The cost of operating vehicles rises as pavement surface becomes rougher; fuel efficiency declines, tire wear increases and repair costs rise. Oregon has over 3.4 million registered light vehicles, which includes passenger cars, pick-ups, vans and SUVs; and over 90,000 registered medium and heavy trucks, as illustrated in **Figure 30**. Total statewide vehicle miles traveled in 2015 was 35.9 billion, which includes Oregon-based and non-Oregon based vehicles. Over 90 percent of the miles driven in Oregon are by light vehicles; about 7 percent of the miles are by commercial trucks.

Figure 30

Oregon Registered Vehicles 2015				
Medium car	1,597,000			
Van	229,000			
SUV	761,000			
Light Truck	780,000			
TOTAL Light Vehicles	3,367,000	33,291	million	92%
Medium Heavy	47,000	805	million	2%
Heavy Truck	46,000	1,903	million	5%
Total Registered 2015	3,458,900	35,999	Total VMT	

Source: ODOT, figures rounded may not sum to 100 percent.

According to the 2015 Consumer Expenditures Survey²² households spent on average 17 percent of their after-tax income on transportation. About one third of transportation costs are from vehicle operating costs associated with fuel, oil, tires, maintenance and repairs. As pavement condition deteriorates, more and more miles driven will be on rough pavement, causing vehicle operating costs to rise and impact household budgets.

The National Cooperative Highway Research Program (NCHRP) Report 720²³ conducted extensive research to estimate the impacts of pavement condition on vehicle operating costs for five vehicle categories: medium car, van, SUV, light truck, medium truck and articulated truck. **Figure 31** illustrates the impact of pavement condition on vehicle operating costs using estimates from that report. For light vehicles, the report estimates vehicle operating costs rise by 23 percent when driving on rough pavement²⁴ compared to smooth pavement. For medium heavy and heavy trucks, the report estimates costs rise by 15 percent. Vehicles are driven on pavement with varying conditions over the course of a year. Estimating actual vehicle operating costs would require detailed data that is not currently available. However, using hypothetical assumptions allows the exploration of potential impacts of rough pavement on vehicle operating costs with information from NCHRP Report 720.

Figure 31

2015 Vehicle Operating Costs for Smooth Pavement Compared to Rough Pavement			
	Average Vehicle Operating Costs, dollars per mile	NCHRP Cost Factor for Rough Pavement	Operating Cost on Rough Pavement, dollars per mile
Light Vehicles*	\$0.159	1.23	\$0.197
Medium Heavy **	\$0.355	1.15	\$0.409
Heavy ***	\$0.785	1.15	\$0.903

**2016 Automobile Association of America ""Your Driving Costs""
<https://exchange.aaa.com/wp-content/uploads/2016/04/2016-YDC-Brochure.pdf>
 **NCHRP Report 720, ibid
 *** American Trucking Research Institute, Operational Costs of Trucking 2015, Table 8
<http://atri-online.org/wp-content/uploads/2015/09/ATRI-Operational-Costs-of-Trucking-2015-FINAL-09-2015.pdf>

Figure 32 illustrates the cost impact when 20 percent and 30 percent of statewide vehicle-miles-traveled (VMT) occurs on rough pavement using the cost factors from the NCHRP Report 720²⁵. Using statewide VMT is appropriate for an estimate of this type, because deterioration patterns of state highway pavement condition is likely to occur on county and city pavements as well. Households and businesses do not differentiate between pavement ownership. This hypothetical example is designed to illustrate the potential magnitude of impacts to Oregon highway and road users.

²² <https://www.bls.gov/cex/tables.htm>, Table 1203 "Average Expenditure, Share, and Standard Error Tables – Income Before Taxes"

²³ This is the same source used for the original Rough Roads study: NCHRP Report 720 "Estimating the Effects of Pavement Condition on Vehicle Operating Costs, 2012" Table 7-5: Effect of Roughness on Vehicle Operating Costs, which is provided in the *Appendix*.

²⁴ Pavement condition is measured using the International Roughness Index (IRI), which is the most commonly used measure for evaluating and managing road systems worldwide. See *Appendix* for more information.

²⁵ See *Appendix* for further detail on cost calculations.

Figure 32

Potential Impact of Rough Pavement on Oregon Registered Vehicle Operating Costs, millions of 2015 dollars					
Total Estimated Expenditures for year 2015 Driving on Smooth Pavement		Total Expenditures if 20 % of Miles Driven on Rough Pavement	Total Expenditures if 30 % of Miles Driven on Rough Pavement	Change in Cost With 20% Rough	Change in Cost With 30% Rough
Light Vehicles	\$5,309	\$5,558	\$5,682	5%	7%
Medium Heavy	\$286	\$295	\$299	3%	5%
Heavy Truck	\$1,494	\$1,539	\$1,561	3%	4%
Total Statewide	\$7,088	\$7,391	\$7,542	4.3%	6.4%

Total annual statewide vehicle operating costs would rise by about 4 percent if 20 percent of VMT was driven on rough pavement, which increases statewide expenditures by \$300 million a year. Total statewide vehicle operating costs would rise by over 6 percent if 30 percent of VMT was driven on rough pavement, which represents an increase of \$450 million in annual vehicle operating costs.

On a statewide scale such as this, a shift in transportation costs has implications for economic activity. For businesses, higher transportation costs shift money away from more productive spending in areas related to investment and market expansion, and profit margins shrink. Rising costs such as this have the potential to reduce demand in key economic sectors in Oregon associated with business investment for expansion, research and development, and in consumer sectors. Households shift spending out of “quality of life” purchases, consumer goods and savings to accommodate the rise in vehicle operating costs.

Summary/Conclusions

This study provides a high-level strategic look at the long range implications of investment decisions. The purpose of the study is to provide information to assist in making investment decisions that must accommodate the need to evaluate trade-offs, disinvestment and prioritization. The cost of maintaining and preserving existing facilities prevents investment in new and growing areas of the state when funding is insufficient to meet basic preservation and maintenance needs. Oregon must devise new ways to develop efficient use and management of facilities and proactively prepare for disinvestment. Disinvestment impacts the economy through higher transportation costs, safety risks to individuals and businesses, and congestion. **Figure 33** presents costs and benefits identified for the four analysis scenarios developed for this study, illustrating trade-offs associated with different levels of funding.

Figure 33. Summary Comparison of Scenario Costs and Benefits

	Scenario 1 Current Funding	Scenario 2 Limited Highway Corridors	Scenario 3 Preserve Priority Corridors	Scenario 4 Meet Needs
Economic Impacts				
Forfeit Jobs	75,000 - 120,000	70,000 - 90,000	50,000 - 60,000	0
Lost GDP, billions	\$155 - \$605	\$144 - \$355	\$88 - \$156	0
State Infrastructure Condition				
Bridges Repaired	130	355	482	1179
Pavement % Fair or Better	53%	68%	76%	90%
Seismic Budget, billions	\$0.0	\$1.0	\$1.4	\$1.8
Seismic Program	US 97 & OR 59	Phases 1 & 2	Phases 1 - 3	Phases 1 - 4
Enhance Budget, billions	\$0.4	\$0.9	\$1.8	\$3.0
Other Programs, billions	\$0.5	\$1.3	\$1.5	\$2.0
20 Year Budget*, billions	\$8.7	\$14.7	\$17.7	\$25.5
Bridge Backlog, billions (disinvestment)	\$7.4	\$5.7	\$4.3	\$0.0
Pavement Backlog, billions (disinvestment)	\$4.6	\$2.5	\$1.7	\$0.0
Total Cost, billions (Budget + Backlog)	\$20.7	\$22.9	\$23.7	\$25.5
* See scenario descriptions for detailed list of assumptions. Increased budgets are for 20-year core highway budget categories only: Maintenance, Pavement, Bridge, Seismic, Enhance and Other, not entire ODOT budget; dollars are expressed as 2016 values.				

While the transportation investment needs are large in scale, any additional investment in the highway system will contribute to Oregon’s economic competitiveness. The return on investment for the transportation system includes new jobs, more state output, lower transportation costs, and greater safety. In order to optimize the use of limited investment funds, the state, cities and counties should work together strategically to protect current infrastructure and coordinate future investment projects.

Oregon recently reached 4 million in population and is forecast to reach 5 million by 2036. The state must continue to address transportation needs in order to accommodate future growth while maintaining economic competitiveness. Investment decisions made today will impact the state’s transportation system – and the state as a whole – well into the future.



Rough Roads Ahead 2: Economic Implications of Deteriorating Highway Conditions

Appendix

Disinvestment Definitions

The “National Cooperative Highway Research Program (NCHRP) Synthesis 480: Economic and Development Implications of Transportation Disinvestment”¹ reports on current knowledge and practice in the field of disinvestment effects on transportation system integrity.

The NCHRP Synthesis 480 (<https://www.trb.org/Publications/Blurbs/172915.aspx>) presents definitions that were adopted for this analysis, which are stated below:

- **Disinvestment:** a process by which an infrastructure asset (which may be a specific facility, program, or network) is allowed to fall below previously accepted standards of condition or performance by either (1) investing resources elsewhere, or (2) simply not investing resources in the disinvested asset. This may also include choosing not to invest in new infrastructure or assets as needed to maintain an accepted level of performance on an existing facility or system.
- **Intentional disinvestment:** a conscious policy choice to disinvest in an infrastructure asset in order to make funds available elsewhere or to manage funding shortfalls.
- **Passive disinvestment:** a policy choice (or series of policy choices) that while not intended to allow an infrastructure asset to fall below previously accepted standards of condition or performance has just such an effect over time.

Fix-It Priority Corridors

Fix-It corridors include all the routes in the OTIA Stages 1-3, Seismic Phase 1 and 2 Lifeline Routes, and Priority Routes from the Highway Management Team. **Figure A1** illustrates the OTIA investment stages overlapping with Fix-It priority routes outlined in bold. **Figure A2** illustrates the Seismic investment phases overlapping with Fix-It priority routes outlined in bold.

The order of investment on the Fix-It routes is based on the OTIA staging priorities. The only OTIA routes prioritized were those overlapping the Fix-It priority corridors. The Fix-It corridors were further segmented and prioritized based on the Oregon Seismic Plus Program. Seismic funds were assigned to Fix-It priority corridor bridges that are also on Lifeline Routes in later scenarios.

¹ <https://www.trb.org/Publications/Blurbs/172915.aspx>

Figure A 1

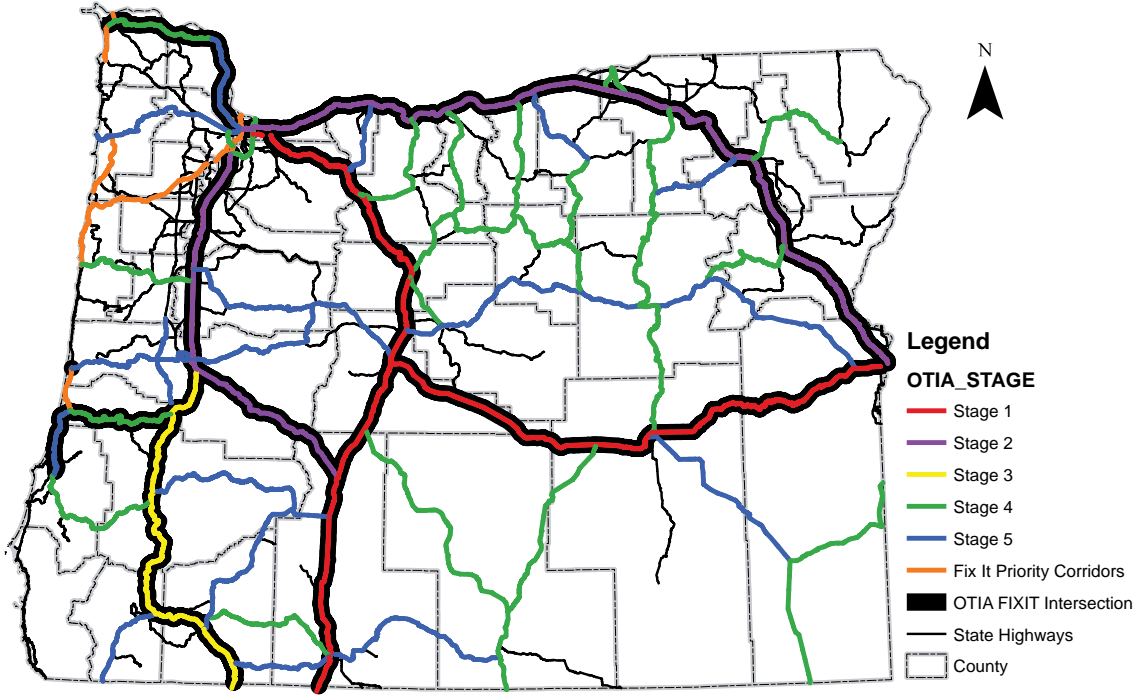
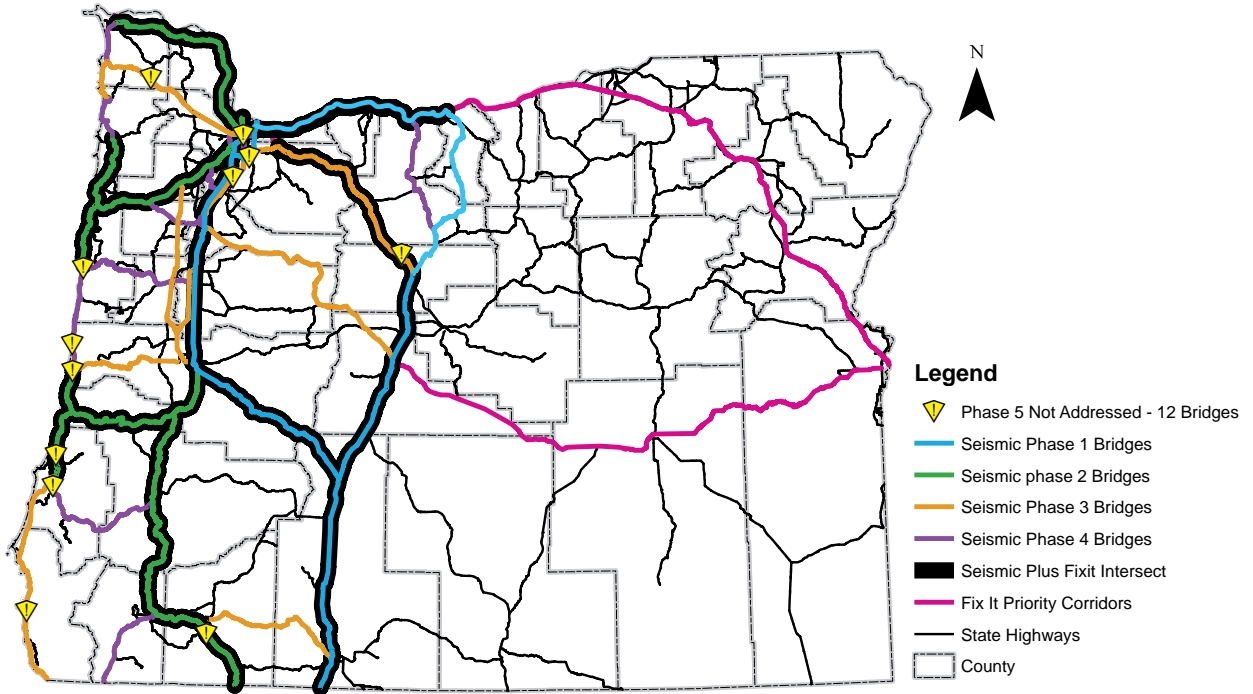


Figure A 2

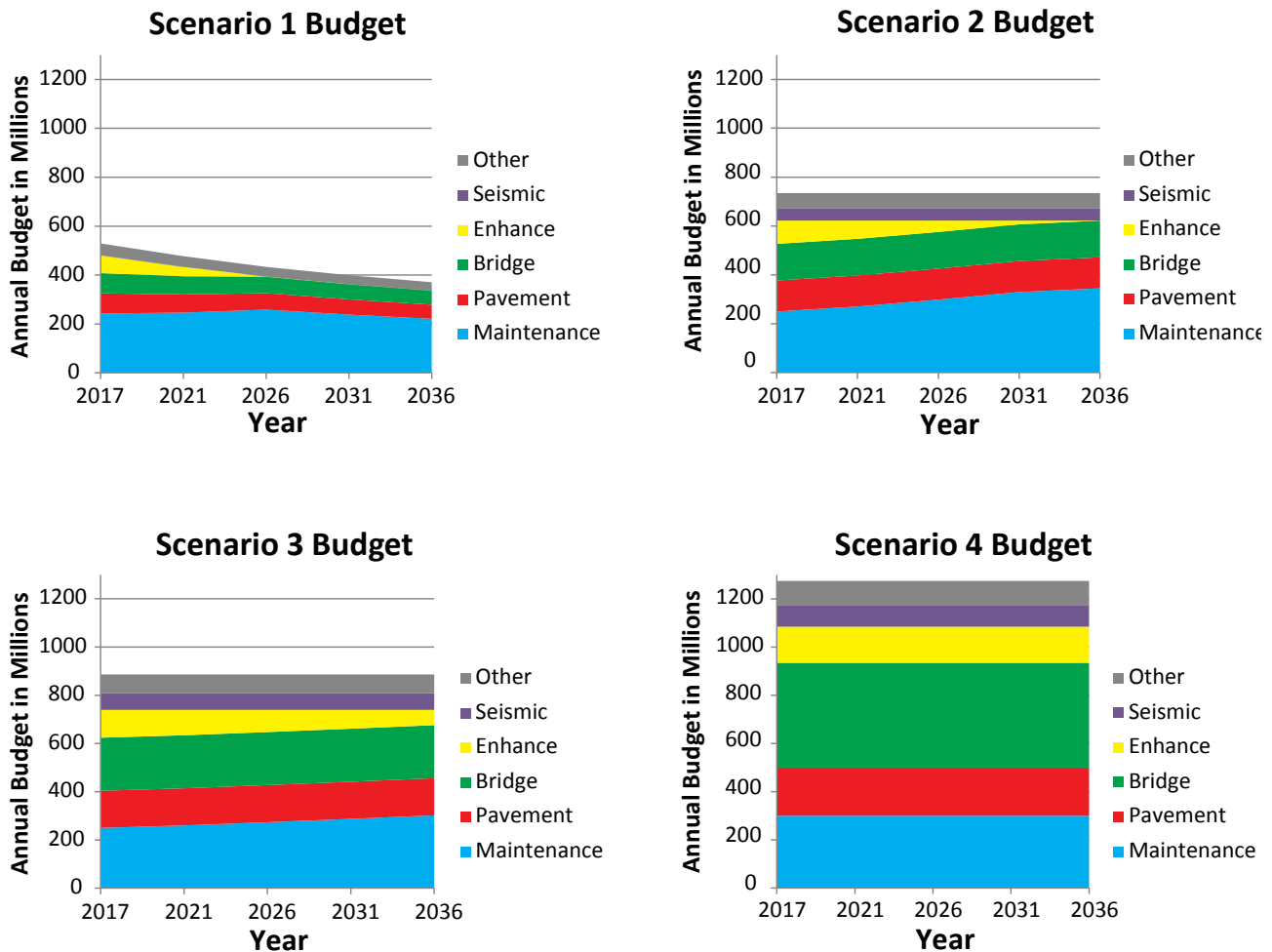


Enhancement Investment Examples

- The category of Enhance includes projects on ODOT Priority routes in areas where:
- Freight bottlenecks exist.
- Congestion relief is needed.
- Area Commissions on Transportation have selected projects, such as operational improvements, auxiliary lanes, passing lanes, traffic smoothing treatments, and bottleneck solutions.

Scenario Budgets

Figure A3



Revenue Source Assumptions for “What If” Scenarios 3 and 4

Figure A4
Scenario 3 Revenue Source Assumptions

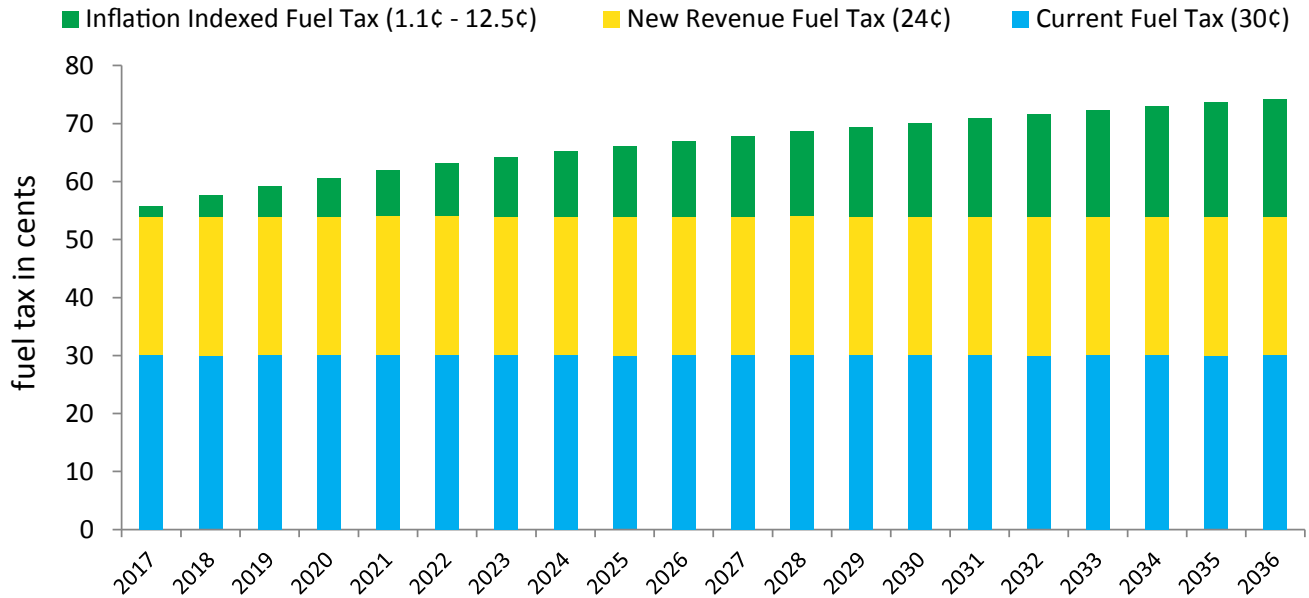
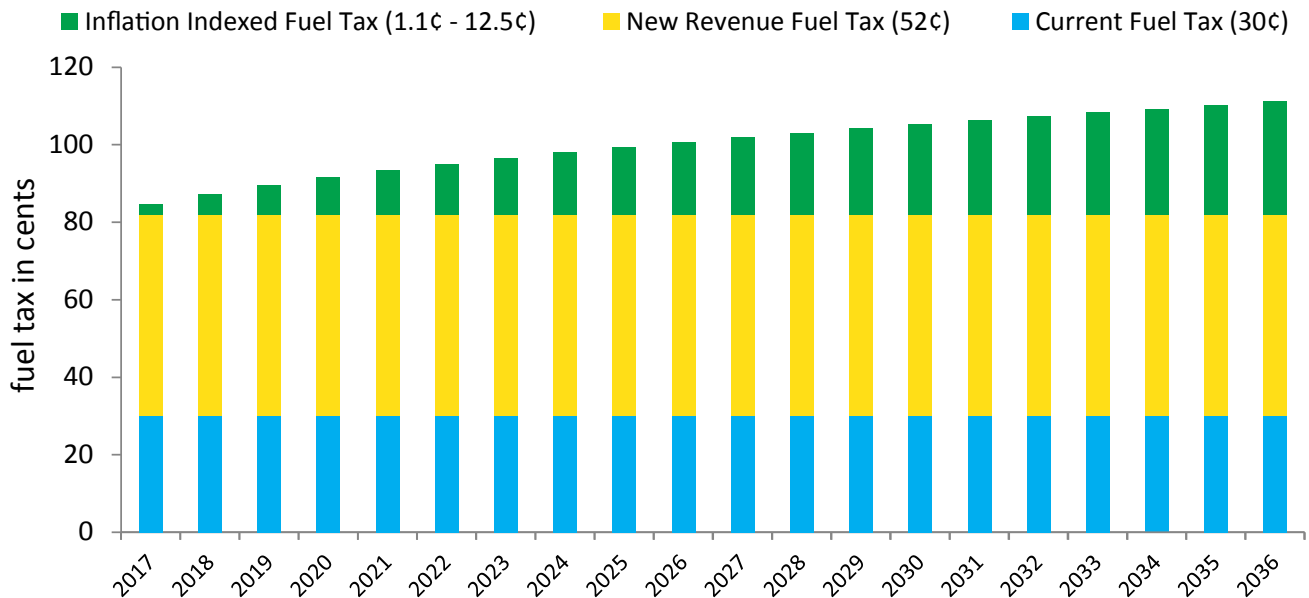


Figure A5
Scenario 4 Revenue Source Assumptions



Bridge Model

Bridge conditions were forecast using the ODOT Bridge Model, developed by using bridge inspection and load rating data. ODOT statewide bridge inspection program captures over 100 data points per bridge per inspection, including location, age, design type, size, traffic, component (deck, superstructure, and substructure) and the associated element conditions, among others. The Bridge Program is responsible for load rating, which determines allowable load capacity for 20 truck categories. Using load rating and inspection information, which in many cases has been recorded since the 1980s, bridge condition trends can be estimated and used to plan future needs.

Several assumptions regarding costs, deterioration rates and their consequences were considered:

- Costs were generated using previous project data, including multipliers for preliminary engineering and construction engineering.
- Deterioration rates were determined based on statistical analysis of historical data. Results are based on projects that improve condition ratings, so preventive maintenance activities are not included. Component rating deterioration rates were assumed to be linear. However, actual recorded deterioration rate may be slower due to localized repairs of deficient elements. While localized repairs may prevent a bridge from being listed as structurally deficient, it will not change the overall deteriorating condition most likely to require future rehabilitation or replacement.
- Remaining service life decreases with each year the bridge is in service, even though parts that would close it to traffic deteriorate faster than others (i.e. decks).
- For this study, weight restrictions are assumed to occur 10 years after a bridge first becomes structurally deficient.

For example, observed inspection data shows that bridge deck ratings tend to drop one point (out of a possible 9) every 12 years with a standard deviation of five years. This change is independent of other variables, such as location, and assumes basic maintenance occurs. When the rating reaches a value of 4, which FHWA defines as ‘Structurally Deficient,’ without rehabilitation the bridge may lose load capacity and be closed to specific trucks. Smaller bridge elements, e.g. joints or bearings, may also contribute to problems on bridges. Based on the bridge design life, component and element conditions, the Bridge Model calculates the remaining service life of each state-owned structure. Using the historic data, future bridge conditions can be predicted.

The Bridge Model was calibrated based on a sustainable work level. A sustainable rate includes:

- Bridge replacements at 1 percent per year. Assuming a bridge lasts 75-100 years, the expectation is to replace 1 percent of bridges per year, which is about 27 bridges per year based on the current inventory.
- Bridge rehabilitation projects at 3 percent per year. Each bridge is expected to have 2 or 3 major rehabilitation projects during its lifetime, which is about one project every 20 to 30 years. A sustainable rate of rehabilitation would then be about 3 percent per year which works out to about 80 bridge rehabilitation projects. Thus, for these scenarios bridge rehabilitation projects are forecast to apply to 3 percent of bridges per year.

Bridges are assumed to be weight restricted 10 years after they reach poor condition (NBI=4).

The Bridge Model uses current and projected bridge conditions, funding levels, and priorities (varying from route to seismic resilience) to generate rehabilitation or bridge replacement needs by a forecast year. Thus, the Bridge Model can be used to evaluate the effects of changing priorities and funding levels on forecast bridge investments.

The ODOT Bridge Section has begun augmenting inspection methods with the latest non-destructive testing and scanning technology to improve inspections. This additional information will improve the Bridge Model. In the future, ODOT asset management software will also allow for more specific Weibull-distribution failure predictions on individual bridge elements, which will also improve forecasts of bridge investment needs.

Oregon Statewide Integrated Model

What it is: a data driven forecast model designed to represent the Oregon economy with respect to land-use and transportation by simulating the activity and market exchanges made by people and businesses. Household and business location decisions are simulated, as well as the travel generated by activities such as commuting to work, purchasing commodities for industrial production and transporting final goods to markets within Oregon and outside of the state. It is designed for statewide and regional long-range transportation planning and policy analysis. Information from the SWIM is designed to inform other modeling tools, such as metropolitan planning organization travel models, freight models, and regional studies.

Why it is important: SWIM is designed to serve as a testing ground to evaluate “what if” scenarios related to areas we can control, such as public policy related to taxes, fees and land use rules; areas we cannot control such as rising oil prices, national recessions, and population growth; and other issues impacting decisions related to the Oregon transportation system.

Why it was developed: In the early 1990s there was federal interest in developing tools that integrate land use, transportation, economics and the environment. The Federal Intermodal Surface Transportation Efficiency Act (ISTEA, 1991) and the 1990 Clean Air Act Amendments were enacted so local and state agencies could do a better job of coordination on land use and transportation decisions. In response to these acts, the level and type of analysis and information requested from modeling and analysis tools and methods changed nationally.

Oregon’s response to these new mandates was formation of the Oregon Modeling Improvement Program in 1994. The program was implemented cooperatively, led by the Oregon Modeling Steering Committee, which includes membership of over 15 public agencies. The committee seeks to improve state-of-the-practice and promote state-of-the-art modeling in Oregon and serve as a consensus forum and support group to coordinate land-use-transportation modeling efforts of federal, state, regional and local agencies. The SWIM model development has included extensive technical review by national and international experts.

How it has been used: The SWIM has been used for a variety of studies:

Rough Roads Ahead: The Cost of Poor Highway Conditions to Oregon’s Economy (2014): SWIM was used to prepare a high-level strategic comparison between the current ODOT forecast budget and an alternative budget designed to preserve and maintain current conditions of state highways, roads and bridges. The analysis provided a sense of the magnitude of potential economic impacts of deteriorating bridges and pavement. Results indicated deterioration would place Oregon at a competitive disadvantage, with the potential to lose 100,000 jobs and \$94 billion in gross state product, and raising vehicle operating costs for light and heavy vehicles.

Seismic Bridge Options Economic Impact Analysis (2013): SWIM was used to produce high-level estimates of avoidable economic impacts associated with a major seismic event on the Cascadia Subduction Zone. The analysis provided a general sense of the magnitude and direction of avoidable economic impacts compared to the investment needed for a pre-emptive mitigation program. Findings indicated investing \$1.8 billion toward seismic mitigation would avoid the loss of \$84 billion in Oregon gross domestic product, which results in a benefit/cost ratio of 46. Accounting for the estimated 12 percent chance of the earthquake occurring within the next 50 years adjusts the benefit/cost figure to 5.6, further indicating mitigation investment is a sound business decision for Oregon.²

Oregon Freight Plan (2010): SWIM was used to evaluate the variation in statewide and regional economic activity and commodity flow in order to evaluate uncertainty associated with economic volatility on alternative Freight Plan strategies. This information enabled decision makers to better assess the robustness of freight strategies and avoid the creation of barriers prohibiting the freight industry from reacting nimbly to economic change.³

Oregon Transportation Plan Update (2005): SWIM was used for scenario analysis designed to develop a long-range plan that is effective and relevant under conditions of uncertainty in several key areas. Two sensitivity scenarios were used to evaluate impacts of higher fuel prices and more relaxed land use policies affecting available land for future development on urban boundaries and rural areas. Four policy scenarios provided information evaluating different funding options, program priorities and other related issues.⁴ This modeling analysis earned ODOT an FHWA/FTA Transportation Planning Excellence Award.⁵

Economic & Bridge Options Report (2003): SWIM was used to examine the economic impacts of expected bridge weight limits throughout the state due to an increasing number of cracking problems on aging bridges. The model simulated the response of trucks to bridge weight restrictions and quantified the impacts on statewide and regional industry production and jobs, transportation costs and changes in travel and land use patterns. The model estimated Oregon's bridge problem could cost the state as much as \$123 billion in lost production and 88,000 forfeited jobs over the next 25 years.⁶

Newberg-Dundee Bypass (2002): SWIM was used to evaluate the potential for a bypass to induce additional development in Yamhill County. A concern regarding induced growth associated with the bypass has been a significant issue in the bypass planning process. The SWIM was used successfully to evaluate the nature and general magnitude of induced growth effects. The results were very important to the land use exceptions process and a subsequent court appeal.⁷

Eastern Oregon Freeway Alternative (2001): prompted by a legislative directive (HB3090) to ODOT to study the construction of a new freeway, SWIM was used to evaluate whether population and traffic growth would be diverted from the Willamette Valley to regions east of the Cascades. Analysis revealed a new freeway would not shift growth away from the Willamette Valley.⁸

² <https://www.oregon.gov/ODOT/Planning/Documents/Cascadia-Subduction-Zone-Earthquake-Economic-Impact.pdf>

³ <https://www.oregon.gov/ODOT/Planning/Documents/OFP-Modeling-Analysis.pdf>

⁴ <https://www.oregon.gov/ODOT/Planning/Documents/OTP-Policy-Analysis-Report.pdf>

⁵ <https://www.oregon.gov/ODOT/Planning/Documents/OTP-Modeling-Excellence-Award-2008.pdf>

⁶ <https://www.oregon.gov/ODOT/Planning/Documents/Economic-Bridge-Options-Report.pdf>

⁷ <https://www.oregon.gov/ODOT/Planning/Documents/Newberg-Dundee-Bypass-Environmental-Impact-Statement.pdf>

⁸ <https://www.oregon.gov/ODOT/Planning/Documents/Eastern-Oregon-Freeway-Alternatives-Study.pdf>

Willamette Valley Livability Forum (2001): This was the first analysis conducted using the newly developed Statewide Integrated Model. The forum initiated a comprehensive regional visioning process for future land use and transportation in the Willamette Valley. Modeled scenarios varied by land use, road networks, public transit networks and mileage tax. By modeling various combinations of policy options, decision-makers identified likely conditions which influenced adopted policies shaping the Willamette Valley for future generations.⁹

Model design features: The Statewide Model is described as an “integrated” model because the sub-models are interconnected. Information is shared back and forth between the sub-models, mimicking the reactive and interactive behaviors observed in the real world. The model is designed to represent how people and businesses share information and exchange goods and services based on prices and location. The integrated modular design better represents real-world conditions and activity, but requires an immense amount of data, significant development time, powerful computing capabilities and trained staff. For these two reasons, very few states have a statewide economic, land use and transportation model like Oregon’s.

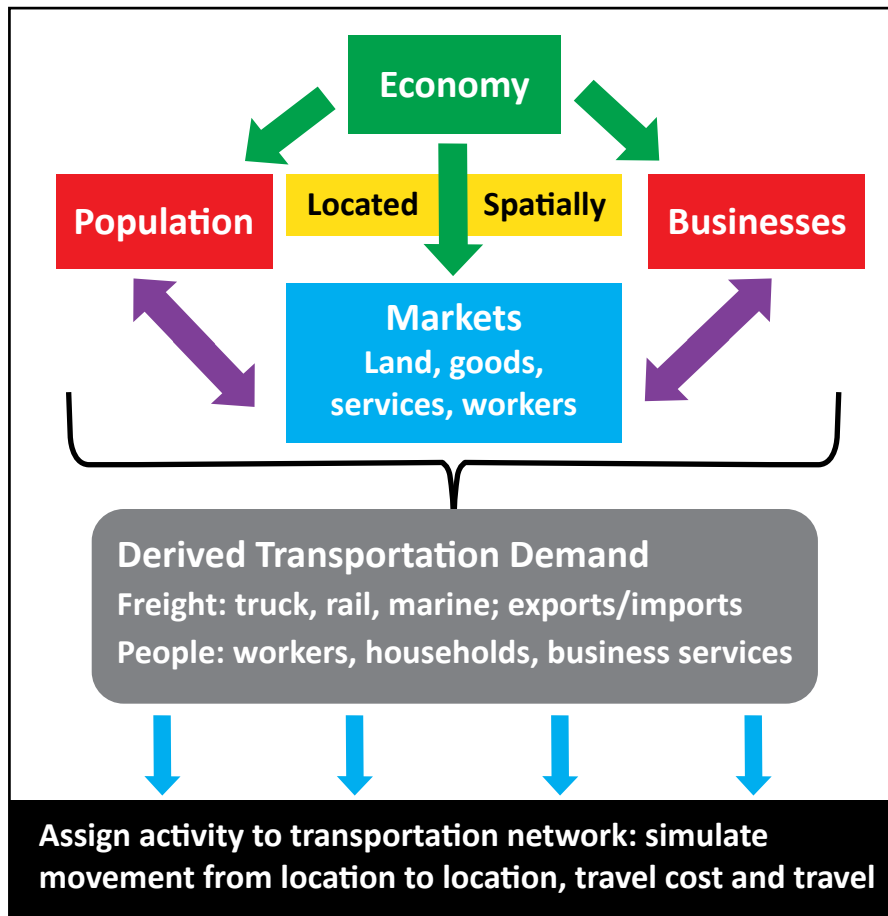
The Oregon Statewide Integrated Model consists of specialized sub-models that interconnect with each other:

- **Economic Model:** based on the official state revenue forecast prepared by the Department of Administrative Services, Office of Economic Analysis; provides statewide totals for employment by industry, inflation rate, imports and exports, unemployment rate.
- **Population Synthesizer:** simulates a population with observed Oregon characteristics such as age, household size, household location, income, occupation, worker/non-worker/student status.
- **Production Location Model:** simulates where businesses locate, the commodities they purchase to use as production inputs, number and type of workers hired, the amount of floorspace they purchase/lease for their production facility, and production of goods and services sold based on market prices.
- **Land Development Model:** identifies land availability based on floorspace prices and vacancy rates for firms and households to rent or purchase.
- **Person Travel:** simulates person activity for a typical weekday for the people simulated by the Population Synthesizer; activity involving travel is assigned a travel mode such as auto, transit, or rail.
- **Commercial Goods Transport:** simulates how commodities are moved as freight by different modes of transport, such as marine, rail, and truck for a typical weekday.
- **External Goods Transport:** simulates freight movement for exports, imports and through the state.
- **Transport Model:** assigns trips to a computer network, trips generated in the Person Travel Model, Commercial Goods Transport model, External Goods Transport model.

⁹ <https://www.oregon.gov/ODOT/Planning/Pages/Technical-Tools.aspx#SWIM>

Figure A6 illustrates the interaction and connections between the different activities represented within the model via the specialized sub-models.

Figure A6: SWIM2 Schematic



SWIM is used for scenario analysis. A reference scenario is developed to represent current conditions or policy most likely for a 20-year planning horizon. Alternative scenarios are developed to represent the “what if” areas of analysis. This way, a range of potential futures are identified and implications associated with uncertainty can be assessed. Typically, SWIM is used to evaluate potential impacts on employment and gross state product. Other elements of the model may be reported, but the level of reporting depends on the level of detailed data prepared for the model setup. The full model documentation is available online here: <Insert link once documentation is posted online?>

Current Pavement Program Strategy

Because overall pavement preservation needs exceed available funding, the pavement preservation program follows a strategy refined over the years by ODOT’s Pavement Committee leadership team. ODOT uses the following guiding principles when making decisions about allocating pavement dollars:

- Focus investments on the highest priority route classifications from a state level perspective.
- Prioritize work locations which maximize pavement service life for funds expended.
- Primary investment on “just in time” paving before a road deteriorates to poor condition.

- Prioritize locations requiring significant maintenance expense to save on maintenance costs.
- Distribute projects across all parts of the state to balance pavement conditions geographically.
- Allocate a portion of additional funds for high-cost projects to help reduce poor pavement backlog.
- Increase the allocation towards higher-cost backlog projects at higher funding levels.

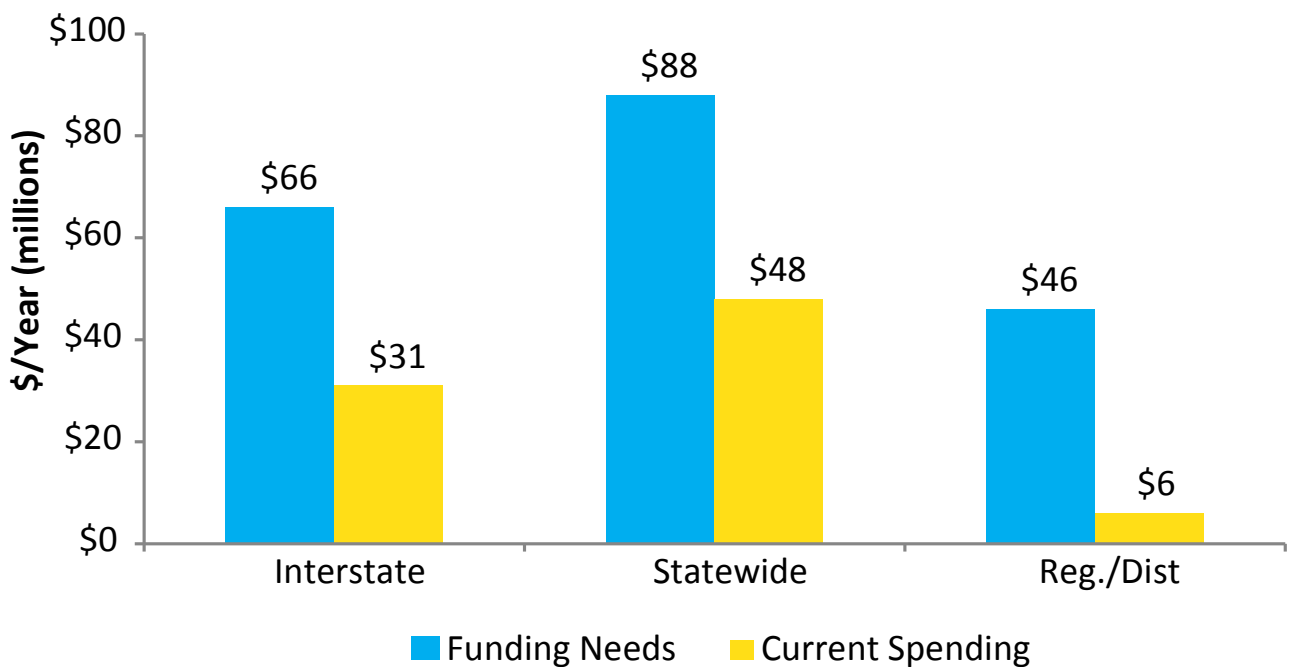
The strategy prioritizes pavement conditions by state highway classification into three layers. Interstate highways are the highest priority and have the highest level of condition. Statewide routes like US 97, US 101, or US 26 are the next highest priority. Region and district level routes like OR 99E or OR 99W are at a lower priority. While this strategy allows the program to meet the resurfacing needs on the highest priority routes, the lower priority routes must wait even longer for resurfacing. In fact, on most of the lower traffic roads in the system, resurfacing projects are no longer programmed and treatments are limited only to seals and patching, leaving pavement to deteriorate over time.

Pavement preservation projects are also prioritized by cost effectiveness. Over the long run, it is more cost effective to do low cost thin resurfacing and seal treatments on pavements with only minor deterioration than to employ a “worst first” approach by spending money rehabilitating poor pavement at high cost. In order to maximize investments, projects which can benefit from a long service life extension at low cost receive the highest priority.

Figure A7 illustrates spending needed compared with actual spending. In the 2018-2021 Statewide Transportation Improvement Program ODOT will spend about \$85 million per year while the need is actually \$200 million per year to preserve pavement conditions.

Figure A7

Pavement Needs vs. Spending By Highway Class



While the prioritization process follows a sound, logical and proven strategy, the net effect of the strategy and limited funding for pavement repair has resulted in declining pavement conditions on routes of local significance, particularly those district level state highways that act more like city streets than major thoroughfares. Many routes in the Portland metro area fit in this category, such as Lombard Street or 82nd Avenue, illustrated in **Figure A8** below, and pavement conditions on these routes have declined significantly over the years.

Figure A8



Lombard Street (Northeast Portland Highway)



82nd Avenue (Cascade Highway North)

While lower priorities from a state perspective, many of these highways are important to local communities. Additional investment would allow for more paving projects on main streets, which could be leveraged with other elements—such as utility conflicts, storm water quality requirements, ADA requirements, access management, improved sidewalks, bike lanes, and streetscapes—into community revitalization and downtown redevelopment projects.

While everyone enjoys driving on smooth roads, rough surfaces become a safety issue on higher speed facilities due to potential for hydroplaning and vehicle damage from potholed surfaces. Urban district level state highways are typically lower speed facilities where this type of risk is lower, but other risks arise such as cars veering into bike lanes to avoid potholes. This is also a factor considered in determining project selection priorities and tends to direct resources to rural segments rather than urban ones.

Pavement Roughness Vehicle Operation Costs Data

The following tables were used to construct estimates of the additional cost of vehicle operation on rough pavement relative to smooth pavement.

(Recreation of) Table 7-5 Effect of Roughness on Vehicle Operating Costs								
speed	Vehicle Class	Vehicle Operating Costs						
		Baseline Conditions cents per mile 2011 fuel cost, 2007 Main/Repair	Adjustment Factors from Baseline Conditions					
			IRI (m/km)					
		1	2	3	4	5	6	
35 mph	Medium car	14.0	1.02	1.04	1.08	1.015	1.22	
	Van	16.1	1.01	1.02	1.05	1.11	1.18	
	SUV	16.3	1.02	1.03	1.09	1.2	1.34	
	Lt Truck	23.9	1.01	1.02	1.06	1.13	1.22	
	Articulated Trk	57.7	1.02	1.03	1.07	1.13	1.19	
55 mph	Medium car	16.8	1.02	1.04	1.15	1.15	1.22	
	Van	20.2	1.01	1.01	1.11	1.11	1.17	
	SUV	20.8	1.02	1.03	1.2	1.2	1.32	
	Lt Truck	34.6	1.01	1.02	1.12	1.12	1.2	
	Articulated Trk	90.7	1.01	1.02	1.1	1.1	1.15	
70 mph	Medium car	21.3	1.02	1.03	1.14	1.14	1.21	
	Van	26.5	1.01	1.01	1.1	1.1	1.16	
	SUV	28.2	1.01	1.03	1.18	1.18	1.29	
	Lt Truck	48.1	1.01	1.01	1.1	1.1	1.17	
	Articulated Trk	130.0	1.01	1.02	1.08	1.08	1.13	

Source: NCHRP Report 720 "Estimating the Effects of Pavement Condition on Vehicle Operating Costs, 2012"

The following table was created by averaging values presented in Table 7-5.

NCHRP Report 720 Average Adjustment Factors (no speed differential)							
Vehicle Class	Baseline Conditions cents per mile 2011 fuel cost, 2007 Main/ Repair	Adjustment Factors from Baseline Conditions					
	IRI (m/km)						
	1	2	3	4	5	6	
Average Across Speeds	Medium car	17.4	1.02	1.04	1.12	1.10	1.22
	Van	20.9	1.01	1.01	1.09	1.11	1.17
	SUV	21.8	1.02	1.03	1.16	1.19	1.32
	Lt Truck	35.5	1.01	1.02	1.09	1.12	1.20
	Articulated Trk	92.8	1.01	1.02	1.08	1.10	1.16

The following tables present the detailed calculations used to produce the estimated costs associated with driving on rough pavement.

Extra Cost of Rough 20% of VMT	20% of State VMT in millions	Cost on smooth	Cost on rough	Extra cost, millions of dollars	Change in Total Cost w/20% rough
Light Vehicles	6,658	1,062	1,311	249	4.7%
Medium Heavy	161	57	66	9	3.0%
Heavy Truck	381	299	344	45	3.0%

Extra Cost of Rough 30% of VMT	30% of State VMT in millions	Cost on smooth	Cost of rough	extra cost, millions of dollars	Change in Total Cost w/30% rough
Light Vehicles	9,987.3	1593	1966	374	7.0%
Medium Heavy	241.5	86	99	13	4.5%
Heavy Truck	570.9	448	515	67	4.5%

International Roughness Index

The International Roughness Index (IRI) is the most common measure used worldwide to evaluate and manage pavement condition. The IRI is a required annual reporting metric to FHWA, which is a scale for roughness based on simulated response of a motor vehicle to the roughness in a single wheel path of the road surface.

