The Sellwood Bridge Project: A Health Impact Assessment

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Executive Summary

Multnomah County Health Department (MCHD) undertook a Health Impact Assessment of the Sellwood Bridge Replacement project at the request of former County Chair Ted Wheeler. The goals of this Health Impact Assessment (HIA) are to enhance the health of Multnomah County residents by informing the Sellwood Bridge Project Team and other regional decision-makers about how the proposed bridge redesign may affect human health, and to offer potential mitigation strategies when adverse health effects are found.

The Sellwood Bridge Project, led by Multnomah County, has already conducted public outreach and has selected a Locally Preferred Alternative (LPA) as required by the National Environmental Policy Act (NEPA). This HIA evaluates the LPA and highlights health promoting aspects of the bridge while offering suggestions to mitigate adverse health effects (without unduly burdening the project).

The Sellwood Bridge replacement project is exemplary because it places great importance on supporting bicyclists and pedestrians while addressing general transportation concerns. Safer and more spacious bicycle and pedestrian lanes on both sides of the bridge will encourage the use of active transportation modes for both recreational purposes and commuting. The new bridge will also be able to carry public buses adding to the active transportation choices in the Sellwood community.

One area of public health concern is the potential for crashes involving bicyclists and pedestrians using the shared paths on either side of the bridge and potential crashes between bicyclists and motor vehicles at intersections where the bridge connects with other streets. Health concerns about the Sellwood Bridge project are also centered on construction activity that is expected to last four years. During this phase, there is a potential for deteriorated air quality and high noise levels that will affect both area residents and construction site workers.

Multnomah County Health Department developed its mitigation recommendations based on a review of scientific literature, guidelines, and data on similar projects, where available. The Sellwood Bridge Project Team has already considered some of the health impacts of the proposed bridge and has included ways to enhance health and to decrease the potential for harmful impacts. MCHD's recommendations either reinforce these health-related decisions or complement the measures already proposed by the Sellwood Bridge Project Team.

The mitigation measures recommended by Multnomah County Health Department for the protection of public health are summarized in the table that follows.

Recommended mitigation measures		Health benefits	Potential partners
Improve bicyclist and pedestrian safety			
	Utilize signage and lane markings on shared use paths to reduce the risk of bicycle-pedestrian collisions	Reduced risk of pedestrian and bicyclist injuries	Bicycle and pedestrian advocacy groups Initiative for Bicycle and Pedestrian Innovation (PSU) MCHD
	Consider a variety of strategies to enhance safety at the west end intersection		
	Consider visual and physical barriers between the motor vehicle and on-road bike lanes		
	Continue to seek input from the Bicycle/Pedestrian Working Group during project design		
Maintain safe air quality during construction			
	Require and/or provide incentives for the use of clean die-sel technology and practices from potential contractors when soliciting bids for constructing the replacement bridge	Reduced risk of res-piratory health issues for area residents and construction site workers	Oregon Department of Environmental Quality, Air Quality Program MCHD
	Consider applying for grants from Oregon Department of Environmental Quality, or US Environmental Protection Agency to fund clean diesel technology for contractor equipment		
	Monitor project-related air quality during the construction phase of the bridge		
	When feasible, modify construction activities requiring diesel-powered engines on air stagnation days		
	Coordinate with other county or city projects to assure that concurrent projects do not degrade air quality		
	Educate area residents on ways to reduce exposure to diesel PM 2.5		
Maintain safe noise levels during construction			
	When feasible, adjust the construction schedule to allow for adequate quiet for residents	Reduced risk of stress, sleep distur-bance, and chronic disease for area resi-dents	MCHD
	Educate residents on types, times, duration, and health effects of the construction-related noise		
	Assist residents in implementing noise reduction strategies		

1 Introduction

The Sellwood Bridge, built in 1925, is structurally unsound and in need of replacement. In 2006, the Sellwood Bridge Project, led by Multnomah County, began as a "planning effort to develop a locally-supported alternative to address the long-term transportation deficiencies posed by deterioration of the bridge." As with many capital improvement projects addressing transportation needs, this bridge will have both intended and unintended effects on human health. Researchers have noted direct and indirect human health impacts resulting from transportation infrastructure projects worldwide that have affected air quality, water quality, noise levels, access to green space, physical safety, social connectedness, and a variety of other factors.

2 Purpose

This Health Impact Assessment (HIA) was undertaken to protect public health by (1) trying to forecast the most significant positive and detrimental health impacts of the project, and (2) proposing potential mitigation strategies without unduly burdening the project. The Sellwood Bridge Project team has issued a Draft Environmental Impact Statement (DEIS), conducted public outreach, and selected a Locally Preferred Alternative (LPA) as required by the National Environmental Policy Act (NEPA). This HIA evaluates the anticipated health effects of the LPA during both the construction and operational phases of the project.

The findings and recommendations of this HIA will be presented to the Multnomah County Commissioners, the Sellwood Bridge Project Team, and other regional decision makers before final decisions are made on the design of the bridge. The HIA will provide objective analysis and recommendations that we hope will be incorporated into the plans for a replacement bridge.

3 Scope of this Health Impact Assessment

Our review of the DEIS indicates that the Sellwood Bridge project is likely to result in significant positive impacts on human health once it is completed. It is expected that, for most aspects of this project, there will be minimal adverse public health impact, or that state and federal regulations will assure adequate protection of human health.

However, three components of the Sellwood Bridge Project may result in significant health impacts and will be explored in some detail in this HIA. They are (1) bicyclist and pedestrian safety, (2) air quality during construction, and (3) noise levels during construction. These topics were selected for further analysis based on the magnitude of the potential impact on health, the population affected, data availability, public concern, extent of analysis in the DEIS, and feasibility of incorporating HIA recommendations in Sellwood Bridge planning decisions.

4 Project Background

4.1 Existing conditions on the bridge

The Sellwood Bridge is a fixed-span truss bridge that spans the Willamette River and connects the Sellwood and Westmoreland neighborhoods on the east side of the river with Oregon Route 43/ Macadam Avenue on the west side. It is the busiest two-lane bridge in Oregon. The Sellwood Bridge has been in need of replacement for years, and Multnomah County has made many temporary repairs and system changes to prolong the life of the bridge pending a long-term solution. Yet, even with these fixes, the following design issues remain which can only be addressed through a bridge replacement:

Narrow traffic lanes without shoulders

Narrow sidewalk - The only sidewalk across the bridge is on the north side and is four feet three inches wide and is only three feet wide at some points because of light poles. The limited space on the sidewalk restricts access for some disabled users and often forces bicyclists to walk their bikes or use the motor vehicle travel lanes which can put both the biker and surrounding drivers at risk. Connections to the trail on the west side of the river do not meet Americans with Disabilities Act or Oregon Department of Transportation standards.

Inadequate bicycle infrastructure across bridge – There are no bike lanes across the bridge and poor connections to the street system on the east side of the Willamette River. It is also difficult for bicyclists to access the trail system on the east and west sides of the river. Currently, Multnomah County designates the Sellwood Bridge as a "Caution Area" for bicyclists. This means that the county has determined that bicyclists might encounter hazards such as narrow lanes, high traffic volumes, and difficult intersections.

Inadequate bicycle and pedestrian safeguards at intersections – The bridge lacks bike crossing facilities and has insufficient pedestrian crossing facilities in the north-south direction where the bridge meets OR 43. The west-side intersection does not include any signage guiding bicyclists or pedestrians across the intersection. The connection to the Willamette Greenway Trail is cumbersome and unsafe for bikers and pedestrians.

Bridge not designed to withstand earthquakes

4.2 Locally preferred bridge design

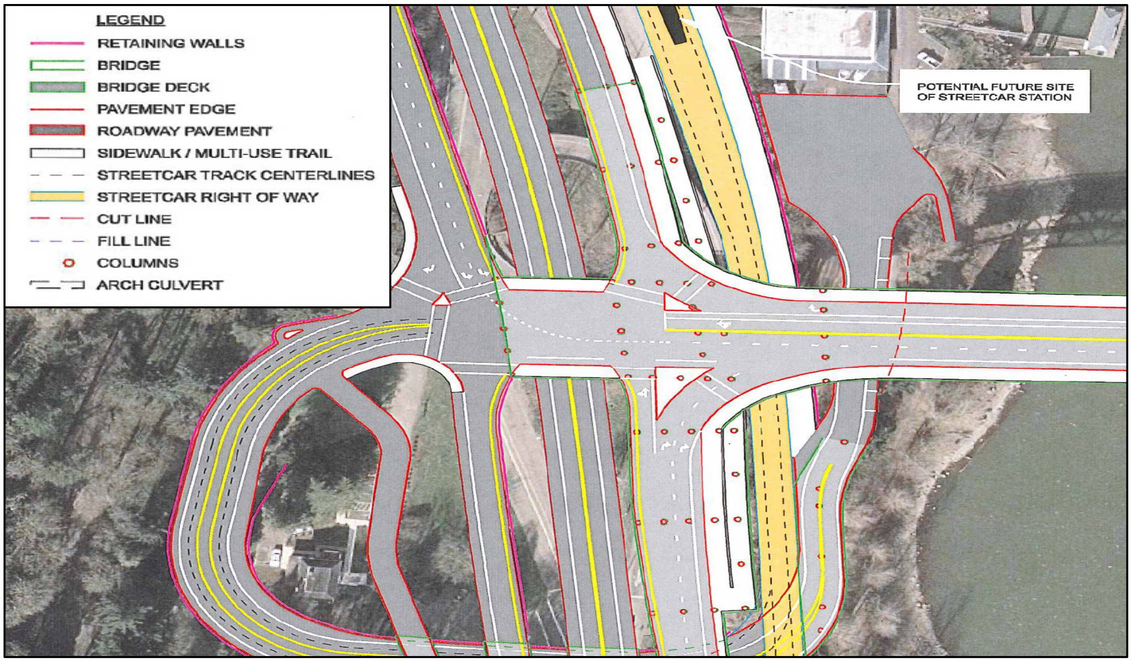
The DEIS was released to the public for a month-long comment period in November 2008. Public comments guided the selection of one of the five proposed bridge designs, which became the Locally Preferred Alternative (LPA) in February 2009.

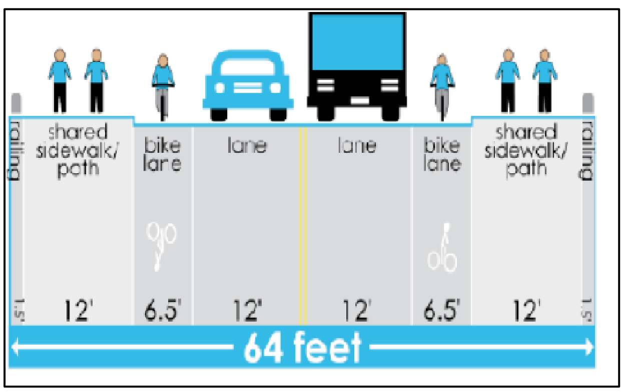
The LPA for the Sellwood Bridge has a number of features that will support human health, including:

- A cross-section of 64 feet at its narrowest point: two 12-foot travel lanes, two 12-foot shared use sidewalks, and two 6.5-foot bike lanes/emergency shoulders (Figure 1)
- A grade-separated and signal-controlled interchange at the OR 43 (SW Macadam Avenue) intersection on the west end (Figure 1)
- A pedestrian-activated signal at the intersection of SE Tacoma Street and SE 6th Avenue on the east end
- Capacity to accommodate buses
- Capacity to accommodate future streetcar
- Narrower bridge cross-section at the OR 43 interchange on the west end (reduced from five lanes to four lanes)
- Improved bicycle/pedestrian facilities on the west end including the replacement of spiral ramps with single, long switchback ramps on the north and south sides of the bridge

These features of the LPA are likely to increase bicycling and walking across the bridge while reducing the risk of injury to these bridge users. The Sellwood Bridge replacement project is exemplary because it places great importance on supporting bicyclists and pedestrians while addressing general transportation concerns. By creating infrastructure that encourages active modes of transportation, the bridge project is directly addressing the problems of low physical activity rates and increasing obesity in the

Figure 1. **West-side Intersection Design (top); and Locally Preferred Alternative (Alternative D) Transportation Cross-Section (bottom)**





Source: CH2MHill, Proposed Sellwood Bridge, 2009

region. The Centers for Disease Control's (CDC) Guide to Community Preventive Services states that improving access to active transportation can increase the number of people who are physically active three times a week by 25%. [1]

In 2006, 53% of residents over the age of 18 (approximately 239,000 adults) in the county were either overweight or obese.[2] Multnomah County residents at a healthy weight were more likely to meet national guidelines for moderate physical activity (30 minutes for 5 or more days a week) than overweight and obese individuals. In 2005, 63% of those in the healthy weight range met the physical activity recommendation while only 56% of overweight individuals and 45% of obese individuals met the recommendation.

Obesity and inadequate physical activity have traditionally been addressed by encouraging individual-level lifestyle changes. However, a growing number of studies indicates that more effective solutions involve improvements to the built environment that support physical activity. The Sellwood Bridge replacement project is an uncommon example of holistic transportation planning that addresses both transportation needs and a significant public health problem.

In addition to expanding bicycle and pedestrian facilities, the LPA also anticipates potential extension of streetcar service into the southern and eastern areas of the county by designing a bridge that can accommodate streetcar stops and related bike and pedestrian traffic. By supporting better public transit service in the Sellwood area, the new bridge is likely to improve connectivity to the downtown Portland area, boost economic opportunity for the Sellwood area, and provide another option for active transportation.

Restricting the proposed bridge to two lanes of vehicular traffic is also beneficial to public health because it limits exposure to mobile sources of air pollution. The two-lane bridge will not overwhelm the capacity of the street network in the Sellwood neighborhood or contribute to congestion or traffic safety issues in this way.

It is clear that the locally preferred alternative for the Sellwood Bridge replacement project has the potential to result in several significant health advantages for area residents. The remainder of this document will examine ways in which the project can support health and safety even more fully.

5 Analysis of Health Impacts of the Replacement Bridge

The following sections expand on the analysis conducted in the DEIS in three areas. The potential health impacts related to bicyclist and pedestrian infrastructure of the LPA and construction-related air quality and noise are examined in greater detail. In each of the three areas of potential health impact discussed below, the analysis will:

(i) Define the health concern,

(ii) Describe the expected magnitude of the health effect where possible and the populations likely to be affected,

(iii) Explore the factors that may increase or decrease the likelihood of health effects, and

(iv) Offer recommendations for mitigating negative health impacts or conducting additional analysis where insufficient information is available.

5.1 Improve bicyclist and pedestrian safety

As described above, construction of the LPA would result in vast improvements to bicyclist and pedestrian facilities across the bridge. New features include on-road bike lanes/emergency shoulders and 12'-wide raised shared use paths on each side of the bridge (Figure 1).

According to the DEIS, bicycle and foot traffic across the bridge is expected to rise between 1,600% and 1,700% over the next 25 years with an average daily count of over 14,000 bicycle and pedestrian crossings on weekends. The estimate is based on a variety of factors including the improved bike and pedestrian infrastructure, latent demand (i.e., people who were avoiding the bridge will start using it), and the increased bridge use documented on the other Portland-area bridges during the past 15 years.

Over time, the increase in cycling and walking over the bridge may be beneficial to safety. There is some evidence that when cycling and walking rates increase, injury rates go down.[3] This "safety-in-numbers" effect has been experienced in Europe where cycling and walking have become routine transportation modes for daily-life activities. Some U.S. cities where cycling is on the rise (such as New York, San Francisco, Seattle, and Portland) are experiencing similar trends. Locally, the City of Portland Bureau of Transportation has documented the improvement in safety as cycling increased over the past 18 years (Figure 2).[4]

Though cycling rates have increased in the United States, and cities like Portland have invested in cycling infrastructure, cycling and walking remain much more dangerous than riding in an automobile. Taking distance traveled into account, fatalities were 12 times more likely for cyclists and 23 times more likely for pedestrians as compared to motor vehicle occupants.[5] These data indicate that increased efforts to promote cycling and walking in the United States should be accompanied by coincident efforts to promote safety.

5.1.a Concerns about bike and pedestrian safety

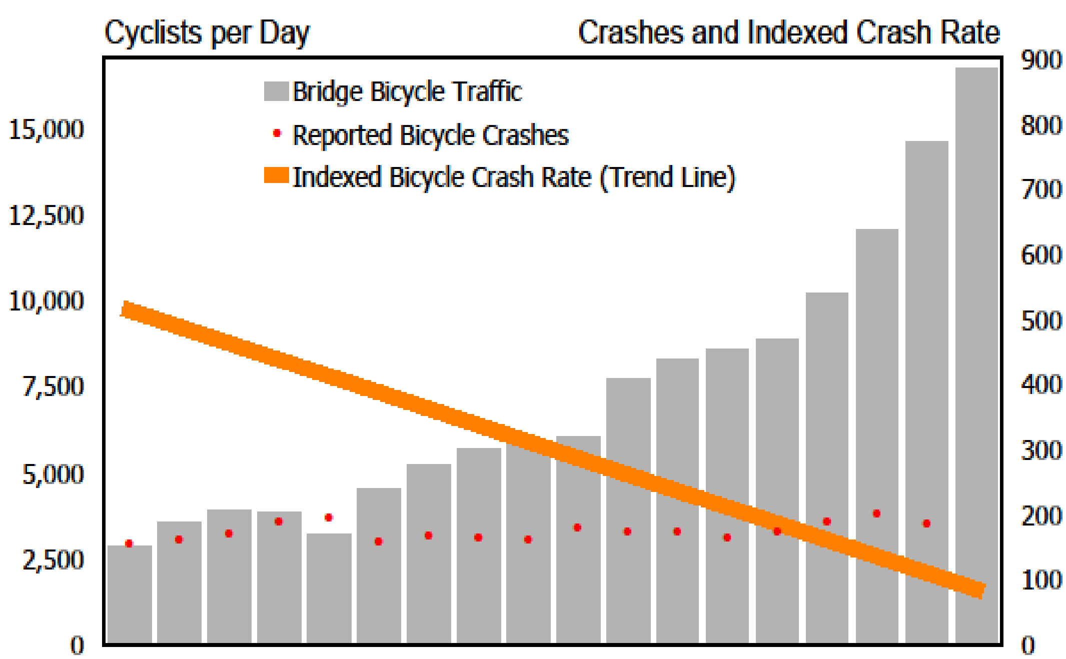
At least for the short term, there may be an increased risk for collisions resulting from large volumes of vehicles, bicyclists, and pedestrians moving in close proximity to each other on the Sellwood Bridge. The Sellwood Bridge Project Team has recognized this potential safety issue and has made a concerted effort to mitigate it. In 2006, they created a Bicycle and Pedestrian Working Group comprised of planning and design firms specializing in bicycle and pedestrian infrastructure, local transportation agencies/ departments, cycling and pedestrian groups, parks and recreation, community representatives, and Multnomah County staff.

Throughout the selection of the LPA and the ongoing design process, the Working Group has provided input on a wide range of bicycle and pedestrian infrastructure issues. This analysis focuses on a subset of the issues addressed by the Working Group—those identified as having the greatest potential public health impact. Through a review of the literature and design manuals two safety concerns emerged: a) conflicts between bikes and pedestrians on the shared-use path, and b) conflicts between automobiles and bikes and pedestrians at intersections, particularly on the west end of the bridge. Since the general elements of the LPA have already been determined, this section will focus on possible refinements to the design that may positively impact health.

5.1.b Anticipated magnitude of health concerns

Establishing a baseline for cyclist and pedestrian safety on the Sellwood Bridge is not possible. At this time, very limited data are available regarding bike and pedestrian safety in Multnomah County. Unless a motor vehicle is involved in a cycling or pedestrian collision and a police report is generated, collisions and near collisions are not tracked. Some hospital emergency room or admissions data are available, but these data have limitations. For example, the location where the injury took place isn't recorded so

Figure 2. Bicycle Traffic and Crashes on Four Portland Bridges —1991-2008



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Bridge Bicycle Traffic	2,850	3,555	3,885	3,830	3,207	4,520	5,225	5,690	5,910	6,015	7,686	8,250	8,562	8,875	10,192	12,046	14,563	16,711
Reported Bicycle Crashes	155	163	171	189	195	160	167	166	161	179	175	173	164	174	188	203	186	*
Indexed Bicycle Crash Rate (Trend Line)	544	459	440	493	514	354	320	292	272	298	230	210	192	196	184	168	128	*
Bicycle Fatalities	2	0	4	3	2	1	5	3	0	0	5	0	4	1	4	0	6	0

Year

Extrapolated from peak period counts

"Crash Rate" represents an indexing of annual reported crashes to daily bicycle trips across the four main bicycle bridges.

*2008 Reported Bicycle Crashes data not yet available

Source: City of Portland, Bureau of Transportation, 2009 these data sets of are of little use when assessing safety at a particular location like the Sellwood Bridge. We also are unaware of any models that can be used to project the rate of collision for the replacement bridge.

5.1.c Factors contributing to safety concerns

A growing body of literature examining collisions between pedestrians, cyclists, and motor vehicles provides insight into how infrastructure and user behavior can contribute to avoidable crashes. This literature can inform design refinements for the new Sellwood Bridge.

Conflicts between bikes and pedestrians on the shared-use path

The LPA includes shared paths on each side of the bridge for slower or less experienced cyclists and pedestrians. The current version of the plan allows flexibility so that path users will be able to travel bi-directionally. However, users traveling at different speeds and directions may pose safety issues. A recent review of the literature on the effects of bike infrastructure on safety showed that riding on sidewalks is 1.8 to 16 times riskier than on-road cycling.[6] Additionally, risk is elevated if the cyclist is going against the flow of on-road traffic, particularly near an intersection.[7] Fortunately, pedestrian-bicycle collisions requiring a hospital visit appear to be infrequent. In a study of 2,558 people who were treated for cycling or pedestrian-related injuries in hospital emergency departments, only 0.8% of injuries resulted from a pedestrian-bicycle collision.[8]

Multiple behavioral factors contribute to unsafe shared path use. Pedestrians may have difficulty anticipating which direction a cyclist may take if bi-directional travel is allowed. Also, cyclists may have difficulty predicting when pedestrians, dogs, children, or skaters may change speed or direction quickly. Sporadic unexpected movements like these leave little if any reaction time for the cyclist to avoid a collision.[9] According to the Austroads Research Report on shared path conflicts, verbal disagreements over the use of space, pedestrians' concern with cyclists' speed on the path, failure of cyclists to yield to pedestrians, cyclists and pedestrians traveling in groups, and uncertainty or disregard of rules can also create unsafe conditions.[10]

Infrastructure features (or lack thereof) may contribute to unsafe conditions as well. Safety issues may result from unmarked paths, lack of signage, inferior lighting, and inadequate path capacity for the volume of users.[11] Another consideration is cyclists' stopping sight distance. Stopping sight distance is the distance needed to come to a complete and controlled stop. Vegetation, posts, signs or other objects can obscure this distance.

Some infrastructure elements have been effective in improving safety. Pavement markings may help maintain order on the shared path, particularly when there are high volumes of cyclists and pedestrians.[12] [13] When Bicycle Victoria, a non-profit community based organization, added a center line on a path so that users would keep to the left and overtake on the right, 29% more of path users complied with the path rules.[14] Posting signage about shared path rules was also found to be an effective strategy for influencing path user behavior and knowledge.[15]

Conflicts between automobiles and bikes and pedestrians at intersections

In a recent report of cyclist fatalities and serious injuries in New York City, 89% of fatalities and 70% of serious injuries occurred at or near intersections. In addition, over 95% of fatalities and 75% of serious injuries involved motor vehicles.[16]

Several factors contribute to conflicts at intersections. In a 2004 study conducted in Japan, researchers found that a higher number of turning lanes at signalized intersections significantly increased the risk of cyclist and motor vehicle crashes.[17] A potential cause of high collision rates between motor vehicles and cyclists at intersections may be due to the "look-but-failed-to-see" phenomenon.[18] At intersections, motor vehicle drivers may be looking for other automobiles but may not see bicycles approaching on their right side or from the opposite direction because they aren't expecting to see them. Also, right-turn lanes often allow a right turn on red and this can be a problem when motorists fail to stop completely and there is free-flow movement through the intersection.[19] In situations where a bicyclist is traveling straight through an intersection and the motor vehicle is turning right, it is necessary for the bike and car to cross paths. According to the American Association of State Highway and Transportation Officials (AASHTO), pavement markings may be useful in directing cars and bikes to cross paths before reaching the intersection.[20] Another potential safety issue at the intersections is cyclists traveling on the wrong side of the road or against traffic to either enter or exit a shared use path or trail.[21] Bicyclists' travel against traffic is particularly dangerous and should be discouraged.[22]

5.1.d Recommended prevention strategies

Bicycle and pedestrian safety issues are affected by human behavior as well as infrastructure. Since it can be difficult to change individual behavior, refinements to infrastructure can be a good strategy for improving public safety on a large scale.

Many of the following recommendations have already been considered by the Bicycle and Pedestrian Working Group. Though the recommendations are relatively small modifications to the LPA, they may result in additional reductions to the number of pedestrian and bicyclist injuries.

Utilize signage and lane markings on shared use paths to reduce the risk of bicycle-pedestrian collisions

The following strategies could be implemented to control the flow of bicycles and pedestrians on the shared use path: add "wheels and heels" yellow lane markings to separate bicyclists and pedestrians, direct bicyclists to travel in the same direction as automobiles (one-way, with traffic), and add signage and pavement markings to communicate path rules. This recommendation was also suggested by the Bicycle and Pedestrian Working group.

Consider a variety of strategies to enhance safety at the west end intersection

As mentioned above, intersections can be dangerous for cyclists and pedestrians. At the west end intersection there will be additional obstacles nearby such as bus stops and streetcar stations. The safety benefit of some of the strategies below may need to be weighed against the potential impact on motor vehicle traffic. Some safety strategies to consider are:

- Prohibiting right turns on red
- Allowing cyclists to cross the west side intersection independent of motor vehicles
- Using signage/flashing lights to provide ample warning when approaching intersections
- Using signage and lane markings to direct cyclists transitioning from the on-road bike lane to the shared use path in order to access the connecting trails
- Including large curb cuts/ramps near the end of the bridge to allow cyclists who have used the road to access the existing trail network via the shared use path
- Checking bicycle stopping sight distances near intersections
- Posting way-finding signage to direct cyclists to common destinations such as the Springwater Corridor, Lake Oswego, or Downtown Portland

Consider visual and physical barriers between the motor vehicle and on-road bike lanes

Bike lanes are a safe option for experienced cyclists. Consider enhancing the bike lane by elevating it and painting it green. Though such "cycle tracks" have not been studied extensively, they show promise as an added safety element.[23, 24]

Continue to seek input from the Bicycle/ Pedestrian Working Group during project design

5.2 Maintain safe air quality during construction

As with all transportation infrastructure projects, the Sellwood Bridge replacement project has the potential to affect air quality. During the construction phase, the removal of the old bridge and the construction of the replacement bridge will generate air pollution resulting from dust and the use of diesel-powered equipment and vehicles. Once the new bridge is operational, the additional traffic volume on the new bridge may increase air pollution levels in the vicinity of the bridge.

The Sellwood Bridge DEIS states that daily traffic on the replacement bridge is not projected to rise to a level that would trigger air toxics analysis under federal law. Given the low potential to increase air toxics to significantly higher levels, this issue is not explored in this HIA.

With regard to construction activities, the Sellwood Bridge DEIS anticipates an increase in construction-related dust and proposes appropriate mitigation measures. The remainder of this section will examine construction-related air quality concerns for the Sellwood Bridge Project.

5.2.a Concerns about health effects of diesel particulate matter during construction

Vehicles and machinery used during construction are typically fueled by diesel and, especially in the case of older equipment and vehicles, emit large amounts of pollutants including particulate matter. Diesel exhaust contains many potentially harmful gases and particulate matter. While there is public health concern about the health effects of many of these pollutants, the greatest health concern is around exposure to diesel particulate matter.

The majority of particulate matter in diesel exhaust falls into the category of fine particulate matter, or PM 2.5, which includes particles that are 2.5 microns or smaller in size. PM 2.5 is small enough to drift 300 meters (approximately 900 feet) from the emission source and can be inhaled easily. Chemicals attached to the surface of diesel particulate matter include known or potential human carcinogens that can result in lung cancer given a sufficient dose and long-term exposure. This makes diesel particulate matter more dangerous than other types of particulate matter in the air.

The possible consequences of a shorter term of exposure, such as the anticipated four-year construction period, are also relevant to the Sellwood Bridge project. If particulate matter concentration is sufficiently elevated for this period health consequences of exposure to particulate matter may include irritation of the eyes, throat, and lungs, neurophysiologic symptoms (e.g., lightheadedness, nausea), and respiratory symptoms (e.g., cough, phlegm). There is also evidence that particulate matter can cause an immunologic effect leading to asthma-like symptoms or worsening of existing respiratory problems.[25]

Public health concerns related to the Sellwood Bridge fall into two categories. First, operators of diesel-powered equipment and other workers in the construction area may be exposed to high levels of diesel particulate matter over the course of each work day. Second, the collocation of a large amount of diesel-powered machinery and vehicles may pose a threat to the health of area residents by raising localized PM 2.5 levels.

5.2.b Anticipated magnitude of health concerns

Construction workers

Concerns about occupational exposure to particulate matter in construction settings were raised in a study conducted by Northeast States for Coordinated Air Use Management (NESCAUM) in 2004.[26] Researchers in this study collected air samples in the cabs of heavy duty diesel equipment as well as at the perimeter of the five construction sites studied. The study estimated that equipment operators spent 20-50% of a 8-hour workday in the cab of equipment whose engine was running. Air sample analysis showed that equipment operators were exposed to a wide range of concentrations of fine particulate matter (PM 2.5), from 2 $\mu g/m^3$ to 660 $\mu g/m^3$. Towards the higher end of this range, the average 24 hour exposure to particulate matter (when combining exposure inside the cab and at ambient concentrations) would exceed National Ambient Air Quality Standards by nearly 2 to 3.5 times.

The NESCAUM study also found elevated PM 2.5 levels in the air at the perimeter of the construction sites. This indicates that regardless of whether workers are in the cab of a diesel-powered vehicle or near the perimeter of the work site—they have higher than background level of exposure to PM 2.5 from diesel.

As of the writing of this report, planning for the replacement bridge has not reached a stage when construction details of the bridge project are known. Consequently, it is unknown how many workers will be working on the construction site or the duration of their employment at the site. The Sellwood Bridge project construction period is expected to last 4 years, so occupational exposure to diesel particulate matter from this project is of finite duration. However, it is likely that the workers at the site will move to another construction project once the new bridge has been completed. Their occupational exposure to potentially high levels of diesel particulate matter from the bridge replacement project may be just one episode in a series of exposures that span their working lives.

Currently, there are no occupational exposure standards for diesel exhaust set by the federal Occupational Safety and Health Administration[27] or by the State of Oregon. However, the National Institute for Occupational Safety and Health (NIOSH) supports the recognition of diesel exhaust as a "potential occupational carcinogen" and, therefore, recommends that occupational exposures be limited to the "lowest feasible limits."[28] Unless contractors voluntarily impose stricter standards for occupational exposures to diesel emissions on their work site there are no protections for construction-site workers.

Ambient air quality standards have been set by the federal government and some state governments to protect the general population, which includes sensitive sub-populations such as children and the elderly, from adverse health effects of air pollution. The federal government, the state of California, and the state of Oregon have set standards related specifically to ambient exposure to diesel particulate matter. U.S. Environmental Protection Agency (USEPA) has established a non-cancer reference concentration level of 5 $\mu g/m^3$, meaning that at this level of exposure over a lifetime, there is no appreciable risk of non-cancerous health effects in humans.[29] In Oregon, the Department of Environmental Quality has set an Ambient Benchmark Concentration for diesel particulate matter of 0.1 $\mu g/m^3$; above this level the risk of developing cancer increases to more than 1 in 1,000,000 over a lifetime of exposure (Table 1).

Assuming diesel equipment operators and construction workers spend much of their working lives employed at construction sites, the concept of a lifetime risk of cancer and non-cancer health outcomes embodied in state and federal diesel PM standards is meaningful in the context of construction site exposure to diesel particulate matter. Comparing the diesel PM 2.5 exposure findings of the NESCAUM study with the standards set by state and federal air quality programs shows that the typical exposure of diesel equipment operators and construction workers over a significant portion of their lives engenders significantly higher risk than is considered "safe" by either standard. It is anticipated that Sellwood Bridge workers will also be assuming an excessive level of non-cancer risk comparable to that experienced by workers participating in the NESCAUM study. In addition, based on Oregon's cancer benchmark concentrations, it is also clear that construction workers who are exposed continuously to higher concentrations of diesel particulate matter will have a much higher risk of developing cancer over their lifetimes.

Area residents

As mentioned above, PM 2.5 can travel up to 300 meters depending on wind speed and direction, weather, and topography. Figure 3 shows the residential areas within 300 meters of the bridge which, according to population estimates,[30] are home to approximately 85 children (0-17 years), 67 seniors (65 years or over), and 382 adults (18-64 years). Given the directions of typical wind flow (towards the southeast in summer and fall and towards the northeast in winter and spring), the areas on the east side of the river have a higher likelihood of being affected by pollutants produced during construction. Based on internet searches, no medical clinics, retirement facilities, schools, or large child care centers were found within 300 meters of the construction area.

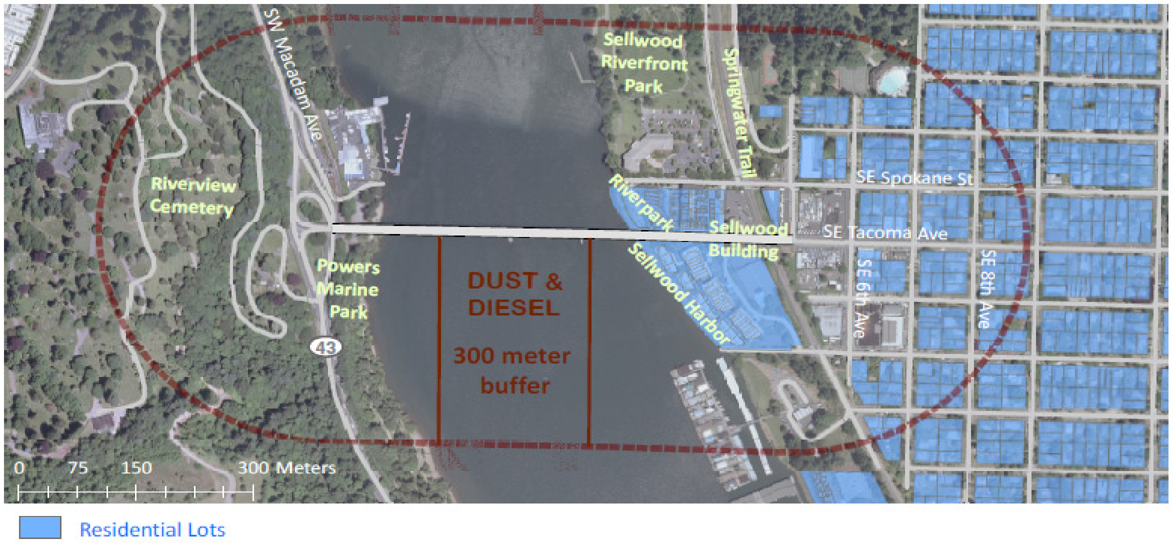
Residents of the Sellwood Harbor and River Park developments at the eastern base of the bridge are of special concern. The location of their residences means that close proximity to construction emissions is unavoidable for much of the four year construction phase. Sellwood Harbor and River Park are also home to many elderly residents, who may be more severely affected by diesel exhaust particularly if they have pre-existing health conditions such as respiratory and cardiovascular issues.

In addition to residential areas, the potential dispersion area includes Powers Marine Park, Sellwood Riverfront Park, and the riverfront recreation trails. Individuals using these facilities for recreation may be more likely to inhale pollutants more deeply into their lungs if they engage in moderate to strenuous physical activity.

Table 1. Ambient Air Quality Standards for diesel particulate matter

	Oregon (Oregon Department of Environmental Quality, Air Quality program)		United States (US EPA)	
	Non-cancer Reference Exposure Level	Cancer Ambient Benchmark Concentration	Non-cancer Reference Exposure Level	Cancer Unit Risk
Diesel particulate matter concentration	-	0.1 µg/m^3	5 µg/m^3	-

Figure 3. Dust and Diesel Buffer around the Sellwood Bridge



As previously mentioned, PM 2.5 has been shown to exacerbate respiratory conditions such as allergies and asthma. While there are scarce data on allergy rates and types in Multnomah County, limited information does exist on asthma rates. Asthma is one of the most common chronic diseases in the United States. The Center for Disease Control and Prevention estimated that almost 23 million people suffered from asthma nationwide in 2008.[31] An estimated 9% of adults in Oregon and 6.8% of adults in Multnomah County were diagnosed with asthma in 2008. In addition to the proportion of residents with a medical diagnosis of asthma, an unknown number of county residents suffer from asthma-like symptoms without having a formal diagnosis. Neighborhood level asthma prevalence is not available. However, county level asthma diagnosis and asthma-related emergency department utilization data provide an understanding of the proportion of residents who are more vulnerable to the effects of air pollution in our community.

Estimating risk of adverse health outcomes due to ambient exposure to PM 2.5

In 2009, the Oregon Department of Environmental Quality (DEQ) updated its modeling of air pollution from all sources in the Portland area for the Portland Air Toxics Solution (PATS) project. This model provides the baseline diesel particulate matter level prior to the commencement of construction activity on the bridge. Figure 4 shows the modeled concentrations of diesel particulate matter which is almost entirely comprised of PM 2.5. In the area surrounding the Sellwood Bridge the concentration of diesel particulate matter ranges from approximately 1.5 to 4 μg/m^3.

With few details currently available about the construction equipment that will be used during this project, Multnomah County Health Department is unable to complete a health effects assessment at this time.

However, health risk assessments for diesel particulate matter have been undertaken in California and by the U.S. EPA. In both of those analyses, the adverse health outcomes resulting from exposure to total PM 2.5 are worrisome both in terms of the array of health effects and the magnitude of the problems associated with this exposure. The California Air Resources Board estimates that lowering ambient PM 2.5 from 2002 levels to 12 μg/m^3 across the state would result in reductions of approximately 2,600 premature deaths, 600 hospitalizations for COPD, 900 hospitalizations for pneumonia, approximately 1,500 for cardiovascular disease, and 500 for asthma.[32] While these data represent health benefits resulting from reduction of PM 2.5 from all sources, it is instructive even in the context of *diesel* PM 2.5 to examine the sizeable toll imposed on human health by exposure to fine particulate matter. Diesel PM 2.5 is estimated to contribute up to 10 to 35% of all PM 2.5 in urban areas.

There is ample evidence of a connection between exposure to diesel PM 2.5 and poor non-cancer health outcomes in epidemiologic literature. The key studies are summarized in US EPA's "Health Assessment Document for Diesel Engine Exhaust" published in 2002. The EPA states that it is reasonable to assume that exposure to diesel PM 2.5 is associated with health effects to the same degree that this pollutant contributes to total PM 2.5.

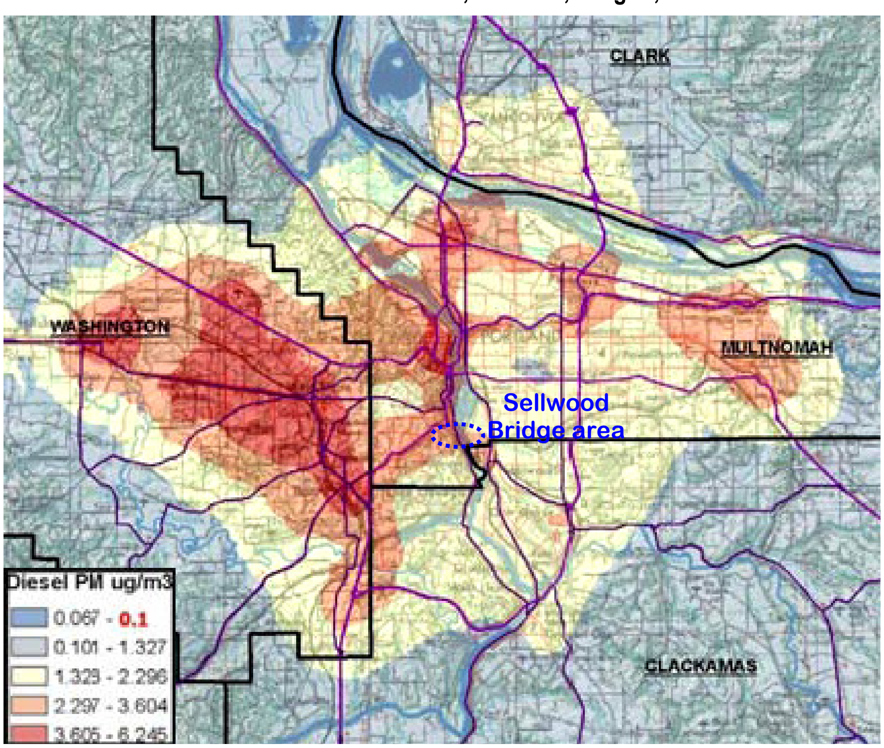
Concurrent construction activities in the Sellwood Bridge area

It is important to bear in mind that the emissions from the Sellwood Bridge will be combined with emissions from other sources including other infrastructure projects occurring in the area. Air quality may reach harmful levels due to the cumulative impacts of the bridge replacement along with other projects.

5.2.c Factors contributing to exposure to air pollutants and illness

In addition to the ambient concentrations of air pollutants there are a number of other factors that determine the level of exposure of individuals in the area and their likelihood of developing illness as a result of the exposure. Only some of these factors are amenable to mitigation measures.

Figure 4. Modeled Concentration of Diesel Particulate Matter, Portland, Oregon, 2009



Source: Oregon Department of Environmental Quality, Air Quality, Portland Air Toxics Solution

Meteorological and topographical characteristics of the area play a significant role in determining exposure levels. The time of year or day, temperature, wind speed and direction, humidity and other factors determine which way the particulate matter is carried from the construction site. Similarly the topography of the area and the height of the buildings or residences (one or two story vs. multi-storied dwelling) also influences where the particulate matter is carried.

Other factors contributing to the level of exposure to diesel particulate matter relate to the air circulation and filtration characteristics of the affected residences. Residents living in houses with air conditioning units or air filtration devices have greater ability to reduce exposure to diesel emissions. Conversely, leaving doors and windows open to the outside air will allow particulate matter to enter houses more readily.

Other day-to-day activities and lifestyle choices of the residents will also determine their level of exposure to diesel particulate matter. People who spend time outdoors during construction activity are more likely to inhale air pollutants. The more strenuous the physical activity (such as running, walking briskly, or playing sports) people engage in the more deeply they will inhale diesel particulate matter and other pollutants.

In addition to characteristics of the residents and houses in the area, the types of diesel-powered equipment used and the manner in which they are used play a significant role in determining how much particulate matter is released into the surrounding air. The age of diesel engines used, the type of diesel fuel used, and the duration of equipment use all determine the levels of particulate matter released into the air. The U.S. EPA estimates that the use of particulate matter reduction technology such as diesel oxidation catalysts (DOC) and catalyzed diesel particulate filters (CDPF) can reduce particulate matter emissions between 20% (DOC and low sulfur fuel) and 90% (CDPF and ultra low sulfur diesel).[34] In a 2008 study by NESCAUM, five different types of construction equipment (five pieces of equipment in all) were fitted with CDPF and fueled with ultra low sulfur diesel and the emissions reductions for this complement of equipment was projected using EPA's emissions calculator and validated information on emissions reductions. It was estimated that over the course of a four year project the emission control practices would reduce particulate matter released by almost 2 tons.[35]

Such significant reductions in diesel particulate matter would benefit residents in the vicinity of the bridge as well as the construction workers who spend much of their work days in close proximity to these engines.

Finally, susceptibility to the array of health outcomes associated with exposure to diesel particulate matter will vary from one individual to the next. The same exposure level can result in different health outcomes depending on individual characteristics such as the person's age or pre-existing health conditions. However, there is some predictability in how exposure to air pollutants in different subpopulations is associated with poor health outcomes. The subpopulations that are more likely to experience air pollution related health issues are known as "sensitive receptor populations." This group is generally comprised of children, the elderly, and those suffering from acute or chronic illness. Land uses associated with these populations include residences, schools, playgrounds, childcare centers, retirement homes, convalescent homes, hospitals, and medical clinics.

5.2.d Recommended mitigation strategies

The above analysis of potential exposure to diesel particulate matter and the exploration of factors that contribute to public health concerns indicate the need for mitigation strategies that address PM 2.5 emissions, dispersion, and individual exposure. The following are Multnomah County Health Department's recommendations regarding construction-related air quality:

Require and/or provide incentives for the use of clean diesel technology and practices from potential contractors when soliciting bids for constructing the replacement bridge. Specifically, the following practices are recommended by U.S. EPA[36]:

- Reduce idling
- Practice good engine maintenance and properly train operators
- Repower or retrofit existing equipment with EPA-verified emission reduction technologies
- Use low or ultra-low sulfur diesel, biodiesel, liquid petroleum gas, and compressed natural gas

Consider applying for grants from Oregon Department of Environmental Quality, or US Environmental Protection Agency to fund clean diesel technology for contractor equipment

The U.S. EPA provides grant opportunities to cover the costs of purchasing and implementing 'clean' technologies. More information about the funding opportunities can be found at http://epa.gov/otaq/diesel/grantfund.htm. The Oregon DEQ Clean Diesel Program may be consulted to apply for appropriate grants for the Sellwood Bridge project. Assistance with the application process may also be provided by the Multnomah County Health Department.

Monitor project-related air quality during the construction phase of the bridge

In consultation with Oregon Department of Environmental Quality Air Quality program, set up an air quality monitoring system, such as the use of nephelometers, to monitor particulate matter in the vicinity of the construction activity in real-time. This information would be invaluable in understanding the concentrations of PM 2.5 to which construction workers and area residents are exposed.

When feasible, modify construction activities requiring diesel-powered engines on air stagnation days

Coordinate with other county or city projects to assure that concurrent projects do not degrade air quality

Educate area residents on ways to reduce exposure to diesel PM 2.5

Educate the public on the health effects of PM 2.5 and other air toxins. Provide a website, phone number, and mailing address for questions and comments about respiratory problems that may be associated with construction activities.

For residents in the project buffer area, encourage residents to use air conditioning/filtration systems for the duration of the construction period and facilitate implementation with elderly, low-income, or disabled residents.

Make residents aware of air quality conditions if diesel particulate matter concentrations warrant changes to daily activity including limiting outdoor activity, closing windows and doors, and/or turning on air conditioning/filtration systems.

5.3 Maintain safe noise levels during construction

Noise will increase during the construction phase of the Sellwood Bridge due to construction activities and equipment. The DEIS states that construction noises are predicted to exceed the Noise Abatement Criteria (NAC) established by the U.S. Federal Highway Administration during the four-year construction phase. Though the DEIS does propose limited construction noise mitigation strategies, minimal modifications to the proposed plan could enhance protection, especially for vulnerable residents.

Once the bridge is operational, the DEIS predicts that typical traffic noise will remain near current levels, between 57-71 decibels. Based on the known details about the LPA, the DEIS concludes that the potential increase in noise, an estimated 3 decibels at the most, is not significant enough for mitigation that would warrant the costs. However, once the final design is completed, the cost benefit of mitigation will be revisited. Therefore, this analysis will focus on the health effects of noise during the construction phase.

5.3.a Concerns about noise during the construction period

Construction noises are often repetitious "impact" and "impulse" noises and have been associated with a variety of health impacts including hearing loss or degradation[37] and self-reported sleep disturbance.[38] People seem to adapt quickly to loud outdoor noises and can sleep through the noise, but their blood pressure and heart rate may increase in response to the noise, which may harm health over time.[39]

In addition, there is a large body of evidence confirming that people are annoyed by noise. People's subjective feelings such as anxiety over the noise source, feelings that the noise could be avoided, or lack of control over the noise contribute to stress. The stress then leads to measureable physical and psychological health effects. Physical effects include hypertension and heart disease and psychological effects include increased aggression and inability to process social cues. [40 41]

The World Health Organization (WHO) has been attempting to address the problem of community noise since 1980. According to WHO, community noise is defined as "noise emitted from all sources except noise at the industrial workplace."[42] Construction noise is considered a main source of community noise. The Federal Highway Administration (FHWA) has established Noise Abatement Criteria (NAC). The acceptable upper limit noise levels are 67 and 72 decibels for residential and commercial land uses, respectively. Oregon adheres to the NAC criteria and when noise levels are within 2 decibels of the NAC, mitigation is considered. In Oregon, mitigation is also considered when there is a substantial increase in noise, defined as a 10 decibel increase above existing conditions. From a health standpoint, it is debatable whether these criteria are stringent enough. In fact, WHO has set a lower residential threshold of 55 decibels.

In Oregon, construction noise is regulated by both local and state government, although it is enforced by the local government. The City of Portland has a Noise Control Officer who is notified of noise disturbances and can modify operations as necessary to decrease or halt noise. In addition, Portland's comprehensive plan has a section about mandatory noise mitigation practices for construction processes, which are included in the DEIS.

5.3.b Anticipated magnitude of the health concerns

The populations most likely to be affected by the excessive construction noise over prolonged periods of time include residents and those who work near the Sellwood Bridge (including construction workers). As with exposure to poor air quality, construction workers may be especially prone to noise-related health impacts since their exposure will likely continue beyond the re-build of the Sellwood Bridge.

Construction workers

The Occupational Safety and Health Administration (OSHA) has developed noise protection standards for construction workers. As duration and decibel thresholds are reached concurrently, mitigations must be employed through administrative strategies (e.g., changing work assignments), engineering (e.g., modifying equipment to make it quieter), and/or protective gear (e.g., ear plugs). In addition to the general health-impacts of noise, occupational noise can cause safety issues by muffling workplace warning signs (e.g., the sound of malfunctioning machinery) and impeding workers' ability to concentrate. According to a review of the existing literature on the effects of noise on construction workers' health, OSHA standards may provide inadequate protection. Some public health researchers have called for more specificity of the construction-related regulations, so that they are in accordance with those established for general industry.[43] However, because some protections are in place for construction workers, the residents' and area workers' health are the primary concern related to the Sellwood Bridge construction.

Area residents and those who work in the area

The construction noise may affect the approximately 534 residents who live within 300 meters of the bridge. This estimation is based on the upper distance limit of 300 meters used by the Federal Highway Administration when modeling traffic-related noise.[44] There are also approximately 5-6 blocks zoned for commercial uses within the noise buffer but it is unknown how many employees work for these businesses.

Estimating risk of adverse health outcomes due to construction noise

As noted earlier, because construction will not commence until 2011, and details of the bridge are still to be determined, it is not possible to estimate the magnitude of the increase in noise due to construction.

However, it is reasonable to conclude that noise in the area will noticeably increase. The construction-related noise will result from increased truck traffic going to and from the worksite, equipment use, and construction activities including those occurring in the staging areas. Staging areas may be located within the official project area and on the east side, this may be near residences.

Considering that noise levels in the Sellwood Bridge area already exceed the NAC at times, the additional construction noise could be significant. Current levels of noise, 57-71 decibels, are categorized as "quiet" to "intrusive." At 90 decibels a person can experience hearing loss with prolonged exposure. Figure 5 shows that typical construction equipment generates noise ranging from 68-106 decibels. At the highest noise level generated by construction equipment, 106 decibels, the sound is characterized as "very annoying" and is comparable to someone shouting loudly 6 inches away.[45] In addition to the increase in the noise magnitude, the nature of the noise may be an issue. Different types of construction equipment generate a variety of noises which may add to residents' annoyance. Also, vibration coupled with noise could exacerbate disturbances. As the vibration associated with high-level low frequency sound increases, the perceived unpleasantness associated with the noise may increase.[46] According to the DEIS, vibratory compaction equipment is expected to have a high construction noise impact.

Quantifying the collective noise generated from multiple pieces of construction equipment in use at the same time cannot easily be done. Simple mathematical operations don't apply as decibels are measured on a logarithmic scale. For example, to the human ear, a 10 decibel increase in noise is perceived as being double the noise.

5.3.c Factors contributing to safety concerns

The health impacts of noise depend on the intensity (measured in decibels) and duration of the noise and the receiver's environment (e.g., indoors, outdoors, near traffic). Multiple individual-level factors affect the impact of noise on a person's health. With prolonged exposure, certain individuals may be at increased risk for health problems related to noise which may result in hypertension and ischemic heart disease. The severity of the health problem may be mediated by one's lifestyle and environment. According to WHO, the following groups may be particularly susceptible to noise health impacts: people who already have health problems like high blood pressure, the young and the elderly, and the visually blind and hearing impaired.[47] Since traffic is a main contributor to community noise, people living near busier streets in the Sellwood area may be especially affected by construction noise.

Physical barriers and sound cancelling devices may be effective in minimizing health effects. Individuals may benefit from wearing ear plugs or utilizing white noise machines. Features of residences such as double-paned windows and air conditioning units, which allow for windows to remain shut, may be useful. On a larger scale, temporary walls or other sound barriers may be warranted.

Figure 5. Noise Levels for Construction Equipment

	Equipment Type	Range in Noise Level at 50 feet (dBA)
Equipment Powered by Internal Combustion Engines		
Earth Moving	Front Loaders	72-84
	Backhoes	72-93
	Tractors	77-96
	Scrapers	80-93
	Graders	80-93
	Pavers	86-89
	Trucks	82-94
Materials Handling	Concrete Mixers	75-88
	Concrete Pumps	81-84
	Cranes, Movable	75-88
	Cranes, Derrick	86-89
	Pumps	68-72
Stationary	Generators	71-82
	Compressors	74-87
Impact Equipment	Mounted Breakers (Hoerams)	76-94
Equipment Powered by Internal Combustion Engines		
	Pneumatic Wrenches	82-89
	Jackhammers & Rock Drills	81-98
	Impact Drivers (Peak)	95-106
Other	Vibrator	69-81
	Saws	72-82

Source: ODOT *Noise Manual* (2007)
dBA = decibels on the A-weighted scale

According to ODOT, an acceptable noise barrier should result in a reduction of a minimum of 5 decibels and cost less than $25,000 per residence that would benefit from it.[48] Lastly, the proper maintenance of construction equipment and the use of noise mufflers may mitigate some of the construction noise.

5.3.d Recommended prevention strategies

While the health effects of noise may not be as serious as those related to air pollution or bicycle and pedestrian safety, they may affect stress levels or general well-being. In addition to the proposed noise mitigation measures included in the DEIS, the following strategies are recommended as the budget allows. Some of these strategies may be cost prohibitive.

When feasible, adjust construction schedules to allow for adequate quiet for residents

Limit loud-noise construction activities performed within 300 meters of an occupied dwelling unit on Sundays, legal holidays, and between the hours of 8:00 p.m. (the DEIS states 10 p.m.) and 6:00 a.m. on other days.

Educate residents on types, times, duration, and health effects of the construction-related noise

Distribute a newsletter to affected residents about the construction schedule and anticipated noise. Provide contact information for noise complaints, questions, or issues. Multnomah County has done this for previous projects with great success. Partner with the Multnomah County Health Department to inform residents and area workers regarding noise-related health impacts.

Assist residents in implementing noise reduction strategies

For the Sellwood Harbor properties, the removal of four condominium units will require a major outdoor wall to be built. Consider building this wall with sound-proofing insulation to protect residents' hearing during and after construction. For example, Quiet Solutions, a California-based materials manufacturer, has a line of sound-proofing drywalls, caulks, tiles and other materials that reduce the perceived noise by up to 86%.[49]

In the summer months, encourage residents to keep windows closed and to utilize air conditioning units to cool homes and muffle construction noise. Other alternatives include the use of ear plugs, noise cancelling headphones, or sound machines during the construction period.

6 Conclusions

There is a strong public health argument for replacing the existing Sellwood Bridge. The current structure has a poor safety rating and is not expected to withstand a significant earthquake. A seismic event of this scale is widely anticipated in the area over the coming decades and the consequence of not having a bridge that is capable of resisting these forces may be disastrous.

The locally preferred alternative for the replacement bridge has been designed with significant attention to the needs of the large bicycling community in the county as well as the needs of pedestrians in the area. The bridge will continue to carry only two through lanes of motor vehicle traffic while expanding the bicycle and pedestrian facilities significantly. From a public health perspective, the changes will mean marked improvements in safety of the bicyclists and pedestrians who currently assume the risk of collisions with each other or with motor vehicles while crossing the bridge. Expansion of bicycle and pedestrian facilities will also draw additional users to the bridge and encourage greater levels of physical activity. Although this is not the primary purpose of the replacement bridge, it represents a non-traditional strategy to address the trend of increasing obesity and overweight in our community.

The new bridge will also allow public transit buses to cross into the Sellwood area providing the community with another mode of active transportation that is currently not available. In addition, the bridge design will accommodate future streetcar access should plans be implemented to expand the streetcar to this part of the county.

Public health concerns about the bridge include (1) bicycle and pedestrian safety on the replacement bridge, (2) air quality during construction, and (3) noise during construction.

The bicycle and pedestrian shared use paths that will span both sides of the bridge are currently in the design phase. There is potential for conflict between pedestrians and bicyclists on this path resulting from a lack of clear expectations of how these bridge users should interact with each other. The paths can be made even safer and easier to use with a few minor enhancements. The improvements suggested in this HIA reflect the experience and knowledge of agencies and individuals that have studied these issues in depth. Many of the recommendations are based on the need to make bridge user behavior more predictable to others by creating guidelines for use of the bridge. An example of this is signage or lane markings designating which parts of shared use paths are to be used by bicyclists and which are to be used by pedestrians. Recommendations also include the creation of appropriate safeguards to protect bicyclists and pedestrians at the intersection with OR 43 on the west side of the bridge.

During the four-year construction period it is anticipated that there will be an increase in particulate matter resulting from the use of diesel-powered equipment in the vicinity of the bridge. The populations most likely to be exposed to potential increases in air concentrations of diesel particulate matter include construction site workers and the residents living within 300 meters of the bridge in the Sellwood neighborhood. Health effects of short term exposure include irritation of the eyes and throat, respiratory problems including shortness of breath, asthma, and bronchitis, and neurophysiologic symptoms including lightheadedness and nausea. Recommendations to lessen the impact of construction on air quality include the use of clean diesel technology and practices such as diesel retrofits and the use of ultra-low sulfur fuels. The HIA also recommends maintaining frequent and detailed communication with area residents about anticipated day-to-day changes in air quality, limiting outdoor activity, and ways to prevent particulate matter from entering the area residences.

Finally, construction-related noise is also expected to be a concern for residents living within 300 meters of the bridge. Excessive noise levels are associated with disrupted sleep, increased stress and chronic diseases resulting from higher stress levels. Limiting construction times and providing information to area residents about anticipated noise levels and ways to contact the bridge team with concerns are among the recommendations of this HIA.

The replacement for the current Sellwood Bridge is expected to be beneficial to county residents' health by increasing safety and opportunities for physical activity. Implementing the recommendations in this document will make the final product even safer through design and construction practices that minimize the detrimental impacts of construction to the health of exposed individuals. The bridge and the construction process can both be examples of healthy transportation infrastructure projects.

References

1. Centers for Disease Control (2005). *The Guide to Community Preventive Services: Physical Activity*. Retrieved March 22, 2010 from http://www.thecommunityguide.org/pa/index.html.
2. Multnomah County Department, Health Assessment and Evaluation. (2008). *Overweight and Obesity in Multnomah Count*y. Accessed on June 1, 2010 at http://www.mchealth.org/hra/haq/fall_2008_obesity.pdf.
3. Jacobsen, P.L. (2003). Safety in numbers: more walkers and bicyclists, safer walking and bicycling. *Injury Prevention*, 9, 205-209.
4. Portland Office of Transportation. (2009). Obtained from Greg Raisman on June 17, 2010.
5. Pucher, J. (2003). Promoting safe walking and cycling to improve public health: lessons from the Netherlands and Germany. *American Journal of Public Health*, 93, 1509-1516.
6. Reynolds, C.C.O., Harris, M.A., Teschke, K., Cripton, P.A., & Winters, M. (2009). The impact of transportation infrastructure on bicycling injuries and crashes: a review of the literature. *Environmental Health*, 8:47. doi:10.1186/1476-069X-8-47.
7. Wachtel, A. & Lewiston, D. (1994). Risk-factors for bicycle motor-vehicle collisions at intersections. *Institute for Transportation Engineers Journal*, 64, 30-35.
8. Stutts, J.C. & Hunter, W.W. (1999). Motor vehicle and roadway factors in pedestrian and bicyclist injuries: an examination based on emergency department data. *Accident Analysis and Prevention*, 31, 505-514.
9. Florida Department of Transportation. (1994). *Florida Bicycle Facilities Planning and Design Handbook*. Accessed on May 17, 2010 at http://www.dot.state.fl.us/safety/ped_bike/handbooks_and_research/bhchpt5.pdf.
10. Austroads. (2006). *Pedestrian-Cyclist Conflict Minimisation on Shared Paths and Footpaths*. Accessed on May 17, 2010 at http://www.industrializedcyclist.com/Ped-cyclist_conflict.pdf.
11. Austroads. (2006). *Pedestrian-Cyclist Conflict Minimisation on Shared Paths and Footpaths*. Accessed on May 17, 2010 at http://www.industrializedcyclist.com/Ped-cyclist_conflict.pdf.
12. Austroads. (2006). *Pedestrian-Cyclist Conflict Minimisation on Shared Paths and Footpaths*. Accessed on May 17, 2010 at http://www.industrializedcyclist.com/Ped-cyclist_conflict.pdf.
13. American Association of State Highway and Transportation Officials. (1999). *Guide for the Development of Bi-cycle Facilitie*s. Accessed on June 2, 2010 at http://www.sccrtc.org/bikes/AASHTO_1999_BikeBook.pdf.
14. Walter, N. (1995). *The White Line Project : A Report on the Impact of a Centre White Line and Directional Arrows in Modifying Trail User Behavior*. Accessed on May 17, 2010 at http://www.bv.com.au/bike-futures/10565/.
15. Austroads. (2006). *Pedestrian-Cyclist Conflict Minimisation on Shared Paths and Footpaths*. Accessed on May 17, 2010 at http://www.industrializedcyclist.com/Ped-cyclist_conflict.pdf.
16. Pucher, J., Thorwaldson, L., Buehler, R., & Klein, N. (In press). Cycling in New York: innovative policies at the urban frontier. *World Transport Policy and Practice*.
17. Wang, Y. & Nihan, N.L. (2004). Estimating the risk of collisions between bicycles and motor vehicles at signalized intersections. *Accident Analysis and Prevention*, 36, 313-321.
18. Reynolds, C.C.O., Harris, M.A., Teschke, K., Cripton, P.A., & Winters, M. (2009). The impact of transportation infrastructure on bicycling injuries and crashes: a review of the literature. *Environmental Health*, 8:47. doi:10.1186/1476-069X-8-47.
19. Communication with Robert Schneider, Ph.D. candidate via email on March 4, 2010.
20. American Association of State Highway and Transportation Officials. (1999). *Guide for the Development of Bi-cycle Facilities.* Accessed on June 2, 2010 at http://www.sccrtc.org/bikes/AASHTO_1999_BikeBook.pdf.
21. Oregon Department of Transportation Oregon. (1995). Bicycle and Pedestrian Plan. Accessed on May 17, 2010 at http://www.oregon.gov/ODOT/HWY/BIKEPED/docs/or_bicycle_ped_plan.pdf.
22. Florida Department of Transportation. (1994). *Florida Bicycle Facilities Planning and Design Handbook*. Accessed on May 17, 2010 at http://www.dot.state.fl.us/safety/ped_bike/handbooks_and_research/bhchpt5.pdf.
23. Communication with Anne Lusk, Ph.D. via email on March 8 and May 27, 2010.

24. Alta Planning + Design. (2009). Cycle Tracks: Lessons Learned. Accessed on June 17, 2010 at http://www.nacto.org/downloads/cycletrack_lessons_learned.pdf.
25. Sydbom A, Blomberg A, Parnia S et al. (2001). Health effects of diesel exhaust emissions. *Eur Respir J,* 17, 733-46.
26. NESCAUM. (2004). *Evaluating the Occupational and Environmental Impact of Nonroad Diesel Equipment in the Northeast. Final Report*. Accessed on May 27, 2010 at http://www.nescaum.org/topics/diesel-vehicle-emissions.
27. United States Department of Labor, Occupational Safety and Health Administration. *Diesel Exhaust Standards*. Accessed on May 27, 2010 at http://www.osha.gov/SLTC/dieselexhaust/index.html.
28. Centers for Disease Control and Prevention, National Institute of Occupational Safety and Health. (1988). *Current Intelligence Bulletin 50: Carcinogenic Effects of Exposure to Diesel Exhaust*. Accessed on May 27, 2010 at http://www.cdc.gov/niosh/88116_50.html#Recommendations.
29. U.S. EPA. (2002). National Center for Environmental Assessment. *Health Assessment Document for Diesel Engine Exhaust.* Accessed on May 27, 2010 at http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060.
30. SimplyMap, 2009 estimated data, accessed on March 17, 2010 from the Multnomah County Library at http://www.multcolib.org/ref/a2z.html#S.
31. Multnomah County Health Department, Health Assessment and Evaluation. (2010). *Asthma in Multnomah County*. Accessed on June 1, 2010 at http://www.mchealth.org/hra/haq/spring2010_asthma.pdf.
32. CARB. (2002). *Public Hearing to Consider Amendments to the Ambient Air Quality Standards for Particulate Matter and Sulfates*. Accessed on May 28, 2010 at http://www.arb.ca.gov/research/aaqs/std-rs/pm-final/pm-final.htm#Summary.
33. U.S. EPA. (2002). *Health Assessment Document for Diesel Engine Exhaust*. Accessed on June 1, 2010 at www.epa.gov/ttn/atw/dieselfinal.pdf.
34. U.S. EPA .(2007). *Diesel Retrofit Technology. An analysis of the cost-effectiveness of reducing particulate matter and nitrogen oxides emissions from heavy-duty nonroad diesel engines through retrofits*. Accessed on May 29, 2010 at http://www.epa.gov/otaq/diesel/documents/420r07005.pdf.
35. NESCAUM. (2009). *Case study report. Regional Construction Retrofit Project*. Accessed on May 29, 2010 at www.nescaum.org/documents/nedc-reg-const-retrofit-project-case-study-rept-20091231.pdf/.
36. U.S. EPA. (2005). *National Clean Diesel Campaign. Cleaner Diesel Makes Good Business Sense Low-Cost Ways to Cleaner Construction.* Accessed on May 29, 2010 at http://epa.gov/otaq/diesel/documents/420f08008.pdf
37. World Health Organization. (1999). *Guidelines for Community Noise*. Berglund, B., Lindvall, T., & Schwela, D. eds. Accessed on March 15, 2010 from http://www.who.int/docstore/peh/noise/guidelines2.html.
38. Passcheir-Vermeer, W. & Paschier, W.F. (2000). Noise exposure and public health. *Environmental Health Perspectives*, 108, 123-131.
39. Stansfeld, S.A. & Matheson, M.P. (2003). Noise pollution: non-auditory effects on health. *British Medical Bulletin*. 68, 243-257.
40. Passcheir-Vermeer, W. & Paschier, W.F. (2000). Noise exposure and public health. *Environmental Health Perspectives*, 108, 123-131.
41. Stansfeld, S.A. & Matheson, M.P. (2003). Noise pollution: non-auditory effects on health. *British Medical Bulletin*. 68, 243-257.
42. World Health Organization. (1999). *Guidelines for Community Noise*. Berglund, B., Lindvall, T., & Schwela, D. eds. Accessed on March 15, 2010 from http://www.who.int/docstore/peh/noise/guidelines2.html.
43. Sutter, A.H. (2002). Construction noise: Exposure, effects, and the potential for remediation: A review and analysis. *American Industrial Hygiene Association Journal*, 63, 768-789.
44. Federal Highway Administration. (2004). *FHWA Traffic Noise Model Version 2.5 Look-up Tables User's Guide*. Accessed on June 4, 2010 at http://www.fhwa.dot.gov/environment/noise/tnm/lookup/25lookup.pdf.
45. Multnomah County, Oregon. (2009). *Final Environmental Impact Statement and Final Section 4(f) Evaluation: Sellwood Bridge*. http://www.sellwoodbridge.org/FEISdownload.aspx.
46. Takahashi, Y., Kanada, K., Yonekawa, Y., & Harada, N. (2005). A study on the relationship between subjective unpleasantness and body surface vibrations induced by high-level low-frequency pure tones. *Industrial Health*, 43, 580-587.

47. World Health Organization. (1999). *Guidelines for Community Noise*. Berglund, B., Lindvall, T., & Schwela, D. eds. Accessed on March 15, 2010 from http://www.who.int/docstore/peh/noise/guidelines2.html.
48. Multnomah County, Oregon. (2009). *Final Environmental Impact Statement and Final Section 4(f) Evaluation: Sellwood Bridge*.
49. Manuel, J. (2005). Clamoring for quiet. *Environmental Health Perspectives*, 113, 47-49.