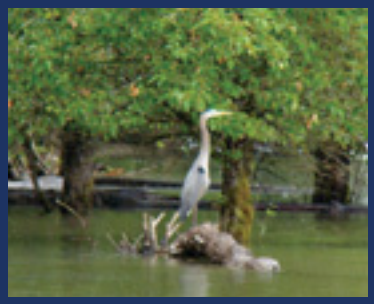

West Hayden Island Health Analysis

November 2012

Multnomah County Health Department in collaboration with:
Oregon Public Health Institute | http://www.orphi.org/
Upstream Public Health | http://www.upstreampublichealth.org/
City of Portland Bureau of Planning and Sustainability
http://www.portlandoregon.gov/bps/

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Introduction

This health analysis addresses one central question: How might annexation of West Hayden Island (WHI) by the City of Portland, and later port development, affect human health?

The Multnomah County Health Department conducted this analysis at the request of the City of Portland's Bureau of Planning and Sustainability. Two public health organizations, Upstream Public Health and Oregon Public Health Institute, provided consultation and technical expertise, and participated on the Health Department's health analysis and research team.

The goals of this analysis are to:

- build on the information already gathered during the West Hayden Island planning process
- respond to stakeholder requests to better understand the potential health impacts of annexation and port development
- aid the City of Portland in integrating health considerations into its planning processes

Overview of Analysis

This health analysis considers the potential impacts of one specific development scenario, guided by Portland City Council Resolution 36805. This scenario includes:

- Retaining at least 500 acres of open space with approximately 2.3 miles of trails
- Up to 300 acres of deep water marine terminal development inside a rail loop
- Replacing the road and adding bicycle and pedestrian infrastructure on N. Hayden Island Drive
- Construction of the Columbia River Crossing (CRC) as planned
- Increased residential development on East Hayden Island, as a result of the adopted Hayden Island Plan
- Initial redevelopment of the Jantzen Beach SuperCenter

This scenario does not include constructing a new bridge from Marine Drive to West Hayden Island. Additional detail for the analysis assumptions is provided in Section II.

This is a prospective analysis of changes planned for the island, how the changes could affect the health of residents of the island and the larger region, and whether potential benefits and harms of the changes are equitably distributed. The analysis draws on the strength of Health Impact Assessment (HIA) techniques[1], but also allows for integration into the well-established Environmental, Social, Economic, and Energy (ESEE) analysis process that is a central part of land use planning in Oregon.

Methods

This health analysis relied as much as possible on peer-reviewed scientific literature, but also used other sources as needed or available. For example, noise data were collected on Hayden Island by a consultant, and the Port of Portland provided air quality data. The health team

1 *For more about HIA and other assessment techniques, see http://www.cdc.gov/healthyplaces/types_health_assessments.htm*

utilized evidence from the scientific literature and local data to estimate the possible impacts of development on West Hayden Island.

This analysis focuses on seven factors that have been identified as concerns during the West Hayden Island planning process and that have been shown to influence health outcomes. These include:

- Air quality
- Noise and vibration
- Light
- Physical activity
- Traffic safety
- Community design and housing
- Employment

The analysis includes a review of each of these seven factors to address the following three questions:

- What are the health issues that could be impacted by this factor?
- How might the development scenario affect the factor, and thus the related health issues?
- What don't we know due to limitations of general scientific knowledge and local data?

Summary of Findings

The health analysis found that all seven factors identified as concerns may affect health—some in negative ways and some in positive ways. The most likely **negative** health impacts are related to air quality, noise and vibration, and community design and housing. These factors show potential for negatively impacting health by increasing respiratory illness, cardiovascular disease, cancer, sleep disruption, and economic instability.

The most likely **positive** health impacts of the development scenario are related to newly available, family wage jobs and improvements in opportunities for physical activity, including the beneficial effects of improved infrastructure for walking and biking as well as open spaces and trails for recreational opportunities. These factors show potential for positively impacting health by increasing life expectancy, decreasing chronic disease, improving mental health, and reducing injuries.

In general, the local population on Hayden Island, particularly those living in manufactured or floating homes, is likely to experience the negative health impacts of the development scenario.

The closer people live to the proposed West Hayden Island development site, the more likely they are to be affected. Children, older adults, and people with low incomes are especially vulnerable to many of the potential impacts. Residents of manufactured homes and floating homes are especially vulnerable to economic challenges due to the potential decrease in property values and personal wealth. The regional population is likely to experience the positive health impacts.

In determining the impacts of the development scenario, the health team considered the following for each factor and its associated health outcomes:

- scale of the impact (i.e., local or regional)
- populations most impacted
- number of people impacted.
- evidence for the link to health outcomes
- likelihood that the development scenario will lead to the health outcome,
- the intensity of the health impact

The analysis also includes a discussion of the potential cumulative and synergistic impacts across factors.

AIR QUALITY

There is sufficient evidence to reasonably expect increases in local air pollution related to the development scenario. Analyses of air quality tend to categorize pollutants in two categories: federally-regulated criteria pollutants and less-regulated air toxics. The development scenario is likely to result in substantial increases in both of these categories:

1) The level of nitrogen oxide (ozone), a criteria pollutant, may increase under the development scenario, requiring additional evaluation, but is not expected to exceed federal standards.

2) Levels of air toxics, which currently exceed state benchmarks on Hayden Island, could increase two to threefold (from 20 to 55 times the state benchmark).

The development scenario is expected to have minimal impacts on greenhouse gas emissions. **The predicted increase in air pollution can contribute to or exacerbate the following health outcomes: respiratory disease, cardiovascular disease, premature mortality, and lung cancer.**

NOISE AND VIBRATION

It is reasonable to expect increases in local noise and vibration, particularly for individuals residing or working along or near freight routes. Increased noise will be buffered to some extent by buildings and trees, though the noise levels already created by aircraft departures from the Portland International Airport and over the Columbia River will continue regardless of the development. **The most likely health impacts as a result of increased levels in noise and vibration are sleep disturbances, annoyance, and stress.** It does not appear that the increased levels of noise and vibration would result in an intensity of exposure that is associated with hearing impairment. **Other health impacts could include: cardiovascular illness and mental health.**

LIGHT

The development scenario may result in minimal health impacts related to light pollution. Port operations involve extensive lighting, as most operate 24 hours a day and illumination is necessary for safety and security reasons. The visual separation caused by the existing railroad berm and the tree buffer, coupled with mitigation strategies, should address this. **Potential negative health impacts of excessive exposure to light at night include: increased sleep disturbance, obesity, diabetes, cancer and depression.**

PHYSICAL ACTIVITY

There is sufficient research to reasonably expect increases in levels of physical activity related to the development scenario. The scenario provides access to improved opportunities for physical activity by expanding infrastructure for biking and walking through improved roadways and trails, and by preserving 500 acres of open space and increasing access to it for recreational opportunities. Physical inactivity is among the top preventable causes of premature death and disability locally and nationally. **Increasing opportunities for physical activity can positively impact the following health outcomes: heart disease, high blood pressure, stroke, obesity, diabetes, and mental health.**

TRAFFIC SAFETY

It is reasonable to expect a modest decrease in traffic-related collisions as a result of the development scenario. Overall, traffic is expected to increase by 115% by 2035, with about 11% of the increase attributed to the West Hayden Island development. Despite the doubling of traffic, the decrease in collisions is likely due to the planned Columbia River Crossing-related interchange improvements on Hayden Island. The total daily truck volume estimate for 2035 without the development scenario is 1,330 trucks. The truck volume added by the development scenario is estimated to be 340 per day which is about one heavy truck traveling down N. Hayden Island Drive every 2.4 minutes. Interaction between trucks and bicyclists and pedestrians is a safety concern; street design will need to accommodate for all modes of travel.

Improved traffic safety can positively impact the following health outcomes: injuries and death.

COMMUNITY DESIGN AND HOUSING

It is reasonable to expect that the development scenario will likely negatively affect local housing conditions by causing property values to decline. A large proportion of Hayden Island residents live in manufactured homes and floating homes which are financed differently than traditional single-family homes. This results in housing costs that are both high and volatile. These homes are a valuable affordable housing resource, but provide limited opportunities for wealth accumulation and are uniquely vulnerable to changes in property value. Decreases in property value as a result of the development scenario will likely result in reduced levels of personal wealth among individuals residing in manufactured homes and floating homes, and could increase economic disparities and poverty on the island. **Economic instability and poverty has a strong connection to health outcomes, including life expectancy and risk of many chronic illnesses.**

EMPLOYMENT

It is reasonable to expect positive impacts on health mainly at the regional level due to increases in employment as a result of the development scenario. It is expected that approximately 2,300-3,700 jobs will be created either directly or indirectly by the development

scenario, and many of these jobs will be living wage jobs. **Many studies show that health improves as income rises, and increases in employment can improve a multitude of acute and chronic health outcomes: life expectancy, mental health, and chronic diseases such as diabetes, heart disease and stroke.**

Cumulative and Synergistic Impacts Across Factors

Many of the health outcomes identified in this analysis will be impacted by more than one of the seven factors, and by multiple development projects. It is reasonable to expect that Hayden Island residents, particularly those living in manufactured and floating homes, will likely be impacted by negative cumulative and synergistic health impacts. These residents may experience decreases in life expectancy, poorer mental health, and increased chronic disease, respiratory illness, cardiovascular illness, cancer, sleep disruption and stress due to multiple environmental changes. For example, residents' mental health may be negatively impacted by noise, light, and community design/housing changes due to West Hayden Island development as well as the construction of the Columbia River Crossing.

Conclusion

There are many potential ways to minimize the health burdens and maximize the health benefits of development on Hayden Island. In addition to identifying potential health effects, this analysis provides a list of potential mitigation measures, organized by the seven factors that have the potential to address the health issues identified. The menu of potential mitigation strategies identified is intended to serve as a resource for decision-makers and the public-at-large as a part of the on-going planning process related to potential annexation of West Hayden Island to the City of Portland and development on the Island.

Table 1: Summary of potential health impacts prior to mitigation

KEY: • low | •• medium | ••• high | ? uncertain or unable to evaluate

Health effects (Factor)	Geographic extent of the impact	Types of people most impacted	Number of people impacted	Evidence in the literature for a link between the change and health outcome	Likelihood that development scenario will contribute to the prevalence of the health outcome	Intensity of the health impact
POSITIVE IMPACT: Employment						
Increased life expectancy	region	Hires for family-wage port jobs (e.g., longshore workers)	2,300-3,700 people in the region	•••	•	•
Improved mental health				•••	••	•
Decreased chronic disease				•••	••	•
Decreased temporary injury & illness				•••	••	•
POSITIVE IMPACT: Physical Activity						
Increased life expectancy	local/region	People in the region who utilize the open space/trail, improved bicycle and pedestrian facilities. Local residents will have improved access to goods and services on the island.	?	•••	•	•
Improved mental health				•••	••	•
Decreased chronic disease				•••	••	•
Decreased temporary injury & illness				•••	••	•

KEY: • low | •• medium | ••• high | ? uncertain or unable to evaluate

Health effects (Factor)	Geographic extent of the impact	Types of people most impacted	Number of people impacted	Evidence in the literature for a link between the change and health outcome	Likelihood that development scenario will contribute to the prevalence of the health outcome	Intensity of the health impact
POSITIVE IMPACT: Traffic Safety (Motor Vehicles)						
Decreased injury	Local/region	Drivers and passengers	Number of people impacted unknown but approximately 11 fewer collisions annually	•••	•••	••
Decreased premature death				•••	••	•••
NEGATIVE IMPACT: Traffic Safety (Bicyclists and Pedestrians)						
Increased injury	Local/region	Bicyclists and pedestrians in close proximity to truck traffic on Hayden Island	?	•••	••	••
NEGATIVE IMPACT: Community Design						
Increased housing related health conditions	local	Manufactured home park residents, floating home residents	Up to 2,000 Hayden Island residents	•	•••	••
Decreased economic stability				•	•••	•••
Decreased social opportunities				•	••	?

KEY: • low | •• medium | ••• high | ? uncertain or unable to evaluate

Health effects (Factor)	Geographic extent of the impact	Types of people most impacted	Number of people impacted	Evidence in the literature for a link between the change and health outcome	Likelihood that development scenario will contribute to the prevalence of the health outcome	Intensity of the health impact
NEGATIVE IMPACT: Air Quality						
Increased respiratory illness	local	Manufactured home park residents, floating home residents	People who live in the 440 manufactured homes and approximately 150 floating homes	•••	••	••
Increased cardiovascular illness				•••	••	••
Lung cancer				•••	•	•••
Decreased life expectancy				•••	?	•••
NEGATIVE IMPACT: Light Pollution						
Increased sleep disturbance	local	Manufactured home park residents, floating home residents	People who live in the 440 manufactured homes and approximately 150 floating homes	••	••	••
Increased cancer				•	•	•••
Increased obesity and diabetes				•	•	••
Increased depression				•	?	?
NEGATIVE IMPACT: Noise & Vibration						
Increased annoyance	local	Manufactured home park residents, floating home residents	People who live in the 440 manufactured homes and approximately 150 floating homes	••	•••	•
Increased stress				•	••	••
Increased sleep disturbance				•	••	••
Increased mental health problems				•	•	•
Increased hearing loss				•••	?	•••
Increased cardiovascular disease				••	•	?

This report addresses one central question: ***How might annexation of West Hayden Island by the City of Portland and subsequent port development on the site affect human health?*** It is a prospective analysis of changes that might happen on the island, how they could affect residents of the island and the larger region, and whether the potential benefits and harms of these changes will be equitably distributed.

Purpose

There are three main goals for conducting this analysis:

1. to respond to stakeholder concerns
2. to build on the information already gathered during the West Hayden Island planning process
3. to aid the City of Portland in integrating health considerations into its planning processes

The multi-year West Hayden Island planning process has identified a variety of stakeholder concerns, including many questions about the potential health impacts of development on Hayden Island. As a result, the Portland Planning and Sustainability Commission directed the Bureau of Planning and Sustainability (BPS) to undertake a health analysis and identify recommendations for addressing the health impacts of potential development on West Hayden Island.

This health analysis is designed to consolidate, organize, and enhance health-related information that has been collected during the planning process and presented in technical reports to date. It aims to integrate local data with the findings of scientific literature, white papers, and information already presented in the following reports:

- Local Impacts of Industrial Development Report (Bureau of Planning and Sustainability, 2010)
- West Hayden Island Public Cost/Benefit Analysis (ECONorthwest, 2012)
- West Hayden Island Economic, Social, Environment and Energy Analysis [ESEE] (Bureau of Planning and Sustainability, 2012a)
- West Hayden Island Concept Plan (WorleyParsons & EcoNomics, 2012)
- West Hayden Island Conceptual Development Air Quality Analysis (Port of Portland, 2012)
- WHI Baseline Noise Study (Daly-Standlee & Associates, 2012)
- West Hayden Island Transportation Modeling Analysis, including supplemental memos on traffic safety and greenhouse gas emissions from the local street network (Portland Bureau of Transportation, 2012)
- Hayden Island Plan (Bureau of Planning and Sustainability, 2009)
- Portland Air Toxics Report (Oregon Department of Environmental Quality, 2012)

For the sake of brevity, the health analysis includes limited description of these reports, Hayden Island, and development proposed for the island. However, the City of Portland provides this information at http://www.portlandoregon.gov/bps/49815.

This health analysis is intended as a tool for the City of Portland and other stakeholders for addressing the health implications of decisions related to the West Hayden Island planning process. Public health and planning practitioners in the United States have increasingly recognized the impacts that community design has on health, and are striving to increase collaboration between the two fields. Integrating health considerations into Portland's planning processes is a critical strategy for achieving the Portland Plan's goals for an educated, healthy, equitable, and prosperous city (City of Portland, 2012).

This analysis builds on previous activities conducted by BPS to integrate health issues into the West Hayden Island project. In particular, BPS intends to integrate the conclusions of this analysis into its Economic, Social, Environmental and Energy Analysis Report (ESEE). BPS staffers consulted with local public health experts about which health issues to address and how to address them.

Both BPS and health experts sought ways to integrate health considerations into the planning process rather than to discuss health as a separate issue. This strategy informed the approach to this analysis. The analysis was conducted by a health analysis team that included staff from BPS, Multnomah County Health Department's Health Assessment and Evaluation unit, Oregon Public Health Institute and Upstream Public Health.

Assessment Topics

This analysis focuses on a set of health assessment factors that were identified by BPS and health experts after reviewing scientific literature, white papers, and documents produced by the West Hayden Island planning process, including summaries of comments from the West Hayden Island advisory group and the public.

This analysis addresses the following factors:

- Air quality
- Noise and vibration
- Light
- Physical activity
- Traffic safety
- Community design and housing
- Employment
- Cumulative and synergistic impacts (see Figure 1 for definition)

Figure 1: Key Public Health Concepts Definitions

Key Public Health Concepts

- **Health determinants:** factors known to affect the health of an individual or a population, including:
    - features of the **social and economic environment** such as income and education
    - features of the **natural and built environment** such as air quality, housing and pedestrian infrastructure
    - a person's **individual characteristics and behaviors** such as genetic make-up and tobacco use
- **Health impact:** an effect on the health status of an individual or population (e.g., a change in the risk or occurrence of disease).
- **Health outcome:** the ultimate effect on an individual or population's health status, either positive or negative (e.g., increased asthma severity, or remission of cancer).
- **Synergistic impacts:** the results of the interaction of multiple determinants, which when combined may magnify or dampen each other's effects.
- **Cumulative impacts:** the sum total of the effects of all determinants.
- **Health equity:** the balanced distribution of health harms, health benefits and health resources (including disease outcomes and access to health care) among population groups.
- **Health inequity:** disproportionate distribution of health harms, benefits and resources among population groups as a result of changeable social factors such as income inequality, differences in educational quality, differences in natural and built environmental conditions, differences in individual health behavior choices driven by factors beyond the individual's control, and unequal access to health care. Health equity is improved as these disparities are narrowed or eliminated.
- **Stakeholders:** Individuals or organizations who are affected by the policy, plan, or project under consideration; have an interest in the health impacts of a decision; and/or have direct or indirect influence on decision-making and implementation.
- **Gray literature:** reports that are not published commercially (e.g., in published journals), but are important because they provide original, current information. Examples of gray literature include technical reports from government agencies and working papers from research groups or committees.

Assumptions of the Analysis

Development Scenario

In general, this analysis addresses one specific scenario for development on the island, guided by the Portland City Council Resolution 36805. The parameters for this scenario were established by the West Hayden Island Concept Plan (Worley Parsons, 2012) and the West Hayden Island Proposed Draft (Bureau of Planning and Sustainability, 2012b). This report assesses how health impacts might change given the proposals in these reports, which we refer to as *the development scenario*.

The scenario for the 800 acres of West Hayden Island includes:

- Retaining at least 500 acres of open space with approximately 2.3 miles of trails, a beach trail along the north side of the island, a non-motorized boat launch and a small parking area.
- Up to 300 acres of deep water marine terminal development inside a rail loop. The terminal consists of three facilities - two bulk export facilities and one auto import/export facility with some associated manufacturing. If a different terminal configuration was analyzed, it is noted.
- Replacing the road and adding bicycle and pedestrian infrastructure on North Hayden Island Drive
- For the purposes of the City's transportation modeling analysis, the state transportation planning rule requires that a high impact scenario be evaluated to look at potential traffic impacts. The high impact scenario assumes two auto facilities with associated manufacturing (which generate more traffic) and a bulk facility with a rail loop. The information presented in the traffic safety section and the green-house gas modeling section use the higher impact scenario.
- The *development scenario* does not include a new bridge from Marine Drive to North Hayden Island Drive on the west side of the island.

Other Assumptions

Hayden Island is expected to undergo additional transitions that could impact the health issues under study. When possible, the following additional impacts were considered:

- Construction of the Columbia River Crossing (CRC) as planned, including freeway, transit and pedestrian/ bike improvements (Federal Highway Administration, Federal Transit Administration, 2011)
- Increased residential development on East Hayden Island, as a result of the adopted Hayden Island Plan
- Initial redevelopment of the Jantzen Beach SuperCenter

Complete redevelopment of the Jantzen Beach SuperCenter, as envisioned in the Hayden Island Plan, will drastically change the layout of the center into a transit oriented development centered on a light rail transit station. This analysis considered the future increased street connectivity in the
mall area.

Depending on the availability of data, not all of these assumptions could be applied to each section of this report. Each section of the report provides additional detail on the underlying assumptions, and the sources of data.

While there are no guarantees about the timing of development on the island, a tentative timeline for changes to occur is as follows:

2013	Initial Jantzen Beach SuperCenter redevelopment completion
2014	Salpare Bay construction completion (375 homes), Lottery Row demolition in preparation for Columbia River Crossing (CRC)
2014-2020	CRC bridge construction, and associated local street improvements near on/off ramps
2019	Light rail service begins (part of CRC project)
2022-2030	Transit-oriented development at rail station
2023-2026	WHI port construction
2026-2028	WHI port operations begin

Health Analysis versus "Health Impact Assessment"

Many of the stakeholders' conversations about potential health consequences of changes to West Hayden Island have included discussion of a Health Impact Assessment (HIA). Through participating in these conversations, we have learned that the term "health impact assessment" is interpreted many different ways. We do not consider this analysis an HIA. However, the analysis employed some of the same strategies of HIA and was informed by the values of HIA (see Table 1).

For public health researchers and other professionals, Health Impact Assessment (HIA) is a specific technical term. HIA is "a systematic process that uses an array of data sources and analytic methods, and considers input from stakeholders to determine the potential effects of a proposed policy, plan, program, or project on the health of a population and the distribution of those effects within the population" (Committee on Health Impact Assessment; National Research Council, 2011). From a public health perspective, there are many ways to assess health; HIA is just one of them.

In order to effectively use resources and add value to the decision-making process, we selected an analytical approach that incorporates assessment strategies from HIA methods, but does not include all of the other stages of HIA. Our intent was to avoid duplication of public processes that have already occurred or are underway as part of West Hayden Island planning.

Table 2: HIA practice and West Hayden Island analysis approach

Elements of HIA practice	West Hayden Island health analysis	
	SIMILARITIES	DIFFERENCES
1. Initiated to inform a decision-making process	intended to inform annexation decision	
2. Utilizes a systematic analytic process	analysis team developed research strategy	
2.1 Comprehensively scopes of health determinants and impacts	scope includes "upstream" or social determinants of health in addition to proximal physical determinants (e.g., noise, air quality)	project scope was determined by staff consultation rather than extensive scoping process
2.2 Solicits & utilizes stakeholder input	utilizes input collected by BPS	does not solicit new input
2.3 Establishes baseline health conditions and describes affected populations	discusses potential disproportionate impacts among populations	does not include extensive assessment of baseline conditions
2.4 Uses best evidence to predict potential impacts	integrates multiple data sources, including local air quality and traffic modeling	limited discussion of direction, magnitude, likelihood, distribution & permanence of potential impacts
2.5 Bases conclusions on transparent, context-specific synthesis of evidence	describes research and analysis process	
3. Identifies appropriate recommendations, mitigations	identifies mitigation strategies that have been used in other settings	final recommendations and mitigations will be determined by other stakeholders
4. Proposes monitoring plan to track decision's impacts		does not propose monitoring or evaluation plan
5. Provides a publicly-accessible document	document will be available on BPS website	

We believe this approach is efficient, and also powerful. While HIA is a relatively new tool that produces a non-binding document, this health analysis can be integrated into the well-established ESEE process that is a central part of land-use planning in Oregon.

For readers who are interested in the details of HIA or how this analysis differs from an HIA, Table 1 compares the methods we employed to Minimum Elements and Practice Standards for Health Impact Assessment (North American HIA Practice Standards Working Group, 2010).

A full HIA may be a very valuable tool in the event that the City of Portland does annex the western half of the island and port development proceeds. Because of the many positive and negative health impacts of such large-scale change on the island, health issues should be considered in conjunction with specific development proposals that arise in the future. An HIA of a more specific development proposal will allow for more robust assessment than is currently possible, given the uncertainties around development components and timelines. Furthermore, such an HIA would allow for collaboration among a wide range of the many stakeholders participating in urban development (e.g., government agencies, private developers, and local residents).

This analysis did not involve "primary" data collection (e.g., gathering new information). Instead, it applied knowledge gathered by other researchers to estimate the possible impacts of development on West Hayden Island. Much of the analysis relies on review of scientific and policy research. We focused on scholarly scientific literature (that is, research reports subject to stringent scientific review before publication), but considered other sources as needed or available. For example, we incorporated noise data collected on Hayden Island by a consultant, as well as important air pollution data provided by the Port of Portland and the Oregon Department of Environmental Quality (DEQ). These specific data sources are discussed in more detail in sections below.

Approach to Analysis

We generally took a similar approach to analyzing each health assessment factor (e.g., air quality, noise and vibration, etc.). We provide a more detailed description of any unique analytic strategies used for each factor. Our analytic approach involved discussing answers to the following three questions.

What are the health issues?

To answer this question, the health analysis team reviewed the findings of research about relationships between the health assessment factor (e.g., noise) and health outcomes (e.g., hearing loss). This analysis looked at a wide variety of health determinants (see SIDEBAR: key public health concepts), including social determinants of health such as livelihood and education. Both positive and negative health outcomes were explored. Discussions of this question may also include findings from research that suggests how different groups of people may experience differences in certain health determinants and/or outcomes.

How will the development scenario affect them?

To answer this question, we discuss how the health issues evaluated in the scientific literature might apply to the population of Hayden Island, and surrounding area as appropriate. In addition, we identify subpopulations that may experience disproportionate benefits or burdens from the changes proposed for the island. We also describe any unique strategies used to make these judgments, including the application of locally collected data. Where known, or applicable, other future assumptions that can affect health issues have been incorporated into the analysis, but are distinguished from affects specific to the West Hayden Island Development Scenario.

What don't we know?

We identify the limitations of our analysis and when possible, describe the information that would be necessary to produce a more thorough analysis.

To summarize the health impacts of the development scenario, the health team considered the following for each factor and the related health outcomes:

1. scale of the impact (i.e., local or regional)
2. populations most impacted
3. number of people impacted
4. evidence for the link to health outcomes
5. likelihood that the development scenario will lead to the health outcome
6. intensity of the health impact

A low, medium, and high scale was used to describe the likelihood that the development scenario will lead to the health outcome, the evidence for the link to health outcomes, and the intensity of the health impact. In some instances we were unable to evaluate the health impact due to lack of information or uncertainty.

Scale of the impact

The scale of the impact refers to the geographic extent of the health impact. In general, *local* refers to impacts that will be experienced on Hayden Island. ***Regional*** refers to impacts that will be experienced throughout the general Portland Metropolitan Area.

Populations most impacted

We identify groups of people who are likely to experience a greater benefit or burden from the health determinant or outcome listed. These differential impacts could be due to physiological, social, or geographic characteristics that affect their exposure and/or vulnerability to a condition (e.g., people of a certain age, having a particular health condition, living in a certain type of housing).

Number of people impacted

When possible, we attempt to estimate the number of people who may be impacted, positively or negatively.

Evidence in the literature for the link between the change and the health outcome

This is a rating of the degree of confidence in the connection between an environmental change and a human health outcome. The rating is based on information documented in scientific literature.

Likelihood that the development scenario will lead to the health outcome

Likelihood is a judgment about how likely it is that the development scenario will lead to the specified health impact due to change on the island. The judgment is based on descriptions produced during the West Hayden Island planning process.

Intensity of the health impact

Low-intensity outcomes are ***minor*** health problems that may contribute to poor health over time in affected people.

Medium intensity outcomes are ***moderate*** health problems that result in annoyance, minor injury or risk of illness to affected people.

High-intensity outcomes are ***severe*** health problems that result in moderate or severe injury, harm, or illness to affected people.

Current Conditions

Demographics

In the 2010 Census, Hayden Island had a population of 2,270 (U.S. Census Bureau, 2012a). Approximately 200 youth under the age of 20 years live on the island, and many of the youngest are bussed to Faubion Elementary School in Northeast Portland. According to Metro's forecasting models (Sonny Conder, n.d.), there will be approximately 2,681 households on the island in 2035. Assuming 1.5 persons per household, the total population is expected to be approximately 4,022 people in 2035.

Compared to the rest of the metropolitan Portland area, Hayden Island's population is older and slightly poorer. The median age of residents in 2010 was 54.3 years, which was 17 years older than the Portland Metro area median. The average annual median family income for Hayden Island is $46,143, which is well below $56,275 for the Portland metro area. The poverty rate for Hayden Island is 17.5%, which is slightly higher than the rate for the Portland metropolitan area (U.S. Census Bureau, n.d.-a). Given the older population and relatively lower income level compared to the region, we can surmise that many island residents may live on a fixed income.

The community located closest to the West Hayden Island potential development site is a 440-household manufactured home community. Because the manufactured home community is only a portion of the census track that covers all of Hayden Island, there is not detailed demographic information available describing this particular community. However, in 2008, CASA of Oregon, a non-profit community development corporation, conducted an affordable housing survey and collected some information about the community. The average annual household income of the 19 residents who responded was $31,200. This amount is only 13 % above HUD's very low income limit of $27,150 and 28% below the low income limit of $43,450 for a 2-person household in the Portland-Vancouver-Beaverton area for 2008. The HUD income limits are important as these are used to determine eligibility for applicants.

Also, 54% of household residents were age 55 or older and 65% said they were on a fixed income. The average home value within the manufactured home community is $13,900, making the homes much more affordable than the rest of Hayden Island. These findings should be interpreted with caution as only 4% of the manufactured home community residents responded to the survey. However, when these data are considered along with anecdotal information, we can guess that relative to the Hayden Island census tract as a whole, the manufactured home community is likely to have a higher percentage of seniors, persons on fixed incomes, and persons with pre-existing medical conditions. This community may be especially vulnerable to the impacts described in this report.

Hayden Island adults who work tend to work in professional jobs, with 70.4% of workers in white-collar positions (ESRI Business Analyst using 2010 Census data, n.d.). Unemployment is relatively low at 8.5%. This statistic may be low because of the number of retirees on the island In contrast, nearby North Portland's unemployment rate is above 10% and has been chronically high for decades.

Many of the adults on the island are high school graduates without a college degree. Compared to the metropolitan area, Hayden Island has a higher percentage of high school graduates (93.6% vs. 90.4%), but a lower percentage of college graduates (20.6% vs. 33.4%) (ESRI Business Analyst using 2010 Census data, n.d.; U.S. Census Bureau, n.d.-a).

The majority of Island residents are Non-Hispanic White and there are very few Black, Asian, or Native American residents (U.S. Census Bureau, n.d.-b) However, like the rest of the Portland metropolitan area, Hayden Island has grown more ethnically diverse in recent years. Notably, the Hispanic population nearly tripled between 2000 and 2010, and now comprises about 7% of Hayden Island's population (U.S. Census Bureau, n.d.-b, n.d.-c).

"Twenty-minute neighborhood" analysis

The City of Portland uses the term "twenty-minute neighborhood" to describe a health-supporting residential environment where residents can access basic goods and services within walking distance of their homes. The City's 2012 assessment of these characteristics for Hayden Island-Bridgeton (HI-Bridgeton) showed that the area lacks essential resources such as a hospital, community center, and public school (City of Portland Bureau of Planning and Sustainability, 2012).

Eating healthy foods may be challenging for island residents as there is only one full-service grocery store on the island (and the land it occupies is slated to be taken by the Columbia River Crossing project). Currently, only 7% of Hayden Island-Bridgeton residents live near a full-service grocery store, and there is no farmers' market. Very few residences are near frequent transit service. Though there is a large amount of commercial space on the island in Jantzen Beach SuperCenter, it is not easy to access on foot or by bicycle.

Health indicators

It is difficult to obtain data that describe health conditions at small geographic scales, such as Hayden Island. For the purposes of this assessment, we estimated the number of people on Hayden Island that currently may be affected by certain health conditions or behaviors. We based these estimates on the Multnomah County results from the Behavioral Risk Factor Surveillance System (BRFSS) national survey. Limitations of the BRFSS data are that results are only available at the county level, and are based on self-report by the survey respondent rather than actual measurements or a review of medical records. Table 2 presents rates of health problems among adults in Multnomah County as a whole, and applies them to the adult population of Hayden Island. The table provides a rough sense of how many individuals on the island might be affected by these problems.

Table 3: Estimated prevalence of selected health conditions, Hayden Island residents age 18 and over

	Multnomah County adults reporting the condition (Centers for Disease Control and Prevention, 2010; Health Statistics, Oregon DHS, 2012)	x **2,066 residents in 2010** (U.S. Census Bureau, 2012a) =	**Estimated Island residents with condition**
fair or poor health, 2010	15%		310
asthma, 2006-2009	9%		186
current smoking, 2010	11%		227
obesity, 2010	26%		537
angina, 2006-2009	3%		62
diabetes, 2010	7%		145
high blood pressure, 2006-2009	23%		475

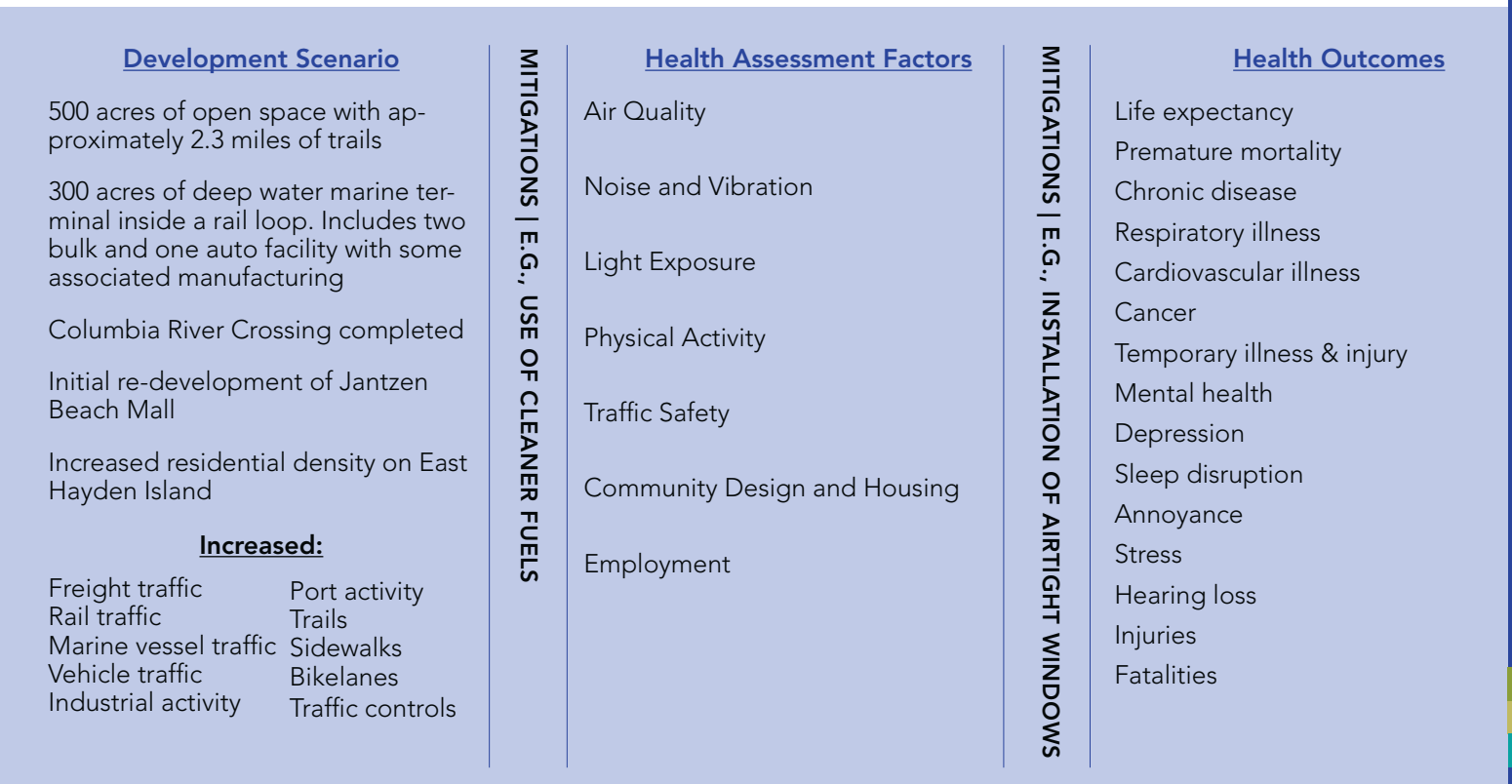
It is virtually impossible to predict how many island residents will be affected by these conditions in 2035, given all the factors that may change in the interim – e.g., underlying disease trends, risk factors for diseases, prevention efforts, medical technology, island demographics, etc.

This section discusses the potential impact of the development scenario on seven health factors, as represented in Figure 2. Each individual assessment section provides an overview of a few health outcomes that are related to each health determinant or factor under assessment (e.g., air pollution). This is not an exhaustive discussion of all potential outcomes and relationships, but rather a brief presentation of the relationships that seem strongest from the research literature, or of the most concern to community members, other stakeholders, and public health professionals.

For each of the health factors, we discuss health outcomes related to the factor and describe how the development scenario, or other assumed changes to the environment, could affect the outcomes. We present any special methods used to assess potential changes in health outcomes related to the development scenario. We also describe the distribution of the positive and negative health outcomes among different population groups. Each assessment section concludes with a discussion of any limitations of the analysis of this particular factor, or what we do not know about the relationships between the health factors and health outcomes.

The final assessment factor is cumulative and synergistic effects. This section describes how different health factors may operate in concert with each other (e.g., magnifying or interfering with each other) or in an additive manner. The Conclusions section includes a table and description of the positive and negative impacts of all of the seven factors or determinants in sum total.

Figure 2: Schematic illustration of the relationship between the development scenario, health assessment factors, and key health outcomes



Air Quality

Geographic extent of impacts: Local – approximately a half-mile to three miles from the development site

Populations most impacted: Hayden Island manufactured home park and floating home residents

There is sufficient evidence to reasonably expect increases in local and regional air pollution related to the development scenario. Analyses of air quality tend to categorize pollutants in two categories: federally-regulated criteria pollutants and less-regulated air toxics. The development scenario is likely to result in substantial increases in both of these categories:

1) The level of nitrogen oxide (ozone), a criteria pollutant, may increase under the development scenario, requiring additional evaluation, but is not expected to exceed federal standards.

2) Levels of air toxics, which currently exceed state benchmarks on Hayden Island, could increase two to threefold (from 20 to 55 times the state benchmark).

The development scenario is expected to have minimal impacts on greenhouse gas emissions.

SUMMARY

Analyses of air quality tend to categorize pollutants into two types: criteria pollutants and air toxics. Both these types of pollutants can impact health directly. A third type of pollution - greenhouse gases (GHGs) - can impact health indirectly through the effects of climate change on the environment.

Criteria pollutants are contaminants that fall under federal air quality ambient concentration standards. There are six criteria pollutants:

- particulate matter (PM_{10} and $PM_{2.5}$)
- ground-level ozone (smog)
- carbon monoxide
- sulfur oxides
- nitrogen oxides
- lead

The Portland airshed currently meets all existing federal standards for criteria pollutants.

Air toxics are contaminants that do not have a federal ambient concentration standard limiting their emission. Air toxics include:

- diesel particulate matter (DPM)
- benzene
- polycyclic aromatic hydrocarbons (15 PAH)
- metals including manganese, nickel and lead

The State of Oregon has adopted ambient air benchmark concentrations – or health-based goals – for more than fifty air toxics. Benchmark concentrations are intended to decrease

adverse health consequences of air pollution by reducing air toxics to levels that an individual (including a sensitive individual) could breathe for a lifetime without increasing their cancer risk by 1 in a million or experiencing non-cancer health effects. Some air toxic levels in Portland exceed Oregon's benchmarks, and are projected to continue exceeding them for at least the next five years.

Greenhouse gases are a combination of pollutants, including two criteria pollutant that contribute to global warming. The primary greenhouse gases are carbon dioxide, methane, nitrous oxide and fluorinated gases. Changes to the environment that result from global warming will likely impact health (e.g., through flooding, heat injury, injuries from severe weather, and changes in infectious disease patterns).

The following analysis will examine possible effects of both criteria pollutants and air toxics potentially resulting from the development scenario. The primary sources of air pollutants considered in this analysis result from:

- port operations – exhaust from ships, cranes, forklifts, etc.
- port-related transportation – emissions from the various trucks, trains, and barges serving the port

Though we expect there will likely be health impacts resulting from port construction, we do not have enough information (e.g., number and types of construction equipment, location of staging areas, and timeframes for construction) to assess construction-related air pollution levels and their impacts.

Port-related air pollution considerations

Port operations create somewhat distinctive air pollution concerns related to the sources and characteristics of port-generated emissions.

Marine vessels burn residual fuel oil and affect PM2.5 levels in the Pacific Northwest (Kotcheruther 2012). A recent study modeling marine vessel emissions in the Pacific Northwest indicates that marine vessels can contribute up to 30% of monthly average PM 2.5 in urban areas and up to 50% of monthly average PM2.5 in rural/remote areas (Kotcheruther 2012).

Fortunately, marine vessel emissions are expected to drop in the near future. As of August 2012, the International Maritime Organization (IMO) agreed to include North America in an Emissions Control Area where emissions from sulfur and nitrogen oxides must be controlled within 200 nautical miles of the coast (Kotcheruther 2012). Fuel sulfur content is expected to drop to 1% in 2012 and 0.1% in 2015 (Kotcheruther 2012).

Emissions from rail operations are also an issue, with diesel particulate matter and PAH-15 being the most concerning rail emissions. The California Air Resources Board (CARB, 2012) has noted that in rail yard facilities, locomotives are typically the largest source of diesel PM emissions. Diesel-fueled trucks and other vehicles are the second largest sources (CARB, 2000). The DEQ PATS study (described more below) examined emissions from source categories, including rail activities. For rail, total estimated emissions in 2017 are predicted to be 2-10 times benchmark, and concentrated within

approximately one mile of rail corridors[2] (DEQ PATS report, Rail Summary Paper, figure 94).

Rail yard idling is the most concentrated source of rail emissions in the PATS area. California and Washington have conducted numerous studies to look at the increased risk of cancer in relation to the distance people live from a rail yard. CARB created land use guidelines that include "Avoid siting new sensitive land uses within 1000 feet of a service or maintenance yard." The CARB guidelines also state that: "Within one mile of a rail yard, consider possible siting limitations and mitigation approaches." (CARB, 2005).

These findings are relevant to West Hayden Island development in that the development scenario currently shows:

- Some floating home residents live about 0.4 miles from the outer edge of the proposed rail loop
- A majority of the homes in the manufactured home community and several floating homes on the Oregon Slough are within 1 mile of the proposed rail loop or the railroad mainline that traverses the island.

What are the health issues?

Health risks from air pollution depend on the type of air pollutants and their concentration and distribution in the environment, as well as on characteristics related to the people exposed. Intensity and duration of exposure, age, overall health status, and pre-existing health conditions are especially important. People most susceptible to severe health problems from air pollution include individuals with existing heart or lung problems, the elderly, pregnant women, children, and people who work outside. (HHS Report). An overview of adverse health impacts due to both criteria pollutants and air toxics is presented in Figure 2.

Respiratory disease

Criteria pollutants including total suspended particulate matter, fine particulate matter, sulfur dioxide, ozone, and nitrogen dioxide exacerbate and contribute to respiratory illness (2007 Oregon AQ data summaries DEQ). Particulate matter (PM) from motor exhaust is especially of concern. Fine particles less than 10 or 2.5 micrometers in diameter (PM_{10} and $PM_{2.5}$), stay suspended in the air for long periods of time and can be inhaled deeply into the lungs. Particulate matter exposure contributes to, and exacerbates, respiratory problems including asthma (Brook et al., 2010; Pandya, Solomon, Kinner, & Balmes, 2002; United States Environmental Protection Agency, 2009).

Air toxics such as polycyclic aromatic hydrocarbons (PAHs) and formaldehyde, are also linked to respiratory illness, including asthma (Delfino, 2002; 2007 Oregon AQ data summaries DEQ). The highest risk air toxics associated with on- and off-road gasoline and diesel emissions include diesel particulate matter, 15 PAH, benzene, 1,3-Butadiene, arsenic and chromium.[3] Other exhaust-related compounds related to respiratory illness include sulfur dioxide, ozone, and nitrogen dioxide (DEQ 2007)

2 *Ibid. Figure 94*

3 *Oregon Department of Environmental Quality, "Portland Air Toxics Solutions Committee Report and Recommendations", Section 7.4, April 2012.*

Figure 3: Schematic illustration of air quality-related health outcomes

The Health Effects Institute reviewed recent literature and found that exposure to traffic-related air pollution exacerbates asthma, and also found evidence suggesting a strong causal role for air pollution in childhood asthma (HEI Panel on Health Effects of Traffic-Related Air Pollution, 2010). These researchers also identified an exposure zone within 300 to 500 meters (1/5 to 1/3 of a mile) from a major road (e.g., an interstate highway) as being most highly affected by traffic emissions. The range, from300 to 500 meters, reflects the variable influence of background pollution concentrations, season, and meteorological conditions (HEI Panel on Health Effects of Traffic-Related Air Pollution, 2010).

Cardiovascular disease

Criteria pollutants including fine particulate matter, carbon monoxide, and ozone contribute to cardiovascular disease and its symptoms such as chest pain (2007 Oregon AQ summaries DEQ). Reviews and recent studies reveal that $PM_{2.5}$ exposure causes cardiovascular dysfunction and related mortality and reduces life expectancy (Brook et al., 2010; Pope III et al., 2002; Pope III, Ezzati, & Dockery, 2009; United States Environmental Protection Agency, 2009, HEI Panel on Health Effects of Traffic-Related Air Pollution, 2010). Air toxics including 1,3-Butadiene and diesel particulate matter contribute to cardiovascular disease and death (2007 Oregon AQ data summaries DEQ). Reviews of research on ambient air pollution and health show associations between cardiovascular disease and pollution (as well as cancer) (Brook et al., 2010; Katsouyanni & Pershagen, 1997).

Cancers

Particulate matter is associated with different types of cancer (Pope III et al., 2002; United States Environmental Protection Agency, 2009). Air toxics such as cadmium, formaldehyde, and diesel particulate matter contribute to lung and nasal cancer (2007 Oregon AQ data summaries DEQ). Studies on urban air pollution suggest ambient air pollutants are a risk factor for lung cancer with the estimated risk of cancer for people exposed to significant levels of pollution being up to 1.5 times that for people who are not exposed (Delfino).

Premature mortality

The World Health Organization has found that long term exposure to ambient PM concentrations (a criteria pollutant) leads to a reduction in life expectancy from cardio-pulmonary and lung cancer mortality. It also appears that there is no safe level of PM exposure , or a level at which there is no effect on health (World Health Organization, 2003). Air toxics are associated with cardiovascular disease and cancer which also contribute to risk of premature death (2007 Oregon AQ data summaries DEQ).

Adverse health conditions related to climate change

Some air pollutants are also greenhouse gases, which contribute to global climate change and consequent health conditions. These include heat-related illness, infectious diseases spread by rodents, insects, water and food, and injuries and deaths related to severe weather events (American Public Health Association, 2011; McMichael, Woodruff, & Hales, 2006; Pachauri, Reisinger, & Intergovernmental Panel on Climate Change., 2008).

How will the development scenario affect them?

Method used to estimate impacts

This analysis used three studies as the basis for estimating the impacts and health outcomes of air pollution:

- Study 1 - DEQ's Portland Air Toxics Solutions (PATS) 2017 Modeling Summary
- Study 2 - The Port of Portland's Emissions Inventory Data from 2008
- Study 3 - The Portland Bureau of Transportation's Transportation Modeling Analysis for 2035

Results of these studies were used to estimate changes in air toxics, criteria pollutants, and greenhouse gases that would be produced under the development scenario. Scientific literature on air pollutants and health outcomes was used to estimate the potential for health outcomes of pollution levels predicted by Studies 1 and 2.

It is important to note that Studies 1, 2, and 3 derive data from different sources, which examine different combinations of pollutants, which are measured at different geographic scales, by different measurement units, for different time periods. Because of these differences, it is difficult to fully-align this data with the assumptions described in the Introduction section. In particular, the Transportation Modeling Analysis assumed the CRC and future transportation infrastructure, while the other studies in this section did not. As a result, we are unable to draw conclusions about the cumulative health impacts of exposure to the pollutants examined in the three studies However, they are the only local air quality data sets currently available and each study contributes to our overall understanding of potential air quality impacts.

Study 1: Portland Air Toxics Solutions (PATS) (air toxics)

The PATS project used an established method of air quality modeling to predict future year 2017 concentrations of 19 air toxics. The project

includes use of air toxics ambient benchmark concentrations adopted as clean air goals by the Oregon Department of Environmental Quality. For non-carcinogenic pollutants, the benchmarks are the annual contaminant air concentrations below which an individual would not experience adverse effects. For carcinogens, the benchmarks are the annual concentrations below which an individual would experience an increase in lifetime cancer of less than one in a million. In other words, if the benchmark concentration is exceeded for carcinogens, one excess cancer case would be expected to develop per 1,000,000 people with daily exposure over a lifetime. It is important to note that an individual's cancer risk will be influenced by a variety of factors; air toxics exposure is only one factor.

PATS model projections/estimates are based on the most current and detailed emissions information from industrial, mobile, and residential activities. The model factors in topography and weather patterns, as well as changes in economic conditions, population growth, and new regulatory requirements.

In the Portland-Vancouver area, the PATS model estimated air toxics concentrations and risk at 2,386 discrete receptors. The receptors, which can be thought of as virtual air quality monitors, were located at Census block group centroids and other locations in the PATS regional study area. In general, the PATS modeling predicted that impacts on air quality are relatively localized, with greatest impacts occurring about a half-mile to 3 miles from identified emission sources.

Portions of Clark County are included in the PATS model because they are a part of the larger airshed. Emissions estimates in Clark County including the Port of Vancouver along the river were developed by the Southwest Clean Air Agency and DEQ. A uniform growth factor was applied in the PATS model to projected emissions region-wide; however, specific port developments, such as the new Terminal 5 in Vancouver have not been modeled.

The best local surrogates for estimating future air quality at West Hayden Island (WHI) under the development scenario are Terminal 4 and 5 with their associated bulk loading and auto loading/unloading operations. Terminal 4 has one auto facility with an associated manufacturing facility and two small bulk facilities. Terminal 5 has two bulk facilities and a rail loop. Both terminals occupy a much larger geographic acreage than proposed on West Hayden Island. It is assumed the new terminal will be more efficient and thus be able to handle a higher volume of activity in a smaller physical space than the existing Terminal 4 or 5. Emissions from actual development could differ. In the PATS study, risk data were predicted for areas near both of these terminals. Of the 2,386 receptors in PATS, two were near Terminal 4 and one was adjacent to Terminal 5. In addition, there were three receptors covering West Hayden Island.

The approach in the analysis presented here was to look at the PATS modeled risk data at the three receptors near Terminals 4 and 5 resulting from emissions attributed to terminal operations only. This involved looking at the previously

modeled risk data by source category; no new modeling work was done.

Of the many source categories or emissions used in PATS, four are associated with terminal activity:

- Onroad mobile (trucks and cars
- Marine (including tug operation)
- Rail
- Non-road mobile (including support equipment like forklifts, and other ancillary gas or diesel powered devices)
- Because we do not know the actual volume of activity at the future deep marine terminal proposed for West Hayden Island, we examined similar port activity (e.g. on-road mobile, rail, marine, non-road) at Terminal 4 and Terminal 5. The average risks by source category for the two terminal operations are:
- Onroad Mobile 11%
- Rail 11%
- Marine 33%
- Non-road Mobile 27%.

There are marine emissions contributed from other sources not associated with port activities that may be captured at these receptors, making the marine percentage (33%) higher than just the port contribution. Some other emissions may also be higher than modeled (i.e,. railroad and on road emissions), due to the area over which they are modeled.

To approximate the likely future terminal activity, we averaged the existing activity for facilities at Terminal 4 and 5. We then multiplied this average by 1 to 1.5, and then 2 to 3 to approximate a range of likely future emissions from terminal activity. This is probably a conservative estimate because the modeled receptors don't take into account specific emissions from rail and on-road activity from the future port facilities. We also do not know what type of bulk processing will be in place. The potential range would then be between 32 times and 55 times above benchmark at West Hayden Island.

Table 4 illustrates existing conditions and a range of possible future emissions based on low end development to full build out of the development scenario.

It is important to keep in mind that the emissions data used in PATS is an approximation of actual conditions. As a result, modeled risk from PATS can be useful, but should be interpreted in a relative, general way. More detailed modeling of actual estimated emissions from the development scenario should be performed to estimate future risk levels on West Hayden Island. The results from this more refined modeling could be higher or lower than the initial screening levels using the Terminal 4/5 surrogate as presented here.

In summary, the above calculations suggest that air toxics are expected to increase markedly under the development scenario. The current air quality risk for West Hayden Island is 20 times above benchmark concentrations, or if all risk is from carcinogens, 20 excess cancer cases could be expected to develop in a population of 1,000,000 people with daily exposure over a lifetime.

Table 4: 2017 PATS modeled air toxics concentrations for Hayden Island

	Baseline or Existing Conditions				Development Scenario Conditions Range of Possible Emissions (Future facilities at one terminal: one auto facility with post processing manufacturing and two bulk facilities and a rail loop)	
	Hayden Island PATS modeling receptors (#531, #1386, #1424) *Times above benchmark*		**Terminal 4 at PATS receptors (#446, #1462)** (Facilities: one auto, two small bulk)	**Terminal 5 at PATS receptor (#1387)** (Facilities: two bulk)	**Average of Port facility activity at T4 and T5 added to existing WHI (lower end x 1 to 1.5)** WHI 20 + (12 to 18)	**Average of Port facility activity at T4 and T5 added to existing WHI (higher end x 2 to 3)** WHI 20 + (24 to 35)
Air Toxics	West	East	*Times above benchmark*	*Times above benchmark*	*Times above benchmark*	*Times above benchmark*
Terminal Activity Risk			**13**	**11**	**12-18**	**24-35**
Cumulative Risk (all sources)	**20**	**43**	**48**	**24**	**32-38**	**44-55**
Emission sources	Off road: 39% On road: 15% Wood burning: 27% Area: 14% Industry: 5%	Off road: 50% On road: 23% Wood burning: 11% Area: 14% Industry: 1%	Terminal Activity Only: On-road mobile: 29% Rail: 11% Marine: 33% Non-road mobile: 27%			

Off-road sources: diesel construction equipment, lawn/garden equipment, aircraft, marine, and rail.

On-road sources: gasoline and diesel cars, trucks, buses, and motorcycles.

Wood burning: residential wood combustion.

Area sources: non-permitted fuel use (heating, broilers, etc), asphalt paving, solvents, etc.

Industry: gas stations, metals facilities, wood and glass manufacturing, etc.

The estimates calculated above suggest that by adding one to three new facilities and a rail loop to West Hayden Island, we could expect at the high end, an increase in as many as 55 excess cancer cases in a similarly exposed population of 1,000,000 if all risk was from carcinogens. In other words, the development scenario could increase the excess risk from air toxics on West Hayden Island by two to close to three times. We would also expect the development scenario to result in a higher risk in residential areas adjacent to the project on East Hayden Island.

Studies 2a and 2b: Port Emissions Inventory (criteria pollutants)

Study 2a: Regulatory Compliance. The Port of Portland's emissions inventory consists of data collected through tracking criteria pollutant emissions from mobile sources (ships, harbor craft, trucks, trains and other vehicles) as well as off-road equipment (such as fixed cranes). The port is required to report on these emissions. These data were used to estimate levels of criteria pollutants that could be produced under the development scenario. To approximate increases in criteria pollutants to the region, estimates from the Port of Portland 2008 emissions inventory data for Terminal 4 and Terminal 5 were used. In combination, these two terminals house facilities similar to those proposed under the West Hayden Island development scenario.

As shown in Table 5, the development scenario emissions of criteria pollutants would contribute about 1.4% or less of the Multnomah County emissions totals. Due to continuing emission reduction regulations for diesel engines and cleaner burning fuels, freight emissions associated with a new terminal are expected to be lower than for the same freight modes in 2008. Estimated increases in ozone (NOx and VOC) are consistent with the current ozone maintenance plan for Portland. Emissions from new stationary industrial facilities would be subject to air quality permitting requirements. An anticipated revision to the federal

Table 5: 2008 Terminal 4 and 5 emissions inventory comparison to thresholds

Emissions Inventory (within airshed) **Development scenario conditions** Tons per year		**% of Multnomah County Total**	
Ozone (NOx)	444	1.375%	Meets
Ozone (VOC)	24	0.031%	Meets
Carbon Monoxide (CO)	65	0.025%	Meets
PM10	19	0.091%	Meets

**Provided by Port of Portland, WHI Conceptual Development Air Quality Analysis*
(Note: the 2008 inventory predates a number of regulatory and voluntary measures to reduce emissions.)

ozone standard in 2014, if more protective, could result in additional regulation of VOCs and NOx in the future.

Study 2.b: Health Impacts Perspective - Port operations activities have the potential to generate emissions of criteria pollutants. Combustion emissions associated with mobile sources such as ozone, carbon monoxide, and particulate matter (including diesel particulate matter) are generally the primary concern for health impacts (Breen, Port of Portland, 2012).

Table 6 shows the general categories of mobile sources from the Port's 2008 Emissions Inventory (i.e., column headings) and the actual numbers of vessels visiting the Terminal 4 and 5 facilities during calendar year 2008. The number of trucks, trains, and tugs is based on surveys adjusted for 2008 cargo volumes. It is important to note that 2008 was a period of diminished port activity due to the recession. As shown in the table, auto facilities are associated with higher truck traffic and bulk facilities with heavy tug boat and train traffic. We expect that the West Hayden Island development scenario terminals would draw numbers of marine vessels, tug boats, trucks and trains similar to those of Terminal 4 and Terminal 5 combined. However any increases in activity or traffic will depend on a variety of factors (e.g., type of bulk product, demand for that product).

Study 3: Traffic-Related Pollution Methodology (vehicle miles traveled, greenhouse gas emissions)

The Portland Bureau of Transportation has an interagency agreement with the Portland Bureau of Planning and Sustainability to provide transportation modeling and analysis services for the West Hayden Island Plan. The Transportation Modeling Analysis is based on existing conditions (as of 2005) and predicts future (2035) conditions of traffic-related pollutants for West Hayden Island and the larger study area. The analysis assumes a high impact or worst case traffic scenario generated by two auto terminals and one bulk terminal in 2035 -- both with, and without a new West Hayden Island Bridge for a 300-acre port terminal development (PBOT transportation analysis memo).

It is important to note that the PBOT analysis assumes a different port scenario than the development scenario. PBOT's Study 3 is based on two auto terminals and one bulk terminal, while the development scenario calls for one

Table 6: 2008 Port of Portland Terminal 4 and 5 mobile sources

	Facilities	**Marine vessels**	**Tug boats**	**Tug boats to/from Bonneville Dam**	**Trains** (in and outbound)	**Heavy Trucks** (trips)
Terminal 4	1 auto	126	304	0	412	15,458
Terminal 5	2 bulk	233	437	630	1,262	1,424

auto terminal and two bulk terminals. The purposes of using a higher impact scenario than the development scenario were to: 1) maintain consistency with previous traffic studies conducted for the Columbia River Crossing (CRC), and 2) take into account assumptions included in the Regional Transportation Plan (RTP); this was necessary for determining compliance with the State Transportation Planning Rule.

The PBOT study assumes, as part of its future base condition, the completion of the CRC, the Hayden Island local street network and increased residential development as envisioned in the Hayden Island Plan.

The data used in the PBOT model include:

- socioeconomic data such as population, employment and land-use
- transportation data such as the street network and transit lines used by autos, trucks and transit

The model compiles data statistically to estimate the relationship between the traffic conditions and traveler's transportation mode and route choices. The Transportation Modeling Analysis assumes air quality improvements based on Portland's 2009 Climate Action Plan and related fleet changes that improve vehicle efficiency.

PBOT estimates an increase of about 2,050 vehicle trips daily on Hayden Island due to the addition of two auto terminals and one bulk terminal (PBOT transportation analysis memo). About one quarter of the trips would be made by dual unit trucks or heavy vehicles that are primarily fueled by diesel which contributes to respiratory and cardiovascular illness, as described above (PBOT transportation modeling analysis memo, 2012).

Port-related traffic is expected to account for 12% of total Hayden Island traffic in 2035. The PBOT study results suggest that residents of the manufactured home community may be more impacted by port-related traffic compared to other island residents. The PBOT model suggests that about 22% of the anticipated traffic in the vicinity of the manufactured home community would be port-generated.

PBOT also examined vehicle miles travelled (VMT) and greenhouse gas emissions (GHG) on Hayden Island with and without the port development scenario. The model considered the two-hour peak traffic afternoon span for all local roads on Hayden Island including the freeway, ramps to the freeway and the Marine Drive interchange. In 2035, VMT is projected to increase both with and without port development. Estimates indicate little variation in VMT between development and non-development scenarios, indicating that regional growth has a much greater impact on future road network demand than does the incremental increase in demand from port development on West Hayden Island.

Based on modeling, GHG emissions are expected to decrease on Hayden Island by 2035, primarily due to the planned I-5 improvements associated with the CRC project. The overall daily increase in GHG emissions on Hayden Island with port development is 35 tons, compared to 30 tons without port development. In summary, PBOT

predicts that developing a port will have minimal impact on VMT or greenhouse gas emissions from the local road network on Hayden Island in 2035, in comparison with overall increases from island growth.

This local GHG analysis did not evaluate the potentially beneficial impacts that a West Hayden Island marine terminal might have on GHG emissions from Columbia River ship traffic or rail system freight movement. Both the City of Portland's Climate Action Plan and the Oregon Freight Plan advocate for rail and marine freight infrastructure investments as a means to reduce overall greenhouse gas emissions (City of Portland, 2009; Oregon Department of Transportation, 2010). In general, movement of freight by rail and ship is considerably less carbon-intensive than truck or air freight (Texas Transport Institute, 2012; Corbett, 2007; Oregon Department of Transportation, 2010; McKinnon, 2004; International Maritime Organization, 2009; Donnelly and Mazières, 1999; European Commission, 1999). Infrastructure investments that facilitate mode shifts in freight transport are widely seen as a means to address regional mobility, congestion, and associated air quality problems. A full evaluation of those potential regional air quality benefits was beyond the scope of this study.

Impacts of the development scenario

In summary, there is sufficient research to reasonably expect increases in local air pollution related to the development scenario. The level of nitrogen oxide (ozone), a criteria pollutant, may increase under the development scenario, requiring additional evaluation, but is not expected to exceed federal standards. The development scenario is also likely to result in increased air toxics levels. These levels currently exceed the state benchmark on Hayden Island, and could increase two to threefold (from 20 to 55 times the state benchmark). The development scenario is expected to have minimal impacts on local roadway-related greenhouse gas emissions. A full investigation of the greenhouse gas emission impacts of Columbia River ship traffic or rail system freight movement is beyond the scope of this analysis

These predicted increases in air pollution can contribute to and exacerbate the following health outcomes: respiratory disease, cardiovascular disease, premature mortality, and lung cancer.

While contributing to increased air pollution, the development scenario includes a factor that can offset adverse effects of pollution - vegetation. The Open Space zone included in the plan may have a mitigating effect on air pollutants by maintaining a vegetative buffer between port operations and residential areas on Hayden Island. The Environmental Foundation Study by Entrix notes that trees and other vegetation included in the Open Space zoning of the development scenario could improve ambient air quality by removing air pollutants. Specifically, vegetation intercepts and absorbs potentially harmful pollutants such as nitrogen dioxide, particulate matter, carbon monoxide, and sulfur dioxide (Nowak et al 2006). The air purification services of vegetation that reduce ambient air concentrations of pollutants can improve health and reduce the incidence and/or severity

of respiratory illness such as asthma, bronchitis, lung disease, and respiratory infections (Entrix Foundation Study, 2012).

What don't we know?

The analyses presented above are based on rigorous and scientifically sound data and prediction calculation methods. However, our conclusions are limited by lack of data (e.g., local health data) and gaps in the scientific knowledge base, particularly in being able to predict specific health outcomes.

Points that remain uncertain or that are not reflected in this analysis include the following:

- Most research on outdoor air pollution is related to road traffic and other land-based sources. A recent review found that little is known about ship-related exhaust. Land vehicle exhaust and ship exhaust contain many of the same pollutants (Mueller, Uibel, Takemura, Klingelhoefer, & Groneberg, 2011). However, studies indicate that ship fuel is of lower quality than land vehicle fuels, raising concern about creating greater pollution.
- The literature on cancer effects from air pollution is limited by inadequate characterization of individual exposures that include time-activity patterns and geographic distribution of pollutants at the micro-scale (Katsouyanni & Pershagen, 1997).
- Air pollution levels from port operations will vary with the season, trends in weather such as wind and temperature patterns, land use, and community behavior patterns. We cannot predict or quantify the effects of these factors.
- Data provided by the Port of Portland regarding criteria pollutants could only be studied at the regional level; we could not estimate criteria pollutant levels on a local level for Hayden Island alone.
- The selection of receptors near Terminals 4 and 5 from the regional PATS model is the best available surrogate for this analysis. Emissions from actual development in the future could differ. A more detailed evaluation of the emission sources and quantities could be made in the future to determine the level of significance of the contribution from a future terminal.
- Emission reductions including mandated measures, future regulations, or voluntary actions are taking place and new measures continue to be implemented; however, the turnover rate for vehicle fleet engines is hard to predict. This makes it hard to predict emission reduction rates at the time of port development. EPA has estimated, due to the implementation of the North American Emission Control Area, that diesel PM emissions from ocean going vessels will be reduced by approximately 74% by 2020 (EPA Regulatory Announcement, March 2010). The reduction in emissions could have a mitigating effect on the health outcomes highlighted here.

Noise and Vibration

Geographic extent of impacts: Local

Populations most impacted: Hayden Island manufactured home park and floating home residents

It is reasonable to expect increases in local noise and vibration as a result of the development scenario, particularly for individuals residing or working along or near freight routes. Increased noise from port development will be buffered to some extent by buildings. However, current noise levels due to aircraft departures from the Portland International Airport and over the Columbia River will continue regardless of port development.

The most likely health impacts from the increased levels in noise and vibration are sleep disturbances, annoyance, and stress. It does not appear that the increased levels of noise and vibration related to the development scenario would result in an intensity of exposure that is associated with hearing impairment. Other health impacts could include: cardiovascular illness and mental health.

SUMMARY

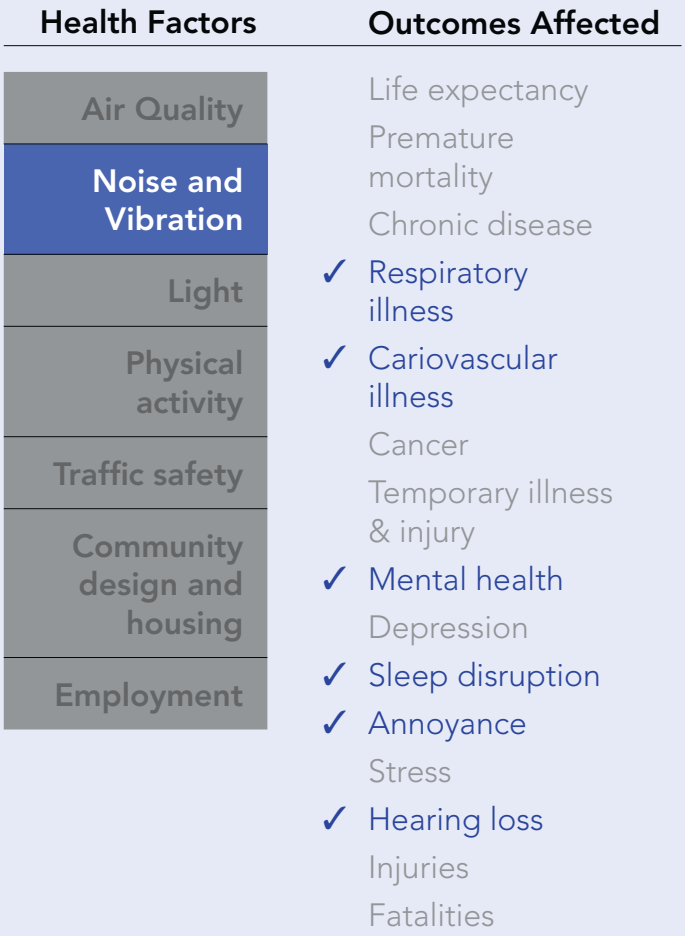
Noise and vibration are closely related, as sound is a form of vibration. There has been little research conducted on the health impacts of transportation-related vibration. As a result, much of the vibration research presented here comes from occupational exposure studies that are more relevant to potential port employees than to residents of Hayden Island.

What are the health issues?

Noise, which is defined as "unwanted or disturbing sound" (U.S. Environmental Protection Agency, 2012), has many health effects. The best-documented health effect of noise is hearing loss. Noise-induced hearing loss is "a major cause of deafness and hearing impairment" in the U.S. (Daniel, 2007, p. 225). In addition to affecting hearing, noise exposure is associated with non-auditory health impacts. These impacts include both psychosocial and physical impacts, such as: annoyance, sleep disturbance, cardiovascular disease, mental illness, and stress (Babisch, 2006). The health impacts of noise on an individual are influenced by genetic, social, and environmental factors, including age, health status, time of day, presence of wall insulation, and more.

Noise levels are measured in several different ways that will be referenced throughout this analysis; the Daly-Standlee & Associates report (2012) provides more information about the differences between noise measurement techniques.

Figure 4: Schematic illustration of noise- and vibration-related health outcomes



Annoyance

The most common health impact of noise exposure is noise annoyance, or "a feeling of resentment, displeasure, discomfort, dissatisfaction, or offense when noise interferes with someone's thoughts, feelings, or actual activities" (Passchier-Vermeer & Passchier, 2000, p. 126). Not surprisingly, annoyance increases as noise level increases. However, noise levels are responsible for only 20% of the difference in individual reactions to noise, as annoyance is a highly subjective outcome that is influenced by social and environmental factors including housing type, level of affluence, fear, and "social utility of the noise source" (Whitfield, 2003, p. 362).

In addition to noise level, noise frequency influences individual annoyance. While high- to medium-frequency sounds, such as emergency sirens, come easily to mind when considering possible sources of annoyance, low-frequency noise is also important to consider. Low-frequency noise is generated by many sources. Built environment features and noise protection equipment are not as efficient at mitigating low-frequency noise effects (Berglund, Thomas, & Schwela, 1999).

Vibration can exacerbate annoyance from noise (Stansfeld & Matheson, 2003). Because trains and heavy trucks in particular create simultaneous noise and vibration impacts, this issue is particularly relevant to port activities. It can also complicate efforts to understand noise impacts and synergistic impacts of noise and vibration, because "people are disturbed and annoyed by both factors; they also tend to 'mix up' these effects or to perceive vibration as noise" (Berglund & Lindvall, 1995, p. 126). While some studies have shown vibration exposure to increase noise annoyance when both vibration and noise are present, others indicate that the relationship between the two is not so straightforward (Howart & Griffin, 1990; Paulsen & Kastka, 1995).

A review of community surveys found that "fear of danger from the noise source, a sensitivity towards noise generally, the belief that the authorities can control the noise, the awareness of the non-noise impacts of the source, and the belief that the noise source is not important" increased noise annoyance levels (Fields, 1992, p. v).

Stress

Noise is a stressor, and people's reactions to stress have physical, psychological, and behavioral components. Stress influences health through the secretion of stress-related hormones and causing behaviors (particularly coping mechanisms) that can increase risk of disease (van Kempen et al., 2002).

Mental health

In general, at lower environmental noise levels, there is a weak association between noise and mental health symptoms, but not between noise and psychiatric disorders (Stansfeld & Matheson, 2003). In a well-known longitudinal study, "no association was found between road traffic noise and psychiatric disorder." However, there was a small association with anxiety (Stansfeld & Matheson, 2003, p. 248). Exposure to higher levels of noise was shown in one study of military aircraft noise to be associated with nervousness and depression (Hiramatsu, Yamamoto, Taira, Ito, & Nakasone, 1997), and one review suggests that "there may be a link to psychiatric disorder at much higher noise levels" (Stansfeld & Matheson, 2003, p. 249).

Sleep disturbance

Sleep disturbance includes trouble falling asleep, difficulty staying asleep (awakenings), and waking up earlier than desired. While occasional sleep disturbances are normal, "sleeping problems or sleep disturbance may become clinically significant as normal physical, mental, and social functioning are hampered" (van Kempen et al., 2002, p. 307).

The research related to sleep disturbance has been largely limited to laboratory experiments, where noise environments can be carefully controlled. There has been a small amount of research conducted in people's living environments, and most of this has been focused on aircraft noise. A smaller number of studies examine noise from railways and road traffic (Berglund et al., 1999). While "exposure to noise disturbs sleep proportional to the amount of noise experienced," outdoor noise levels are not strongly associated with sleep disturbance (Stansfeld & Matheson, 2003, p. 244). Indoor noises and other factors are responsible for 80-90% of sleep disturbance (Berglund et al., 1999). Some studies suggest that rail traffic may be more disturbing to sleep than roadway traffic. Reaction to noise is influenced in part by the time between noises (Berglund & Lindvall, 1995) and the "difference in sound pressure levels between a noise event and background" (Berglund et al., 1999, p. 45).

Studies have generally shown that people become habituated to increased sound exposures both over the course of one night and across the course of many nights. However, this result was not supported in a study examining 14 nights of maximum noise exposure (Berglund et al., 1999; Stansfeld & Matheson, 2003). While those exposed to night-time noise may become habituated in terms of waking up fewer times in the night, no such habituation has been seen for other effects, like increased heart rate and secondary effects (Berglund et al., 1999; Öhström & Björkman, 1988; Stansfeld & Matheson, 2003). These secondary effects

include reduced work performance, tiredness, depressed mood, and a perception of poor sleep quality. These can affect an individual even if he or she has become habituated to noise and does not experience awakenings (Carter, 1996; Passchier-Vermeer, 1993).

While some studies suggest that older adults have increased vulnerability to sleep disturbance, not all studies support this conclusion (Berglund et al., 1999; Reyner, Horne, & Reyner, 1995). Other vulnerable groups include "shift workers, persons who are especially vulnerable to physical or mental disorders, and other individuals with sleeping difficulties" (Berglund et al., 1999, p. 173).

Hearing loss

Noise-induced hearing loss can be caused by both short-term and chronic exposure to noise. Hearing loss can result in difficulties communicating, as it becomes harder to understand speech in everyday settings.

Research suggests "that even a lifetime exposure to environmental and leisure-time noise" at an equivalent continuous level of 70 dBA (decibel A-weighted filter) "would not cause hearing impairment in the large majority of people (over 95%)" (Berglund et al., 1999, p. 41). 70dBA is equivalent to an electric shaver 1.5 feet away indoors or a gas lawnmower 100 feet away outdoors (Daly-Standlee & Associates, 2012). However, when combined with other exposures, including vibration, noise-induced hearing loss may be more likely (Berglund et al., 1999).

Cardiovascular health

The three primary cardiovascular health impacts that have been examined with relation to transportation noise exposure are biochemical effects, hypertension, and ischemic heart disease (IHD), the leading cause of death in the U.S. Of these three impacts, evidence is the strongest for noise's relationship to heart disease (Babisch, 2006).

For those exposed to a daytime average of 60 dBA or less, there is little indication of increased risk of IHD. Studies are relatively consistent, however, in suggesting that risk of IHD increases as noise levels increase (Babisch, 2006). In particular, there is evidence that long-term exposure to noise levels greater than 70 dBA is associated with IHD (Passchier-Vermeer & Passchier, 2000). There is also evidence that long-term exposure to noise levels above 85 dBA indoors and 70 dBA outdoors are associated with hypertension (Passchier-Vermeer & Passchier, 2000; van Kempen et al., 2002).

Studies on hypertension have generally produced mixed results, but newer studies are more likely than older studies to show that exposure to high levels of road traffic noise increase risk of hypertension. Studies have had more consistent outcomes with respect to aircraft noise, with greater exposure resulting in higher risk of hypertension (Babisch, 2006).

How will the development scenario affect them?

Method used to estimate impacts

This assessment of noise and vibration impacts employed the methods detailed in Section 4. In addition, data were collected locally. Daly-Standlee and Associates (DSA) was hired by the City of Portland to collect information about baseline noise levels on the island over seven days in July 2012. DSA established six sound level measurement locations in the vicinity of the manufactured home community to document existing sound levels between Interstate 5 on the east and the BNSF Railroad to the west (see Daly-Standlee & Associates, 2012 for more detail). The data presented in the DSA analysis are considered representative of the conditions that would be found in the community during times when the wind is blowing from the west-northwest and aircraft are departing to the west from Portland International Airport.

This analysis only considered existing noise conditions, and does not include any assumptions regarding changes in conditions due to development of the Columbia River Crossing or future changes to infrastructure and housing capacity as envisioned in the Hayden Island Plan.

Baseline noise conditions

The results show that sound levels throughout the Hayden Island Manufactured Home Community were generally very cyclical over the seven-day period. The highest sound levels generally occurred at each measurement location between 8:00 a.m. and noon on Monday through Friday. The lowest sound levels generally occurred daily at each location between 1:00-4:00 a.m.

The data also show that all the noise descriptor levels were generally lowest at location M1, the measurement location south of N. Hayden Island Drive, and highest at measurement location M6, the measurement location along the Columbia River near Interstate-5, north of N. Hayden Island Drive. Background sound levels during late-night hours across the Hayden Island Manufactured Home Community were highest at homes located along the Columbia River and lowest at homes located closer to N. Hayden Island Drive. Beyond that point along the River, the background noise became a combination of noise from Interstate-5 and noise from industrial operations in Vancouver, northwest of the community. At the west end of the Community, the background noise was influenced more by noise radiating from the industrial operations northwest of the community.

Prior to the study, it was expected that Interstate-5 traffic noise would be a major contributor to the ambient noise at all homes on the east end of the manufactured home community due to its proximity to the highway. However, when the physical conditions at the site were reviewed, homes in the southeast portion of the Community were found to be somewhat buffered from Interstate I-5 traffic noise by several large commercial buildings. Thus, homes located along Hayden Island Drive currently experience some of the lowest background sound levels during late-night hours.

Figure 5: Noise monitoring sites

In contrast to the lower late-night hour background noise levels found at homes along N. Hayden Island Drive, DSA noted that during most daytime hours (6:00 a.m. to 6:00 p.m.), the background noise at homes located near N. Hayden Island Drive was generally as high as that found along the Columbia River near the center of the community. This finding indicated that traffic on N. Hayden Island Drive likely has as much influence on the background noise at homes along it as Interstate-5 traffic has on the background noise at the homes along the Columbia River.

Another significant contributor to noise level is the Portland International Airport (PDX) and the Oregon Air National Guard (ORANG). DSA found spikes in noise that were directly related to departures of commercial and military jets from PDX. Sound from aircraft noise tends to drop off with distance from the Columbia River which is the general flight path of aircraft departing from PDX. Thus, those homes located nearest the river have the greatest exposure to aircraft noise, but even those located further from the river have a significant amount of exposure to aircraft noise.

While there appears to be a slight influence by aircraft noise on the median hourly noise level on the island, the effect is minimal. This is mainly due to the fact that the daily cumulative duration of aircraft noise is generally less than 30 minutes of an hour. When aircraft noise is not present, the noise in the community is generally about the same as would be found in most urban settings.

Impacts of the development scenario

Residents of Hayden Island are likely to experience more noise and vibration under the development scenario, and certain groups will be more affected than others. From a geographical perspective, people living near roadways, new port facilities, and the Columbia River will be most affected.

While most research on noise has focused on single-family detached and multi-family homes (Whitfield, 2003), two studies noted in the 1992 review of community surveys examined the reaction of manufactured home residents to aircraft noise – as well as reactions of residents of other housing types (Fields, 1992). One study found that residents of mobile homes demonstrated "at least 5% greater annoyance," but the survey concerned the noise related to the Concorde, a supersonic jet (Kirschner Associates, 1976). In addition, just as individuals will respond to a noise at the same level in a different way, "distinct communities respond differently to the same noise source at the same level" (Whitfield, 2003, p. 369).

There are many risk factors that affect an individual's risk of hearing loss, including age, race, gender, genetics, health status, and health behaviors (Daniel, 2007). Hearing loss from noise exposure is more prevalent in individuals over 65 years of age than in other age groups (Daniel, 2007). Perhaps more important than age, though, is the impact of pre-existing health conditions There is some evidence that individuals with pre-existing conditions may "have less reserve to cope with the additional noise stress… [and/or] the noise further increases psychophysiological arousal, which may be already higher in these people with health problems" (Babisch, Ising, & Gallacher, 2003, p. 742).

Environmental factors influence the relationship between noise exposure and heart disease; for example, research cites "mediating factors like residence time, room orientation, and window opening habits" (Babisch, 2006, p. 34). These factors may be especially relevant in the case of West Hayden Island because of the limited sound insulation of manufactured housing and the ability of sound and vibration to carry across the water.

Income is another factor that has not been well-researched, but may play a role in health to noise exposure. People with less money may be unable to purchase items or move residences to decrease noise exposure.

While residents of Hayden Island may be affected by port operations and train, truck, ship, and automobile traffic to the port, noise exposure impacts in other parts of the region will likely be limited to increased train, truck, and ship traffic.

What don't we know?

While there is consensus that noise can affect human health in many ways, the precise mechanisms for its impact and the influence of the many mediating factors remain unknown. The existing evidence base on noise, vibration, and health has shortcomings related to: self-selection of research subjects, a narrow focus on medical outcomes, measurement challenges, and a lack of understanding about the impacts of personal variables and how these affect susceptibility.

- While outdoor noise levels do not accurately represent indoor noise levels, many studies use outdoor noise models as a proxy for indoor exposure (Brink, 2011). Studies often fail to account for the many confounding variables related to noise exposure and the factors that influence a person's response to noise. This makes it difficult to draw conclusive findings (Lercher, 1996, p. 118).
- The focus of the evidence base on " 'hard' medical outcomes such as hypertension or myocardial infarction . . . leads to a devaluation of 'soft' responses such as depression or quality of social interaction, despite the legitimate status of the latter variables as health outcomes" (Lercher, 1996, p. 118) and despite the fact that these soft outcomes have profound effects on well-being.
- Studies related to noise exposure and annoyance and cardiovascular health have focused primarily on adult men, and women are included, differences in health impacts have been discovered, but are not well understood (Babisch, 2006). Some research indicates that cardiovascular impacts are greater for young and middle-aged people while others found larger impacts in older adults (Babisch, 2006). Studies on the impacts of noise on cardiovascular health have focused primarily on road traffic, with a smaller number of studies examining aircraft noise (Passchier-Vermeer & Passchier, 2000).
- There has been little research conducted on the health impacts of transportation-related vibration; as a result, much of the vibration research presented focuses on occupational exposures that will be more typical for port employees than for residents of Hayden Island.

Light

Geographic extent of impacts: Local

Populations most impacted: Hayden Island manufactured home park and floating home residents

The development scenario may result in minimal health impacts related to light pollution. Port operations involve extensive lighting, as most operate 24 hours a day and illumination is necessary for safety and security reasons. The visual separation caused by the existing railroad berm and the tree buffer, coupled with mitigation strategies, should address this.

Potential negative health impacts of excessive exposure to light at night include: increased sleep disturbance, obesity, diabetes, cancer and depression.

SUMMARY

What are the health issues?

Light-at-night exposure, or LAN, affects health in two main ways: by disrupting sleep and by disrupting circadian rhythms. The precise mechanisms through which LAN influences health outcomes are not fully understood. However, the limited evidence is generally consistent "in support of the hypotheses that altered lighting can play a role in breast cancer causation, and there is growing interest in a lighting and /or sleep connection" to other outcomes including prostate and others cancers, depression, obesity, diabetes, and cardiovascular disease (Stevens et al., 2007, p. 1357)including artificial light, has a range of effects on human physiology and behavior and can therefore alter human physiology when inappropriately timed. One example of potential light-induced disruption is the effect of light on circadian organization, including the production of several hormone rhythms. Changes in light–dark exposure (e.g., by nonday occupation or transmeridian travel.

Humans are naturally adapted to a 24-hour cycle of light and dark, with a different light-to-dark ratio depending on the season and location. However, we have shortened the dark cycle and lengthened the light cycle through the nearly ubiquitous use of artificial light (Chepesiuk, 2009). Disrupting our circadian rhythms impacts health in several ways, primarily by changing our melatonin cycle and by impacting our "clock genes" – those 10-15% of our genes that are controlled by our circadian clock (Chepesiuk, 2009; Reiter et al., 2011).

Sleep disruption

Like noise and vibration exposure, light-at-night (LAN) exposure can disrupt sleep. The effects of disrupted sleep are discussed in the ***Noise and Vibration*** section above. Both low- and high-intensity artificial lights, such as those lighting homes and workplaces, can result in insomnia and inadequate rest (Salgado-Delgado, Tapia Osorio, Saderi, & Escobar, 2011).

Figure 6: Schematic illustration of light-related health outcomes

Cancer

Much research has recently focused on the link between LAN exposure and/or frequent travel across time zones and cancers, particularly breast cancer and prostate cancer (Navara & Nelson, 2007; Reiter et al., 2011; Sigurdardottir et al., 2012). Studies examining shift workers and flight attendants have generally consistently shown elevated risk for breast cancer, and more recently, for prostate cancer (Reiter et al., 2011; Sigurdardottir et al., 2012). In addition, recent studies have suggested that other specific cancer types and perhaps "a generalized elevation of all cancer subtypes" are connected to LAN and circadian and melatonin disruption (Reiter et al., 2011, p. 17).

The pathway by which LAN is thought to increase cancer risk is primarily through melatonin disruption, perhaps because human melatonin rates are elevated when it is dark out and melatonin serves to slow tumor growth (Reiter et al., 2011).

Obesity and diabetes

Research on the connections between sleep disruption and circadian disruptions have been carried out primarily in experiments on mice and rats with a few studies examining impacts in humans. However, in humans, "chronic disturbances in circadian endocrine rhythms ...[are] associated with an elevated incidence of obesity and diabetes" (Reiter et al., 2011, p. 18).

One study that controlled for many other factors indicated that "sleep loss lowered the feeling of satiety" and when "extended over time, this imbalance would be expected to cause increased food consumption and weight gain" (Reiter, Tan, Korkmaz, & Ma, 2012, p. 569)unless serious changes are made, a majority of adults and many children will be classified as overweight or obese. Whereas fatness alone endangers physiological performance of even simple tasks, the associated co-morbidity of obesity including metabolic syndrome in all its manifestations is a far more critical problem. If the current trend continues as predicted, health care systems may be incapable of handling the myriad of obesity-related diseases. The financial costs, including those due to medical procedures, absenteeism from work, and reduced economic productivity, will jeopardize the financial well-being of industries. The current

review summarizes the potential contributions of three processes that may be contributing to humans becoming progressively more overweight: circadian or chronodisruption, sleep deficiency, and melatonin suppression. Based on the information provided in this survey, life-style factors (independent of the availability of abundant calorie-rich foods. Genetic studies of obese individuals suggest that there is a connection between circadian disruption and food consumption, as well as between circadian disruption and limited sleep duration. Thus, an obesity outcome may be a result of circadian disruption, melatonin disruption, and/or sleep disruption (Reiter et al., 2012)unless serious changes are made, a majority of adults and many children will be classified as overweight or obese. Whereas fatness alone endangers physiological performance of even simple tasks, the associated co-morbidity of obesity including metabolic syndrome in all its manifestations is a far more critical problem. If the current trend continues as predicted, health care systems may be incapable of handling the myriad of obesity-related diseases. The financial costs, including those due to medical procedures, absenteeism from work, and reduced economic productivity, will jeopardize the financial well-being of industries. The current review summarizes the potential contributions of three processes that may be contributing to humans becoming progressively more overweight: circadian or chronodisruption, sleep deficiency, and melatonin suppression. Based on the information provided in this survey, life-style factors (independent of the availability of abundant calorie-rich foods.

Whatever the specific mechanism, "obesity and diabetes so often occur together in individuals with sleep deficits that the term 'diabesity' has been used to describe this combination of conditions" (Reiter et al., 2012, p. 570) unless serious changes are made, a majority of adults and many children will be classified as overweight or obese. Whereas fatness alone endangers physiological performance of even simple tasks, the associated co-morbidity of obesity including metabolic syndrome in all its manifestations is a far more critical problem. If the current trend continues as predicted, health care systems may be incapable of handling the myriad of obesity-related diseases. The financial costs, including those due to medical procedures, absenteeism from work, and reduced economic productivity, will jeopardize the financial well-being of industries. The current review summarizes the potential contributions of three processes that may be contributing to humans becoming progressively more overweight: circadian or chronodisruption, sleep deficiency, and melatonin suppression. Based on the information provided in this survey, life-style factors (independent of the availability of abundant calorie-rich foods. In studies using mice and rats as the subject, LAN caused increased body mass, impaired glucose tolerance (a precursor to diabetes), and altered food intake timing (Fonken & Nelson, 2011). Animals experiencing circadian disruptions show more signs of obesity and metabolic syndrome -- a group of risk factors that occur together and increase the likelihood of coronary artery disease, stroke, and type 2 diabetes (Reiter et al., 2011, p. 18).

Depression

LAN, circadian disruption, and sleep disruption are also associated with depression (Fonken & Nelson, 2011; Salgado-Delgado et al., 2011).

How will the development scenario affect them?

Method used to estimate impacts

This assessment of light impacts employed the methods detailed in Section III. The analysis did not consider the potential lighting impacts that are the result of other future development on Hayden Island such as the Columbia River Crossing, residential or island infrastructure development, or the mall redevelopment. Because those developments are closer to the potentially impacted community, they will have a more direct impact than the development scenario.

Impacts of the development scenario

Marine terminals have large exterior work and storage areas that are often illuminated for safety and security reasons, as well as to allow for 24-hour operation. This light can affect adjacent properties as well as wildlife in adjacent natural areas. The West Hayden Island port could generate light impacts due to the large expanse of its outdoor work area and the possibility of around-the-clock loading and unloading operations.

Worker safety regulations require a minimum amount of illumination. Experiences at the Port of Portland and other port facilities provide insights into potential light impacts from the West Hayden Island port, as well as potential mitigation measures that help reduce light impacts. Light impacts are reduced with distance and through vegetation. As a result, the amount of existing tree canopy that is preserved between the terminal and the manufactured and floating home communities could affect the amount of additional light exposure experienced by these communities.

Older adults may be more susceptible to the negative health effects of excess light exposure. "In humans, there are numerous reports of age-associated decline in the quality of sleep and circadian rhythms," including changes in melatonin (Karatsoreos, 2012, p. 222; Reiter et al., 2012). In fact, this change in melatonin "may be one of several factors that contribute to the often gradual weight gain that is associated with middle age and beyond" (Reiter et al., 2012, p. 573) unless serious changes are made, a majority of adults and many children will be classified as overweight or obese. Whereas fatness alone endangers physiological performance of even simple tasks, the associated co-morbidity of obesity including metabolic syndrome in all its manifestations is a far more critical problem. If the current trend continues as predicted, health care systems may be incapable of handling the myriad of obesity-related diseases. The financial costs, including those due to medical procedures, absenteeism from work, and reduced economic productivity, will jeopardize the financial well-being of industries. The current review summarizes the potential contributions of three processes that may be contributing to

humans becoming progressively more overweight: circadian or chronodisruption, sleep deficiency, and melatonin suppression. Based on the information provided in this survey, life-style factors (independent of the availability of abundant calorie-rich foods. Further, the disruption of circadian rhythms "may have dire consequences that may be exacerbated by age" (Stevens et al., 2007, p. 1358)including artificial light, has a range of effects on human physiology and behavior and can therefore alter human physiology when inappropriately timed. One example of potential light-induced disruption is the effect of light on circadian organization, including the production of several hormone rhythms. Changes in light–dark exposure (e.g., by nonday occupation or transmeridian travel.

Both the research literature and experience at the Port of Portland and other ports suggest that mitigation strategies to address potential impacts of light pollution are readily available. These strategies are discussed in Section V, Maximizing benefits and minimizing harms.

What don't we know?

- Much of the research examining the mechanisms by which light exposure impacts health have focused on impacts to wildlife and have been conducted on animals in laboratories (Chepesiuk, 2009).
- The scientific exploration of the specific mechanisms through which LAN affects sleep is ongoing (Kantermann & Roenneberg, 2009; Reiter et al., 2011; Stevens, 2009).

Physical Activity

Geographic extent of impacts: local and regional

Populations most impacted: Hayden Island residents, people throughout the region utilizing the open space and trails

There is sufficient research to reasonably expect increases in levels of physical activity related to the development scenario. The development scenario provides access to improved opportunities for physical activity by expanding infrastructure for biking and walking, such as through improved roadways and trails, and by preserving 500 acres of open space for recreational opportunities.

Physical inactivity is among the top preventable causes of premature death and disability locally and nationally, and increasing opportunities for physical activity can positively impact the following health outcomes: heart disease, high blood pressure, cancer, stroke, obesity and diabetes.

SUMMARY

What are the health issues?

Researchers' understanding of the relationships between physical activity and health has steadily improved since the early 1990s, when they expanded the focus of their work from assessing the impacts of intensive vigorous exercise to include a wider range of low- or moderate-intensity physical activities such as walking, biking, gardening and swimming. There are many studies showing the connection between regular moderate exercise and improved health outcomes.

Currently, there are limited public spaces for residents to be physically active. The only park on Hayden Island is on East Hayden Island - Lotus Isle Park, located at N. Tomahawk Island Drive. The park includes a new playground, paved paths, picnic tables and many large trees. Access to the river is not provided at the park. Based on Portland Parks and Recreation targets for park acreage per capita, Hayden Island is currently underserved with parks. This is partially due to transportation constraints between the island and the mainland. In addition to limited access to parks, Hayden Island's sidewalks are incomplete and there are no bicycle lanes.

Life expectancy

Recreation has multiple health benefits. Exercise improves overall health, which reduces public and private health care costs, improves quality of life, and may help people live longer (Nieman, 1998).

Mental health

Types of physical activity that bring people into contact with each other, including walking about one's neighborhood and using parks and recreation facilities, have also been demonstrated to improve mental health and social

Figure 7: Schematic illustration of physical activity-related health outcomes

cohesion (Baum, Ziersch, Zhang, & Osborne, 2009; Cradock, Kawachi, Colditz, Gortmaker, & Buka, 2009; McDonald, 2007; McNeill, Kreuter, & Subramanian, 2006)Colditz, Gortmaker, & Buka, 2009; McDonald, 2007; McNeill, Kreuter, & Subramanian, 2006.

Vegetated landscapes, parks and scenic views each contribute a "sense of place" and personal attachment to particular locations. People are socially connected to the entirety of the built and natural environment by walking, biking and driving through areas with street trees, gardens, parks and other open spaces. High levels of social cohesion can contribute to good health outcomes by enabling the dissemination of health-related information such as care options, and by establishing, maintaining, and promoting social norms and practices associated with healthful behaviors (McNeill et al., 2006)

Chronic disease

In 1996, the U.S. Surgeon General's Office released its first report on physical activity and health. This concluded that moderate physical activity (defined as activities that use large muscle groups and are at least equivalent to brisk walking, such as swimming, cycling, dancing, gardening and yard work, and various domestic and occupational activities) can substantially reduce the risk of developing or dying from coronary heart disease, colon cancer, high blood pressure, and diabetes..

Since the Surgeon General's report was issued, research has built on its conclusions and has also more conclusively demonstrated that for people who are inactive, even small increases in physical activity can yield numerous measurable health benefits (Tilahun et al., 2007). In addition, physical activity has been solidly linked to improved learning and educational attainment among adolescents (Rasberry et al., 2011).

In addition, the Centers for Disease Control and Prevention strongly recommend improving access to places for physical activities such as biking or hiking trails to reduce the risk of cardiovascular disease, diabetes, obesity, selected cancers and musculoskeletal conditions.

Temporary illness and injury

Physical activity has been demonstrated to improve muscle and cardiovascular function, and physical performance, for people with joint or bone problems (Office of the Surgeon General, 1996; Tilahun, Levinson, & Krizek, 2007).

How will the development scenario affect them?

Method used to estimate impacts

This assessment of physical activity impacts employed the methods detailed in Section 4

Impacts of the development scenario

Hayden Island's walking and biking environment will likely be significantly improved in the future. The improvements will result from changes on the island due to the Columbia River Crossing bridge project, Jantzen Beach mall redevelopment, and implementation of other components of the Hayden Island Plan.

All of these projects will add substantial amounts of bicycle and pedestrian infrastructure to Hayden Island east of the port lands, as well as walkable destinations such as a new transit station and new retail opportunities. However, the impacts directly related to the development scenario, recreational improvements on West Hayden Island, and reconstruction of North Hayden Island Drive, is the focus of this analysis.

Depending on how they are designed and constructed, renovations of N. Hayden Island Drive could improve the safety and attractiveness of walking and biking across and along this street and also improve connectivity between the residential neighborhoods to the north and the retail establishments to the south. These improvements could also make the planned open space more accessible to both island residents and visitors.

Improved opportunities for physical activity created by the development scenario are likely to benefit local households and households from other parts of the region in different ways. Regional households will likely benefit most from the recreational opportunities provided by the West Hayden Island trail and trail access improvements. Local residents will benefit from trail and trail access improvements as well. They will also likely benefit from roadway improvements, if these improvements are effectively designed to enhance the ability of bicyclists and pedestrians to safely and comfortably move across and along N. Hayden Island Drive.

Open spaces and natural areas in the West Hayden Island development scenario provide not only areas to recreate, but also an opportunity for local residents and regional visitors to learn about environmental science, natural history, and cultural history of the Columbia River, its islands and the Pacific Northwest. Natural areas and open spaces provide "living laboratories" for active educational programs. Many schools use natural areas as a focal point of interdisciplinary studies. For example, Whitaker

Ponds in the Columbia Slough Watershed is utilized by schools year-round as a living laboratory. This model of learning has been shown to improve critical thinking skills, achievement in standardized tests, student attitudes about learning and civility toward others (Lieberman & Hoody, 1998).

What don't we know?

- Although there will be improvements to the bicycle and pedestrian infrastructure on N. Hayden Island Drive, there will also be an increase in truck traffic related to port activity. The extent to which truck traffic will deter cyclists and pedestrians from using N. Hayden Island Drive is unknown.
- Another uncertainty is the extent that the 500 acres of open space will increase local residents' physical activity levels. Anecdotally, local residents already utilize the open space even though it is private property owned by the port. Though the residents will be permitted to legally access the open space, in all, it will be less space than they are accessing now.

Traffic safety

Geographic extent of impacts: local and regional

Populations most impacted: Hayden Island residents, people throughout the region utilizing the open space and trails, workers commuting to West Hayden Island

It is reasonable to expect a modest decrease in traffic-related collisions as a result of the development scenario. Overall, traffic is expected to increase by 115% by 2035, with about 11% of the increase attributed to the West Hayden Island development. Despite the doubling of traffic, the decrease in collisions is likely due to the planned Columbia River Crossing-related interchange improvements on Hayden Island. The total daily truck volume estimate for 2035 without West Hayden Island is 1,330 trucks. The truck volume added by the development scenario is estimated to be 340 per day which is about one heavy truck traveling down N. Hayden Island Drive every 2.4 minutes. Interaction between trucks and bicyclists and pedestrians is a safety concern; street design will need to accommodate for all modes of travel. Improved traffic safety can positively impact the following health outcomes: injuries and death.

SUMMARY

What are the health issues?

Injuries and fatalities from traffic collisions represent significant health impacts and comprise a large portion of transportation-related health costs. Road traffic injuries have been identified by the World Health Organization as a major public health issue (Peden, 2004). While traffic collisions can result in death and serious physical injury, they can also result in poor mental health outcomes and in ongoing physical pain and injury. Physical and mental health injuries can create a lifetime of health burdens for people involved in crashes.

Physical disability

Several studies have indicated that, even when those injured in a crash report their crash-related medical issues resolved and return to work, many experience "significant, ongoing loss of health-related quality of life and impairment associated with [the] injuries sustained" through the crash (Fitzharris et al., 2007, p.309).

Mental health

Post-traumatic stress disorder, anxiety, depression, and stress are all associated with injuries sustained from traffic crashes (Wang, Tsay, & Bond, 2005).

How will the development scenario affect them?

Method used to estimate impacts

The Portland Bureau of Transportation (PBOT) has conducted a traffic safety assessment of the

Figure 8: Schematic illustration of traffic safety-related health outcomes

West Hayden Island Concept Plan. The methodology is based on the Highway Safety Manual (by AASHTO) and input from the State of Safety report by Metro. The PBOT safety assessment evaluates both N. Hayden Island Drive and the freeway ramp access street intersections. This assessment is based on street network improvements identified in the Hayden Island Plan and the CRC project. The assessment of potential health impacts considers future conditions with increased traffic and truck volumes forecasted from the West Hayden Island Concept Plan.

Impacts of the development scenario

N. Hayden Island Drive will be the access route to the proposed port development as part of the West Hayden Island Concept Plan. The condition of the current roadway varies along N. Hayden Island Drive, but contains many segments with wide traffic lane areas, no bicycle facilities and discontinuous sidewalks. Arterial roadways with multiple lanes have the highest serious crash rate per road mile. Also, higher levels of congestion have lower serious crash rates for all modes, likely due to lower speeds. In addition to the provision of adequate pedestrian and bicycle facilities that are separated from traffic, street lighting is also a factor in multi-modal safety. If N. Hayden Island Drive is improved as part of the development scenario it will present the opportunity to correct current physical safety deficiencies on the roadway.

Without the addition of by West Hayden Island industrial development the total daily traffic volumes for all streets on Hayden Island are expected to increase from 28,800 to 58,800 vehicles by 2035. This is a 104% increase. With development of the by West Hayden Island concept plan daily volumes are expected to increase to 61,800 by 2035, a 115% increase over current volumes. See Attachment A for more information on projected vehicle and truck volumes on Hayden Island at various locations along N. Hayden Island Drive).

Based on modeling of future conditions, the number of annual crashes on North Hayden Island Drive and the freeway ramp access streets is projected to decrease. The current total of

about 26 crashes is reduced to a calculated estimate of about 14 crashes in 2035 without a new West Hayden Island development, and to about 15 crashes with the West Hayden Island development. The most significant decrease in both crashes and crash rates is realized at the intersection level under both future year scenarios.

This decrease in crashes is primarily attributed to the planned roadway and intersection improvements on Hayden Island as a result of the Columbia River Crossing project and build-out of the local street connectivity plan in the vicinity of the mall. The future street network will have more circulation options, especially in the vicinity of the mall, so that not as many vehicles are directed onto N. Hayden Island Drive. The PBOT Safety Assessment report has more detail on the future network differences.

The total daily truck volume estimate for 2035 without development is 1,330 trucks based on existing traffic counts and Regional Transportation Plan data. The truck volumes added by West Hayden Island is estimated to be 516 for all truck types based on PBOT analyses. Approximately half would be heavy vehicles. This estimate is based on a by West Hayden Island development option that would have two automobile processing centers and one bulk terminal.

The development option currently being discussed would instead have one auto terminal and two bulk terminals. Under this option there would be fewer overall trucks generated by industrial development in West Hayden Island, but more heavy trucks. The truck volume added by the development scenario is estimated to be 340 per day which is about one heavy truck traveling down N. Hayden Island Drive every 2.4 minutes. The current draft recommendations for the West Hayden Island concept plan include a daily cap of 175 heavy trucks.

Truck traffic presents distinctive safety hazards. According to National Highway Traffic Safety Administration data trucks are not over-represented in crashes. However, when crashes involving trucks occur, they have higher rates of severity. One researcher concluded, "Examination of pedestrian injury distributions reveals that, given an impact speed, the probability of serious head and thoracic injury is substantially greater when the striking vehicle is an LTV [light truck vehicle] rather than a car" (Lefler).

A significant safety hazard for the mixing of bicycle traffic and truck traffic on roadways is right-turn movements from a public street to a public street. This is described as a ***right-hook*** movement that has been the cause of numerous injuries and some fatalities for bicyclists. Additional right–turn truck movements due to port activity will likely be concentrated in the immediate vicinity of the freeway.

The higher median age of Hayden Island residents may also play a role in traffic conditions and safety. Older drivers are less likely to be involved in crashes, but are more likely to have severe crashes and to die as a result of crashes. Older adults may also be more vulnerable to injury or death as pedestrians, due to limited personal mobility, reduced visual acuity and

hearing abilities. These factors need to be considered in both roadway and the pedestrian networks and facilities.

Another consideration is the impact that high truck volumes and truck sizes have on the physical condition of roadways. If not appropriately designed and maintained the conditions of the roadway can deteriorate and cause driving hazards for other roadway users such as automobiles and bicycles.

The increase in truck traffic with the development scenario may affect safety conditions if N. Hayden Island Drive's current condition is not improved. Improvements to N. Hayden Island Drive over current conditions will be important for pedestrian and bicycle safety. Key factors for pedestrian and bicycle safety include improved facilities, separation from traffic, improved crossings, reduced crossing distances, traffic speed control and illumination.

What don't we know?

- The biggest challenge to predicting the future traffic safety implications on Hayden Island is uncertainty about the Columbia River Crossing project. The CRC has reached a significant milestone in receiving an approved Record of Decision (ROD) by the Federal Highway Administration and Federal Transit Administration. The ROD identifies the preferred alternative for addressing the major transportation and environmental problems in the project area, but many political and financing hurdles remain to completing the project. Some of the improvements identified in the ROD will be deferred or modified, which could have implications for the number of lanes on N. Hayden Island Drive east of N. Pavilion Avenue (the main mall entry street) and pedestrian street crossing distances along this street segment as well as traffic patterns on the island overall.
- There are also uncertainties about the long-term effects of being involved in a collision. Though we know that a significant proportion of crash survivors have long-term problems, there is little agreement about their magnitude (Ameratunga, 2004, p. 1116).

Community Design and Housing

Geographic extent of impacts: Local

Populations most impacted: Hayden Island manufactured home park and floating home residents

It is reasonable to expect that the development scenario will likely negatively affect local housing conditions by causing property values to decline. A large proportion of West Hayden Island residents live in manufactured homes and floating homes which are financed differently than traditional single-family homes, resulting in housing costs that are both high and volatile. These homes are a valuable affordable housing resource, but provide limited opportunities for wealth accumulation and are uniquely vulnerable to changes in property value.

Decreases in property value as a result of the development scenario will likely result in reduced levels of personal wealth among individuals residing in manufactured homes and floating homes, and could increase economic disparities and poverty on the island. Economic instability and poverty has a strong connection to health outcomes, including life expectancy, risk of many chronic illnesses, mental health, depression, stress, and respitory illness.

SUMMARY

What are the health issues?

As an island community whose eastern half was annexed by the City of Portland relatively recently, Hayden Island has different land use patterns and housing types than the rest of the city. Relative to other parts of Portland, and probably to most other urban neighborhoods in the U.S., Hayden Island has few public facilities; most residents live in private developments rather than on city streets. This unique configuration of Hayden Island's housing stock and community spaces has both social and health implications.

The large proportion of island residents living in manufactured homes and floating homes is another notable feature of current development on the island, and one which has major economic implications for these households' well-being. Because there are many health conditions that are affected by housing conditions, these housing types may also have specific effects on their residents' physical health. There has been little research that specifically addresses the health issues related to living on an urban island, in a private development, or in a floating home or manufactured home.

Housing-related health conditions

The type of housing people live in, and the condition of their individual housing units, has an influence on both their physical and their mental health. Housing conditions have been associated with a wide variety of health

Figure 9: Schematic illustration of community design- and housing-related health outcomes

problems, ranging from exposure to heat and cold, gas poisoning from faulty appliances, asthma and respiratory conditions, and learning and mental health problems (Braubach, Matthias, Jacobs, David E., & Ormandy, David, 2011; Jacobs, Wilson, Dixon, Smith, & Evens, 2009).

It is difficult to know how these conditions vary between communities, but generally speaking, in the United States people of color and people who earn lower incomes are more likely to experience housing-related health problems than are White people and people with higher incomes (Jacobs et al., 2009). Similar patterns are observed across high-income nations (Newton, 2011).

People living in manufactured homes may be especially susceptible to housing-related health problems. There is a long history of health problems associated with manufactured homes, though these problems have become less common as successive building and installation codes have been established by federal and state entities. These codes address problems with energy efficiency and ventilation (Tremoulet, 2010), which can contribute to depression, learning problems, and respiratory problems.

Living in a manufactured home may also put people at increased risk for exposure to air toxics from building materials that *off-gas* substances like formaldehyde (Hodgson, Beal, & McIlvaine, 2002; Kilburn, Kaye H., 2000), though this is also less common in newer manufactured homes. Residents of manufactured homes may also be exposed to more allergens because of the physical characteristics of their homes (Sterling & Lewis, 1998), such as a building envelope that is more permeable than those of site-built homes.

There is scant research on floating homes and health, so it is difficult to generalize health conditions that have a special relationship to living in a floating home. However, there may be some health benefits of living in this type of home. One notable feature of floating homes is their ability to rise with the water level, which makes them the housing type best suited to the changing coastlines associated with climate change. Research conducted in Seattle suggests that floating homes may have a smaller ecological footprint than other housing types (Feeney, 2010).

Floating home residents also have a special relationship with waterways and the shoreline, and contact with nature is known to improve mental and physical well-being (Maller, Townsend, Pryor, Brown, & Leger, 2006; Sugiyama, Leslie, Giles-Corti, & Owen, 2008). Research shows that this effect may be especially strong for older adults, female home-makers, and people who earn lower incomes (de Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003).

Economic stability

Housing tenure is a major influence on household wealth, which is in turn an important determinant of health. Wealth, which includes both income (e.g., earnings) and assets (e.g., investments, land, and material goods), has a strong connection to life expectancy and risk of many health problems (see, for example, Chittleborough, Taylor, Baum, & Hiller, 2009; Gruenewald et al., 2012; Marmot, 2005; Skodova et al., 2008; Subramanyam, Kawachi, Berkman, & Subramanian, 2009)Berkman, & Subramanian, 2009.

Housing costs are one of the major expenses households face, and Hayden Island residents experience high housing cost burdens. The Census Bureau estimates that between 2006 and 2010, 51.8% of Hayden Island households were paying more than 30% of their household's income on housing costs; among renters that statistic was 84.1%. (The 30% threshold is a standard measure of housing affordability.)

The statistics are much lower for the City of Portland, where 43.0% of all households and 50.3% of renter households are burdened by their housing costs (U.S. Census Bureau, 2012b). People who live in a floating or manufactured home that they purchased are considered homeowners for the purposes of these statistics, even if they are renting a slot at a moorage or manufactured home park and/or are still paying back the money they borrowed to purchase the home. It is likely that the high rates of housing cost burden on Hayden Island can be at least partially attributed to the high proportion of floating and manufactured homes in the Hayden Island housing stock.

The total housing stock in the Hayden Island-Bridgeton community has remained fairly stable in the past decade with the addition of just 90 units. This 6% increase in housing stock is less than the production in both North Portland and the Portland Metro area. A significant proportion of the housing stock (more than 37%) is mobile homes. This is very different from the prevalent stock (single-family detached) in both North Portland and in the Portland Metro area. This also explains the significantly higher ownership rates on Hayden Island (82%). Mobiles homes are much cheaper to purchase, but pose the added hardships of vulnerability to park closures and ability to sell, regardless of the prevailing state of real estate market.

In the case of both floating and manufactured homes, properties are financed differently than single-family homes, resulting in housing costs that are both high and volatile. Financing the purchase of either of these types of homes is more onerous than obtaining a traditional mortgage for a site-built home. Owners of manufactured homes and floating homes generally

face the challenges that come with what is known as *divided asset* ownership. Under divided asset ownership, one party owns the home and then rents a plot of land or a moorage slip from another party, such as a manufactured home park or a marina.

Because of their relatively low purchase price, floating and manufactured homes are a valuable affordable housing resource. As noted in the East Hayden Island Affordable Housing Study produced by CASA of Oregon in 2008 (see the Methods and Assumptions section), the average monthly space rent in the manufactured home park is $562 and the average home value is $13,900. This is the only source of affordable home ownership for lower-income individuals currently available on the island.

However, manufactured and floating homes provide limited opportunities for wealth accumulation. This is due both to the divided asset ownership situation and because the buildings have a shorter lifespan than traditional houses (MacTavish, Eley, & Salamon, 2006). Without the companion land (or slip) manufactured homes and floating homes are less likely to appreciate in value than traditional homes. Further, both manufactured and floating homes have historically been ineligible for traditional mortgages. So purchasers must rely on personal property loans, which require a larger down payment, and typically have a higher interest rate and often a shorter amortization period. Consequently, these housing types put households at a disadvantage for accumulating wealth.

Though manufactured and floating home owners own their dwellings, it is generally not practical to move homes to another site. Though manufactured homes are built off-site it is generally difficult to move them to a new site once they have been installed (Tremoulet, 2010). In the case of floating homes, there are a limited number of locations where floating homes can be moored (due to environmental protections and permitting laws) and relocating them is very expensive.

Social connections

People's connections to other people and cultural resources, such as community centers, are influenced by the settings in which they live (Forrest & Kearns, 2001; Ilja, 2012). In turn, these social connections affect people's health.

The opportunity to interact with others increases *social capital* for both individuals and the community as a whole; social capital is in turn associated with increased health status (Kawachi, Kennedy, & Glass, 1999; Poortinga, 2006). Casual interaction with a wide variety of people – such as occurs at a community facility – is valuable (Erickson, 2003). Community facilities and services provide important supports for youth development and may help prevent aggression in the community at large (Molnar, Cerda, Roberts, & Buka, 2008). A lack of public space may change how people interact with the community around them (Kirby, 2008).

The residential areas of Hayden Island have a different feel than most of the residential areas of Portland. Because much of the land on the island was initially owned by a few individuals,

most of Hayden Island's homes are part of developments of large tracts of land instead of being on smaller parcels of land purchased by homeowners. Consequently, while people may have private green spaces and facilities for social and recreational activity, public facilities are rare on Hayden Island. There is limited public park land. There are no schools or publically-owned community centers, and even few public roads.

How will the development scenario affect them?

Based on the findings described in the scientific literature, it is likely that the development scenario would have two major effects on the unique housing and social environment on Hayden Island:

1. decreased housing values
2. disruption of the community's social relationships

These could result, respectively, in decreased household economic stability and displacement of the current population from the island. Depending on the impacts of development on housing, livability, and other factors, this displacement could set the stage for gentrification on the island. The section below describes potential impacts to the health determinants presented above.

Method used to estimate impacts

This assessment of community and housing impacts employed the methods detailed in Section III. Where relevant, the analysis considered the potential community impacts that are the result of other future development on Hayden Island such as the CRC, residential or island infrastructure development, or mall redevelopment.

Impacts of the development scenario

It is difficult to predict how the prevalence and/or severity of housing-related health conditions would change under the development scenario. If proximity to port operations and the attendant noise, vibration, and light decrease the desirability of the manufactured home park at the middle of the island, older housing units might be decommissioned more rapidly than is currently the case. This decreased desirability could have larger negative impacts.

The extended construction period of the development scenario, coupled with fears about the effects of port development, may reduce property values on the island – particularly in areas that are near the proposed port and the Columbia River Crossing sites. Given the challenges of ownership of manufactured and floating homes discussed above, decreased property values could present a particular challenge to residents in these types of dwellings.

These effects would be profound for groups of people who have difficulty relocating, such as families with children, people with low or fixed incomes, older adults, and people with disabilities. Declining property values could increase poverty on the island and/or spur displacement of current residents. Poverty and poor physical conditions in a neighborhood can cause

depression and anxiety in residents. These, in turn, can have ramifications for physical health (Hill, Ross, & Angel, 2005). For example, neighborhood problems are associated with declining functioning in older adults (Balfour & Kaplan, 2002).

The development scenario may result in significant changes to the population of the island. People who do not want to live near construction or port operations may move away and remaining residents may have new people or vacant housing units as neighbors. Development-induced displacement is connected to myriad individual and community health problems (Fullilove, 2004; Fullilove & Wallace, 2011).

Displacement could be especially painful for residents because of the disruptions to social relationships. These relationships help people deal with the stress of neighborhood deterioration (Kruger, Reischl, & Gee, 2007), which can in turn result in mental health problems. This is of particular concern on Hayden Island given the fact that there are few formal social organizations to support residents through transitions in their neighborhoods.

The displacement of residents of manufactured homes and floating homes could spur gentrification on the island, if investment in infrastructure results in facilities that cater to wealthier residents or visitors (Clark, 2005). This is particularly concerning because of the recent loss of many housing units as a result of closures of other Oregon manufactured home communities (Tremoulet, 2010). The loss of floating home communities would be significant, given the fact that such communities are increasingly rare and difficult to replicate in new locations.

At the regional level, the development scenario could create vacancies in affordable housing units because of reduced costs on the island, though these units would likely be a last resort for many, given the decreased desirability of the units and the limited services and amenities on the island.

What don't we know?

- Very little research has been conducted about the economic situation, social worlds, and health issues of people who live in floating and manufactured homes. Further, much of the literature about other U.S. neighborhoods may be difficult to apply to life on Hayden Island because of its unusual geography and built environment.
- Few data are available that describe current housing conditions on Hayden Island, so it is difficult to suggest how housing might affect the health of island residents. The last national American Housing Survey was conducted ten years ago and only provides statistics at the citywide level.
- Other aspects of social life are extremely difficult to measure. There is no way to put a number to the uniqueness of island life or its importance to residents or the region as a whole. It then becomes almost impossible to estimate how much life might change as a result of development.

Employment

Geographic extent of impacts: Regional

Populations most impacted: People who become employed by the newly created jobs, local businesses providing services to support the new port activities and employees

It is reasonable to expect positive impacts on health due to increases in employment as a result of the development scenario. It is expected that approximately 2,300-3,700 jobs will be created either directly or indirectly by the West Hayden Island port development. Many of the new jobs will be living wage jobs. While it is difficult to estimate the number of Hayden Island residents who will benefit from the newly created jobs, the region as a whole will benefit from increased employment.

Many studies show that health improves as income rises, and increases in employment can improve a multitude of acute and chronic health outcomes: life expectancy, mental health, chronic diseases such as type 2 diabetes, heart disease and stroke.

SUMMARY

What are the health issues?

Existing research has identified four primary components of employment that influence the health of an employee: income, health benefits (health insurance and paid sick days), work-place conditions, and job security (Clougherty, Souza, & Cullen, 2010). This section provides a brief overview of each of these factors. We then examine what we know about the employment opportunities that the development scenario is anticipated to create, and what these opportunities might mean for the health of the people who are hired.

Income and health

The reason that income has such a strong influence on health is that it determines whether people are able to make healthy choices such as living in safe, healthy homes and neighborhoods, eating nutritious food, fully participating in family and community life, and obtaining timely and appropriate health care (Evans & Kim, 2010).

Income plays a role in determining the ability of a person to access the health supportive resources mentioned above, and to make a wide variety of choices about behaviors that impact health. As a result, income is associated with a multitude of acute and chronic health outcomes, ranging from chronic conditions such as asthma, type 2 diabetes, depression, disability and heart disease, to strokes, acute injury, contraction of communicable diseases, and premature mortality.

The link between income and health is well-documented and many studies clearly demonstrate that health improves as income rises (Clougherty et al., 2010). According to an analysis of the National Health Interview Survey (2001-2005) for example, nearly 31%

Figure 10: Schematic illustration of employment-related health outcomes

of poor adults - i.e., households with incomes less than 100% of the federal poverty level (FPL) - reported their health as being poor or fair, compared to less than 7% of adults with household incomes above 400% of the FPL. Similarly, 32% percent of poor adults (<100% of FPL) reported some sort of activity limitation due to chronic illness, compared with 9.4% for people with household incomes over 400% FPL. Likewise, data from the National Longitudinal Mortality Study (1988-1998) demonstrate that people with higher incomes live longer lives, with individuals at >400% FPL living 6.5 years longer than those at <100% FPL (Clougherty et al., 2010; Yen & Syme, 1999). Low incomes not only degrade the health of adults, but also the health of the children who rely on those adults.

Employee fringe benefits and health

The primary employment benefits that have been demonstrated to impact health are medical insurance and paid sick leave. Numerous studies have demonstrated that people with health insurance are healthier than those without insurance (Piette, Wagner, Potter, & Schillinger, 2004)(Cole et al., 2005; Ettner, 1996; Ross & Mirowsky, 2000; Sorlie, Johnson, Backlund, & Bradham, 1994).

Workplace safety and health

Both local and national data indicate that rates of injury and illness can vary greatly between different job sectors. In Oregon in 2010, 2.2 private sector workers suffered work-related injuries and illnesses resulting in lost work time - days away from work, restriction, or transfer (*DART*) - for every 100 full time employees (Barnhart, 2011). When looking at individual employment sectors, the figures ranged from a high of 3.9 for transportation and warehousing workers — a category that would comprise many of the direct jobs at a port facility on West Hayden Island — to a low of 0.1 for finance and insurance workers. The latter category would include the *induced jobs* expected to be created to support port operations.

Unemployment and job security

Researchers have linked unemployment to stress, depression, obesity, poor self-reported health status, and increases in cardiovascular

risk factors such as high blood pressure and high levels of serum cholesterol. While it is likely that some of these negative outcomes are related to the decreased ability to access health supportive resources due to loss of income, this research also indicates that unemployment impacts health via other psychosocial factors such as the loss of a sense of identity and sense of security that is often provided by a job. These psychosocial impacts lead to measurable increases in stress, anxiety, low self-esteem, and depression that often compound the negative health outcomes more directly related to lack of resources.

The independent impact of these psychosocial factors is perhaps made most apparent in studies of workers facing the likely prospect of layoffs. Despite the fact that the workers are still receiving their paychecks, they still experience higher levels of stress, anxiety, and depression than workers with more employment security (Ferrie, Shipley, Marmot, Stansfeld, & Smith, 1995; Heaney, Israel, & House, 1994; Kessler, House, & Turner, 1987; Muenster, Rueger, Ochsmann, Letzel, & Toschke, 2011; Niedhammer, Chastang, David, Barouhiel, & Barrandon, 2006; Paul, Geithner, & Moser, 2009; Vastamäki, Moser, & Paul, 2009).

How will the development scenario affect them?

Method used to estimate impacts

Estimates of the development scenario's impacts on employment and related health outcomes are based on employment projections provided in other reports related to the West Hayden Island project. These projections provide information on the amount and types of jobs that will result from future growth and development on Hayden Island. In some cases, these projections also provide information on wages related to the new jobs. This analysis focuses on jobs related to port operations. It does not consider the potential employment impacts due to the CRC or other development proposed for Hayden Island. However, it does consider the potential employment pool of future residents of Hayden Island.

Impacts of the development scenario

Income

According to research by the City of Portland (Bureau of Planning and Sustainability, 2012c), 91.5 % of Hayden Island's civilian workforce is employed, compared to 88% for the rest of the region. Despite higher employment rates, however, the Island's median household income, $46,143 (2010), is about 18% lower than the regional median, $56,275.

According to a report by a consultant to the Port of Portland (Martin Associates, 2012), the port expansion would result in the creation of 900 to 1,200 jobs directly related to the operation

of the new port facilities, primarily in the transportation and warehousing sectors. These jobs would primarily be located at the site of the terminal, although the prospective labor pool would likely come from the region. According to this report, these jobs would pay an average of about $50,000/year in today's dollars.

In addition to the direct jobs created by the new port development, the report projected that these direct jobs would lead to 500 to 900 indirect jobs, and 900 to 1,600 induced jobs. The indirect jobs – in firms directly dependent on maritime activity for example providing office supplies, parts and equipment, maintenance and repair services, business services, utilities, communications services and fuel – would pay about $50,000/year, on average. The induced jobs—those providing goods and services to the people with the direct jobs (e.g., financial planners, insurance agents)—would pay about $125,000/year

Some of the lower paying indirect and induced jobs would be located on the island, especially those that may provide direct service to the employees (e.g., food service) working at the terminal. However, the majority of the jobs would be spread throughout the region, many in downtown Portland and in the Columbia Corridor (City of Portland, EOA, 2012).

Assuming that these projections are correct, the fully operational port expansion would almost certainly add to the local and regional supply of relatively well-paying family-wage jobs. However, some of the direct, indirect, and induced jobs would likely be low-wage jobs such as retail ($27,300/year), food and drink service ($16,600/year), and personal service work ($25,360/year).

On average, the 2,300 to 3,700 jobs that would be supported by the fully operational terminals would be above the average annual wage for a job in Multnomah County ($49,208 in 2010). The average job would also be well above the federal poverty level that for a household with an adult and infant was $14,840 (2008), not to mention the more realistic Multnomah County self-sufficiency standard of $35,711 for the same household (Center for Women's Welfare, n.d.).

It is likely that many of the new hires would see their incomes increase as a result of their new positions. Due to the strong correlation between income and health, we would expect to see this increase accompanied with an increased likelihood of improved health.

Workplace safety

Predicting the working conditions for the jobs that will be directly or indirectly created by the development scenario, and whether they would be safer or less safe overall for the workers, requires more data than are currently available. While the transportation and warehouse jobs created by the port have higher rates of workplace injuries, it is likely that many of the workers taking these jobs would be coming from similar types of work. And, while some transportation and warehouse workers would likely be coming from safer professions, it is

possible that the increases in workplace injuries for these workers might be balanced out by workers likewise moving into some of the relatively safer indirect and induced jobs.

Regional variation in impacts

It is difficult to determine what proportion of the new jobs will be held by Hayden Island residents. According to a BPS analysis, 54 (2.3%) of the island's 2,319 jobs in 2010 were held by island residents. If we assume that residents will hold a similar proportion of the island's jobs in 2035, then the number of Island resident-workers would roughly double to 113. If we apply this ratio to the direct port jobs, then we would expect island residents to get 21to 28 of the 900 to 1,200 new jobs created by the terminals, as well as a few of the terminal's indirect and induced jobs, both on and off the island. Further, since the development scenario will improve multimodal access to the mainland, it will make it easier for people who work on the island to live elsewhere, and easier for island residents to work elsewhere.

What don't we know?

- The actual proportion of jobs held by island residents will be influenced by a number of variables that are impossible to predict. Different jobs require different skill sets. It is difficult, if not impossible, to predict whether future island residents will be qualified for, or interested in, the new jobs.
- It is also unclear what future employment trends will be. If unemployment continues to decline over time, then the newly created jobs will have less impact (e.g., fewer people would be unemployed and the newly created jobs may not increase income appreciably).

Cumulative and Synergistic impacts

Geographic extent of impacts: Local

Populations most impacted: Residents of Hayden Island, particularly those living in manufactured or floating homes, especially those with pre-existing health conditions

Many of the health outcomes identified in this analysis will be impacted by more than one of the seven factors, and by multiple development projects. It is reasonable to expect that Hayden Island residents, particularly those living in manufactured and floating homes, will likely be impacted by negative cumulative and synergistic health impacts. These residents may experience decreases in life expectancy, poorer mental health, and increased chronic disease, respiratory illness, cardiovascular illness, cancer, sleep disruption and stress due to multiple environmental changes. For example, residents' mental health may be negatively impacted by noise, light, and community design/housing changes due to West Hayden Island development as well as the construction of the Columbia River Crossing.

SUMMARY

All of the health determinants discussed in this document have the potential to cause health impacts on their own. However, in combination, some of these determinants may have cumulative or synergistic impacts. Synergistic impacts are different than cumulative impacts. Whereas cumulative impacts describe the sum total of impacts, synergistic impacts describe how the combination of determinants or outcomes may modify each other – moderating, magnifying or blocking each other's impacts.

Few studies have been conducted to assess whether or how multiple built environment changes can act in concert. This lack of research is likely due to the complexity of such an undertaking. However, some research has been conducted that suggests synergy of some determinants in causing health impacts.

What are the health issues?

As mentioned previously, vibration can exacerbate annoyance from noise (Stansfeld & Matheson, 2003). It can also complicate efforts to understand noise impacts and synergistic impacts of noise and vibration, because "people are disturbed and annoyed by both factors; they also tend to "mix up" these effects or to perceive vibration as noise" (Berglund & Lindvall, 1995, p. 126). While some studies have shown vibration exposure to increase noise annoyance when both vibration and noise are present, others indicate that the relationship between the two is not so straightforward (Howart & Griffin, 1990; Paulsen & Kastka, 1995).

One study assessed the health impacts of noise, poor air quality, and traffic on a population experiencing all three disturbances at the same time. The study (Klæboe, Kolbenstvedt,

Clench-Aas, & Bartonova, 2000) involved surveying people who were in close proximity to a tunnel construction project about annoyance related to the smell of exhaust, dust and grime, perceived traffic safety, and noise associated with construction. In addition to the surveys, respondents' exposure to construction disturbances was modeled. The results indicated that the higher the noise levels people were exposed to, the more likely they were to be highly annoyed by exhaust smell at a specified air pollution level. Similarly, the higher air pollution levels people are exposed to, the more likely they are to be annoyed by road traffic noise at a specified noise level.

We also know that a modest change to the built environment in isolation, such as adding bicycle infrastructure, has a relatively small impact on physical activity levels. However, a recent meta-analysis of research about associations of various features of the built environment and walking concluded that the combined effect of multiple built environment variables on people's travel choices could be quite large (Ewing & Cervero, 2010).

In summary, the existing literature emphasizes the more ***concrete*** impacts of multiple changes occurring in the environment at the same time. It is reasonable to expect that some of the ***soft*** impacts caused by development scenario changes, such as anxiety and fear, may heighten the more concrete impacts such as sleep disturbance and cardiovascular disease. Though they are harder to study and quantify, these ***soft*** impacts should be considered when assessing overall health impacts.

How will the development scenario affect them?

Method used to estimate impacts

This assessment of the synergistic effects of health impacts employed the methods detailed in Section 4 Where relevant, the analysis considered the potential cumulative and synergistic impacts that are the result of other future development on Hayden Island such as the CRC, residential or island infrastructure development, or the mall redevelopment.

Impacts of the development scenario

It is reasonable to expect that Hayden Island residents, particularly those living in manufactured and floating homes, will likely experience negative cumulative and synergistic health impacts. As shown in table X, many of the health outcomes identified in this analysis will be impacted by multiple factors and will be experienced by the same population (e.g., locals). Therefore, health impacts may be compounded. For example, the mental health of local residents is likely to be negatively impacted by increases in noise, vibration and light and the potential decline in housing values. Though the table shows positive mental health impacts related to increased physical activity and employment opportunities, these positive benefits will mainly be experienced by the regional population. That is – they will not negate or minimize the negative mental health impacts on the local population.

Table 7: Summary of health outcomes affected by the West Hayden Island development scenario

	Air Quality	Noise/ Vibration	Light Exposure	Physical Activity	Traffic Safety	Community Design/ Housing	Employment
Population most impacted	**local**	**local**	**local**	**local/ region**	**local/ region**	**local**	**region**
Life expectancy				+		X	+
Premature mortality	X				X		
Chronic disease			X	+		X	+
Respiratory illness						X	
Cardiovascular illness	X	X					
Cancer							
Temporary illness/ injury				+			+
Mental health			X	+			
Depression			X			X	
Sleep disruption		X	X				
Annoyance							
Stress		X				X	
Hearing loss							
Injuries/fatalities (bike and pedestrian)					X		
Injuries/fatalities (motor vehicles)							

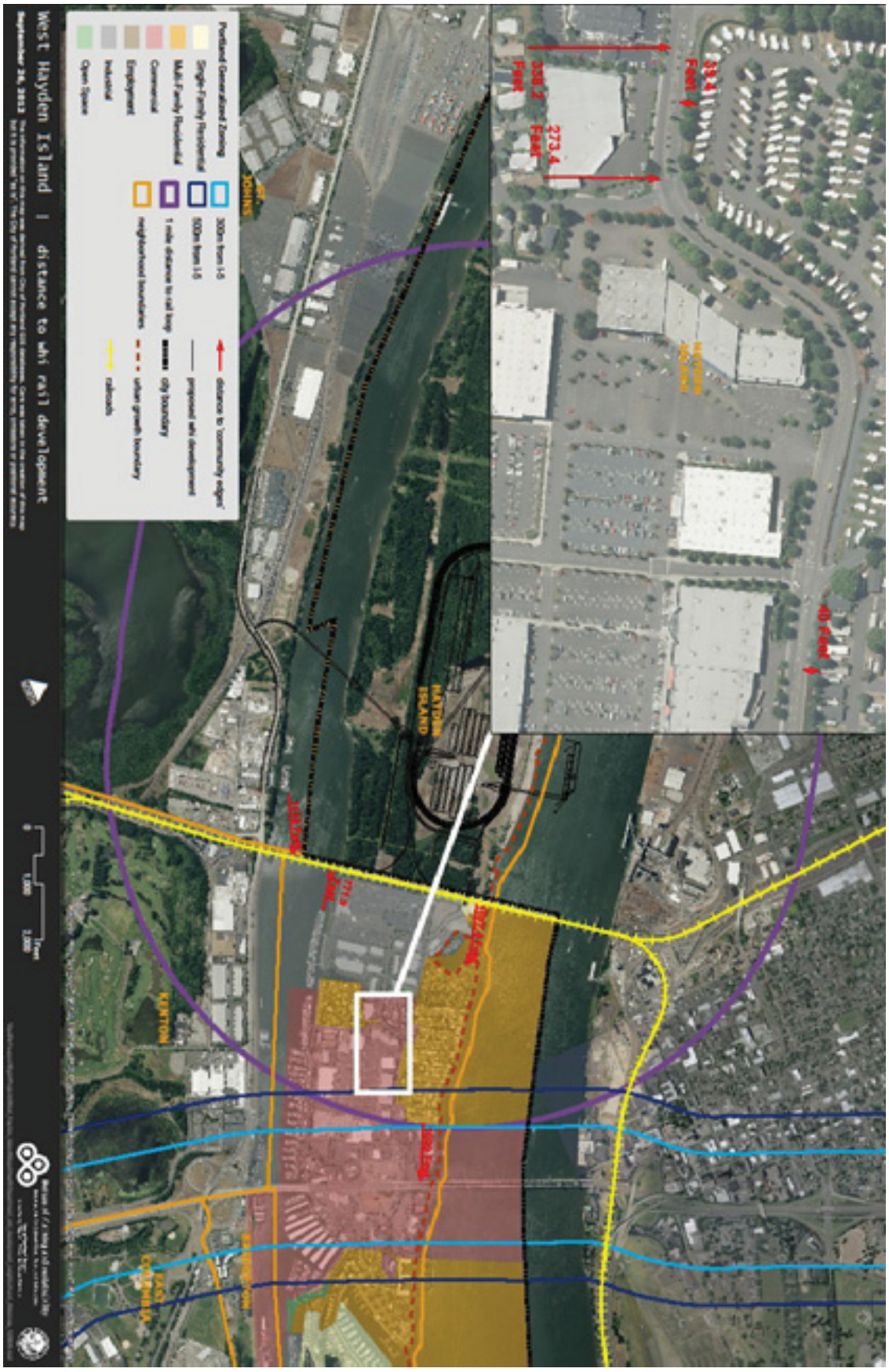
X signifies negative health impacts,
+ signifies positive health impacts

Figure 11 provides a visual representation of how some manufactured home residents may experience negative health outcomes resulting from cumulative impacts. For example, residents living in the eastern part of the manufactured home community just west of Interstate-5 live within one mile of the proposed rail yard (shown in purple) and within 500 meters of Interstate-5 (shown in dark blue), thereby being affected by both the Development Scenario and the CRC project. Studies have shown that living within these rail and major road buffers likely has negative health ramifications, as discussed in the air quality section of this analysis. It's likely that residents will be exposed to air pollutants and noise from both rail and freeway activity and will experience some degree of negative health impacts.

What don't we know?

- It is unknown what combinations of factors will produce cumulative and synergistic impacts and to what extent. If annexation and port development occur, it will be important to monitor local residents' mental and physical health over time. Surveys should be conducted in a variety of formats (e.g., in-person, web-based, by phone) and languages (e.g., English and Spanish) so that it is easy for residents to participate.

Figure 11: Aerial view of island development



By reviewing scientific literature and locally available data, this analysis has described relationships between seven health determinants or factors and certain health outcomes, as illustrated in the schematic diagram in each assessment section. In this section we will provide an overview of the health issues related to the development scenario by:

- summarizing the cumulative health impacts of the development scenario
- identifying ways that health benefits could be maximized and health harms be limited
- discussing the limitations of the analysis presented here

There is a potential to see both positive and negative health outcomes of the planned development. In the summary section below, we discuss the likelihood, intensity, and magnitude of the health outcomes that may occur as result of proposed development.

Generally speaking, the most notable negative impacts will be due to changes in air quality, noise and vibration, and community design and housing. The most likely positive health impacts will be related to newly available jobs, and improvements in transportation infrastructure and recreational facilities.

In general, the local population on Hayden Island, particularly those living in manufactured or floating homes, is likely to experience the negative health impacts, while the regional population is likely to experience the positive health impacts. All of the impacts will have the largest effects on people who live closest to the proposed West Hayden Island port site, children and older adults, people who live in manufactured or floating homes, and people with low incomes and small amounts of wealth. Many current residents fall into more than one of these categories.

There is a wide variety of strategies that could be used to maximize the health benefits and minimize the health harms associated with future development on the island. Many of the potential mitigation measures address more than one health issue, and many have already been discussed in the West Hayden Island planning process, including the negotiation of an intergovernmental agreement between the City of Portland and the Port of Portland.

The final part of this section discusses the various limitations of this health analysis, in terms of data, methods, and resources.

Summarizing health effects

One of the most pressing questions for stakeholders in the West Hayden Island project concerns the cumulative human health effects of future port development. Due to many sources of uncertainty, it is very difficult to estimate how many people will be affected by the development scenario and for how long.

In an effort to summarize the potential cumulative impacts of the development scenario, we have classified the health impacts by: scale of the impact (i.e., local or regional), the populations most impacted, the likelihood that the development scenario will lead to the health outcome, the evidence for the link to health

outcomes, the intensity of the health impact and the magnitude of the population impacted. These qualitative judgments were made by the health analysis team and are described in more detail in the Methods section. The results are displayed in Table 8 .

Table 1: Summary of potential health impacts prior to mitigation

KEY: • low | •• medium | ••• high | ? uncertain or unable to evaluate

Health effects (Factor)	Geographic extent of the impact	Types of people most impacted	Number of people impacted	Evidence in the literature for a link between the change and health outcome	Likelihood that development scenario will contribute to the prevalence of the health outcome	Intensity of the health impact
POSITIVE IMPACT: Employment						
Increased life expectancy	region	Hires for family-wage port jobs (e.g., longshore workers)	2,300-3,700 people in the region	•••	•	•
Improved mental health				•••	••	•
Decreased chronic disease				•••	••	•
Decreased temporary injury & illness				•••	••	•
POSITIVE IMPACT: Physical Activity						
Increased life expectancy	local/region	People in the region who utilize the open space/trail, improved bicycle and pedestrian facilities. Local residents will have improved access to goods and services on the island.	?	•••	•	•
Improved mental health				•••	••	•
Decreased chronic disease				•••	••	•
Decreased temporary injury & illness				•••	••	•

KEY: • low | •• medium | ••• high | ? uncertain or unable to evaluate

Health effects (Factor)	Geographic extent of the impact	Types of people most impacted	Number of people impacted	Evidence in the literature for a link between the change and health outcome	Likelihood that development scenario will contribute to the prevalence of the health outcome	Intensity of the health impact
POSITIVE IMPACT: Traffic Safety (Motor Vehicles)						
Decreased injury	Local/region	Drivers and passengers	Number of people impacted unknown but approximately 11 fewer collisions annually	•••	•••	••
Decreased premature death				•••	••	•••
NEGATIVE IMPACT: Traffic Safety (Bicyclists and Pedestrians)						
Increased injury	Local/region	Bicyclists and pedestrians in close proximity to truck traffic on Hayden Island	?	•••	••	••
NEGATIVE IMPACT: Community Design						
Increased housing related health conditions	local	Manufactured home park residents, floating home residents	Up to 2,000 Hayden Island residents	•	•••	••
Decreased economic stability				•	•••	•••
Decreased social opportunities				•	••	?

KEY: • low | •• medium | ••• high | ? uncertain or unable to evaluate

Health effects (Factor)	Geographic extent of the impact	Types of people most impacted	Number of people impacted	Evidence in the literature for a link between the change and health outcome	Likelihood that development scenario will contribute to the prevalence of the health outcome	Intensity of the health impact
NEGATIVE IMPACT: Air Quality						
Increased respiratory illness	local	Manufactured home park residents, floating home residents	People who live in the 440 manufactured homes and approximately 150 floating homes	•••	••	••
Increased cardiovascular illness				•••	••	••
Lung cancer				•••	•	•••
Decreased life expectancy				•••	?	•••
NEGATIVE IMPACT: Light Pollution						
Increased sleep disturbance	local	Manufactured home park residents, floating home residents	People who live in the 440 manufactured homes and approximately 150 floating homes	••	••	••
Increased cancer				•	•	•••
Increased obesity and diabetes				•	•	••
Increased depression				•	?	?
NEGATIVE IMPACT: Noise & Vibration						
Increased annoyance	local	Manufactured home park residents, floating home residents	People who live in the 440 manufactured homes and approximately 150 floating homes	••	•••	•
Increased stress				•	••	••
Increased sleep disturbance				•	••	••
Increased mental health problems				•	•	•
Increased hearing loss				•••	?	•••
Increased cardiovascular disease				••	•	?

The health analysis found that all seven factors identified as concerns may affect health—some in negative ways and some in positive ways.

Negative health impacts

The most likely **negative** health impacts are related to air quality, noise and vibration, and community design and housing. These factors show potential for negatively impacting health by increasing respiratory illness, cardiovascular disease, cancer, sleep disruption, and economic instability.

Positive health impacts

The most likely **positive** health impacts of the development scenario are related to newly available, family wage jobs and improvements in opportunities for physical activity, including the beneficial effects of improved infrastructure for walking and biking, as well as open spaces and trails for recreation. These factors show potential for positively impacting health by increasing life expectancy, decreasing chronic disease, improving mental health, and reducing injuries.

Cumulative and synergistic impacts

It is reasonable to expect that Hayden Island residents, particularly those living in manufactured and floating homes, will likely experience negative cumulative and synergistic health impacts. Many of the health outcomes identified in this analysis will be impacted by more than one of the seven factors, and by multiple development projects. For example, residents' mental health may be negatively impacted by noise, light, and community design/housing changes due to West Hayden Island development as well as the construction of the Columbia River Crossing.

Many of the potential negative health outcomes we identified, will be experienced by the same population – residents of Hayden Island living in manufactured or floating homes. These residents may experience decreases in life

Populations most impacted

In general, the local population on Hayden Island, particularly those living in manufactured or floating homes, is likely to experience the negative health impacts from the development scenario. Since the regional population is most likely to experience the positive health impacts, the positive health impacts from the development scenario will likely not negate or minimize the local population's negative health impacts.

The closer people live to the proposed West Hayden Island development site, the more likely they are to be affected. Children, older adults, and people with low incomes are especially vulnerable to many of the potential impacts. Residents of manufactured homes and floating homes are especially susceptible to economic challenges due to the potential decrease in property values and personal wealth. Many of the current Hayden Island residents belong to more than one of these vulnerable groups.

expectancy and increases in chronic disease, respiratory illness, cardiovascular illness, cancer, mental health problems, sleep disruption and stress due to environmental changes related to more than one of the seven factors we assessed. Therefore, health impacts may be compounded.

Maximizing benefits and minimizing harms

The sections below offer a menu of strategies that could be used to maximize the health benefits and minimize the health risks and harms that might be associated with the development scenario. These strategies were identified through the health analysis team's review of scientific literature, established best management practices, recommendations of Health Impact Assessments of other port projects, comments gathered through the West Hayden Island planning process, and the professional experience of the health analysis team.

This extensive list is intended as a resource for Hayden Island stakeholders, who have a long history of working to identify and prioritize the resources and needs of the island and the larger community. We urge decision-makers and the broader public to pay special attention to strategies that support equity by mitigating disproportionate burdens and benefits identified in the health analysis.

Following the pillars of the Portland Plan and creating a healthy, equitable, educated, prosperous city requires decisions that are fair for people of all ages, locations, physical abilities, and housing types. Hayden Island is the site of many development projects that support the region as a whole, but the value of these benefits cannot be fully realized if it is produced at the expense of Hayden Island residents' health.

Several overarching themes tie together many of the strategies listed here. First, many entail ongoing monitoring of health hazards – air pollution, noise, and light – if the proposed development proceeds. In combination with ongoing monitoring, the use of adaptive management practices would support the creation of plans that respond to changes on the island. Such an approach would allow for revisiting stakeholders' concerns as the West Hayden Island project develops within the context of other changes on the island (e.g., CRC construction).

Many of the strategies listed below would address multiple health impacts; for example, planting trees could both improve air quality and reduce the distance that sound travels. Finally, the construction of a West Hayden Island bridge to Marine Drive would eliminate many of the truck derived impacts from the development scenario.

AIR QUALITY

Dust and emissions from port operations and construction

1. Require that dust generated by marine terminal development or construction activities meet or exceed DEQ standards (note: DEQ's standards are more stringent than federal standards).

2. Use a carbon and energy life-cycle cost analysis during facility design, with the goal of achieving a more energy efficient product with a smaller carbon footprint verses conventional design.
3. Minimize vehicle idling through design of efficient terminal entry and exit gates, as well as through the adoption of an idle reduction policy that prohibits unnecessary idling by trucks and equipment.
4. Incorporate renewable or alternative energy sources into facilities design where technologically feasible and practical to meet the Port's Carbon Reduction and Energy Management Plan.
5. Consider facility designs that enable on-site use of alternative fuels or distribution to transportation providers.
6. Provide electrical infrastructure and the underground backbone to allow electrification of multi-modes: ships, locomotives, and trucks.
7. Conduct long term periodic perimeter monitoring to collect air samples of dust.
8. Use dust controls: enclosed silos, baghouses, food oil based sprays for grain dust or non-agricultural products to reduce dust.
9. Place spouts further in ship holds during loading of material or installation of apparatus to slow material during exit from the spout (e.g,. adjustable gates or bullets).
10. Enclose conveyors and baghouses.
11. Enclose all material transfer sites.

Marine and rail sources

1. Develop agreements with railroads (Union Pacific and BNSF) to voluntarily reduce locomotive diesel PM emissions in and around the new terminal railyard as a pilot, based on existing California-wide agreement.
2. Include in agreements with railroads preparation of a health risk assessment of the new yard to a) determine projected cancer risk from rail activity, and b) suggest specific mitigation steps.
3. Establish a grant program, lower terminal access fees or other incentives to encourage tug assist vessels to accelerate fleet and engine turnover, repowering and retrofits.
4. Increase on-site diesel engines use of ultra-low sulfur diesel fuel and direct to-rail loading.
5. Meet the North American Emission Control Area fuel requirements by increasing use of alternative fuels and fuel efficiency.
6. Install shore-side power at Terminals to allow some ships to completely turn off their engines while in berth.
7. Continue efforts already in place to replace older engines including repowering tugboats and the port's dredging vessel.

Heavy duty vehicles on the road and/or port equipment

1. Work with partners to integrate funding and establish a grant program to accelerate fleet and engine turnover, repowering and retrofits.
2. Set a goal of having 80% of trucks entering the port meet the 2007 EPA particulate matter emissions standards by 2020, or prior to construction of the new terminal (Port of Seattle, 2012).
3. Require clean diesel fleets for publicly-funded projects.
4. Explore an incentive payment scale to pay higher compensation to contractors who retrofit existing machinery and/or replace older fleets.
5. Provide truck services such as fueling, repair, bathrooms, food and beverages at the Port to reduce reasons for trucks to enter neighborhoods.
6. Reducing vehicle idling through more efficient traffic movement.
7. Switch to cleaner-burning engines and fuels in cargo-handling equipment.
8. Retrofit older equipment with diesel oxidation catalysts, which breakdown harmful pollutants before they are emitted from an engine.

Light duty vehicles on the road

1. Conduct regular area air quality monitoring along North Hayden Island Drive.
2. Implement transportation demand management programs where employees are provided incentives for carpooling, bicycling or using alternative transit.
3. Consider operations and transit improvements.
4. Support Metro's regional transportation planning process to reduce vehicle miles traveled.
5. Improve fuel efficiency and increase use of cleaner fuels (future reductions will also be seen with stricter emission and fuel standards).

Rail and motor vehicle-related emissions

1. Maintain existing tree cover and plant additional low-maintenance trees.
2. Consider purchasing the parcel of land for sale northeast of the rail line.plant it with trees, and turn it into a park in order to buffer the north side of the existing manufactured home park from rail-related air pollutants.
3. Purchase and plant additional trees on resident property located within 300 meters of North Hayden Island Drive.
4. Install air ventilation and filtration in residential units in buildings along North Hayden Island Drive and near Interstate-5 (UC Berkeley Health Impact Group, 2010).

NOISE AND VIBRATION

1. Conduct a noise study, coordinated by the City's Noise Control Office, that focuses on both indoor residential and outdoor noise levels to help develop appropriate mitigation strategies.
2. Implement long-term, year-round noise monitoring at the terminal perimeter.
3. Follow the City of Portland's noise code (Title 18) or the World Health Organization's Guidelines for Community Noise (whichever is more stringent) in port development and operations and in future land use and development planning (especially related to sensitive uses like schools or health services centers).
4. Require trucks operating to and from the port to meet noise guidelines such as those included in the City of Portland's noise code (Title 18) or the World Health Organization's Guidelines for Community Noise (whichever is more stringent).
5. Minimize use of trucks within the port. Explore other options for movement within the property.
6. Mandate longshoreman's association training on railcar braking techniques to reduce train car noise impacts.
7. Restrict freight vehicles on local service streets and streets in close proximity to residential areas.
8. Install traffic calming devices to reduce traffic speeds. Slower speeds create less traffic noise than higher traffic speeds.
9. Utilize "quiet" pavement materials where possible to reduce road noise on truck routes on Hayden Island.
10. Develop a forested buffer between future terminal development and residential areas.
11. Install sound insulation in new construction and upgrade existing residences to minimize noise exposure.
12. Create sound walls to noise exposure.
13. Utilize separated rail crossings to eliminate train whistle noise. Per the WorleyParsons concept plan, every opportunity to avoid onsite road/rail crossings is to be pursued. This limits the need for train horn noise during terminal operations.
14. Incorporate mitigation of air-borne and ground-borne noise and vibration during facility design and construction.
15. Establish programs to monitor and minimize noise and vibration during operations. Incorporate community feedback on noise impacts through use of the community advisory committee

LIGHT

1. Adopt the Dark Sky Model Lighting Ordinance, created by International Dark Sky Association and the Illuminating Engineering Society of North America, at the City of Portland. Implement compliant port lighting. Lighting ordinances establish regulations on fixture types, to help mitigate light pollution and light trespass to neighboring properties. Relevant ordinances have been passed in Oregon municipalities including Wilsonville, Eugene, and Bend.
2. Develop and implement a site lighting plan, including Dark Sky standards, designed by a certified lighting specialist at the beginning of the project, in coordination with facility and site planning experts and including regular updates to evolve with technology.
3. Improve lighting fixtures by using shields, and angle lights to where they are needed to limit glare on neighboring communities
4. Maintain the existing vegetated buffer around the future terminal footprint and limit lighting around terminal edges.
5. Turn lights off when not in use, or use a timer or sensor to turn off lights.
6. Use minimum wattage and warm white tones allowed meeting federal/state standards.
7. Incorporate lighting zones that balance facility lighting needs with natural resource areas during facility design.
8. Utilize Dark Sky Design guidelines for facility lighting with full cutoff lenses.

PHYSICAL ACTIVITY

1. Ensure that bicycle and pedestrian network improvements related to the development scenario provide Hayden Island residents with safe, convenient access to newly created outdoor recreation opportunities. Consider:
    a. developing recreational trails and a potential non-motorized boat launch on West Hayden Island consistent with the concept plan.
    b. developing public trail head facilities on West Hayden Island with a small parking area and interpretative signage.
    c. purchasing adjacent land east of the railroad bridge for recreational and buffering improvements.
    d. developing a community center with nature based/cultural focus on Hayden Island.
2. Promote and improve the local and regional accessibility of new outdoor recreational opportunities via media campaigns and way-finding infrastructure.

3. Follow the City of Portland's best practices for bicycle and pedestrian infrastructure planning and design (contained in their Pedestrian Design Guidelines and the Bicycle Plan for 2030) when planning new bicycle and pedestrian infrastructure related to the development scenario.

Ensure, with street improvements to Hayden Island Drive, that bicycle and pedestrian improvements are made that will connect to future CRC improvements. Also considering safety crossings and modal separation for the island community.

TRAFFIC SAFETY

Traffic safety could be greatly enhanced by separating travel modes from each other in the roadway. This could be achieved through the installation of bike lanes or enhanced bike lanes with buffer striping of the development of a multi-use path – such as the one presented in the Hayden Island Plan.

Right of-way improvements could include sidewalks of adequate width with a buffer, such as planter strips or swales, between pedestrians and vehicle traffic. On-street vehicle parking also provides a buffer for pedestrians, but parked vehicles can also limit pedestrian and vehicle operator visibility.

For pedestrians crossing streets with higher traffic volumes it is helpful to reduce the distance by having narrower vehicular travel lanes or overall roadway width. For truck streets, reduced lane widths should be balanced with adequate truck operating space and visibility for the drivers. Curb extensions provide an extension of the pedestrian facility further into the street for both shorter crossing distance and improved visibility. Other physical roadway improvements include mid-point crossing facilities and pedestrian median islands.

There are also tools that involve signage and signalization for improving pedestrian crossing safety. These include signalized intersections that serve both traffic and pedestrian crossing functions, pedestrian signal changes such as increased pedestrian crossing times, and flashing beacons.

Various streetscape improvements can also improve pedestrian safety and comfort. Street trees that serve as both as a buffer and provide shade and cooling. Street lighting (illumination) provides improved visibility for pedestrians at night. Streetscape improvements can soften the otherwise hostile environment of broad streets and large parking lots. There is no transit service currently planned for North Hayden Island Drive, but with the CRC project a new Light Rail Transit station will be located near the SuperCenter. Pedestrian and bicycle access to this high quality transit service should be considered as part of the North Hayden Island Drive street design.

Specific possibilities include:

1. Review of local street routing choices and West Hayden Island Bridge. Consider keeping trucks off town center streets through the Jantzen Beach SuperCenter Development (Tomahawk Island Drive).

2. Consider constructing the rail and Hayden Island Drive road improvements as some of the first elements of the project, so that this mode could be used for the delivery of materials and equipment.
3. Consider traffic calming devices and buffers between roadway and residential areas.
4. Prior to each terminal phase, review construction management plans with HiNoon and the Advisory Committee to address traffic, noise and vibration.
5. Identify and reserve a suitable construction staging area in North Rivergate that could be used for the proposed barge access during the first phase of construction.
6. Provide adequate lane widths and overall roadway widths for truck streets for safe operating conditions and to reduce the potential of curb, signage and street tree damage. But these widths should be taken into consideration along with the other roadway users (pedestrians, cyclists).
7. Provide separation between cyclists/pedestrians and vehicles with a multi-use path. This would provide maximum separation from traffic on NHID and contribute to the recreational environment of the island.
8. Consider tools such as signage and signalization for improving pedestrian crossing safety. These include signalized intersections that serve both traffic and pedestrian crossing functions, pedestrian signal changes such as increased pedestrian crossing times, and flashing beacons.

COMMUNITY DESIGN AND HOUSING

Community design

1. Create a community center on the island, through land acquisition or donation.
2. Create an island shuttle service with discount fares for residents.
3. Designate floating homes as an historic district/heritage site (which may help preserve the structures).

Housing-related health conditions

1. Provide realty and relocation assistance services for residents.
2. Create a land trust/limited equity housing cooperative at manufactured home community.
3. Create a fund for upgrade and replacement of mobile homes.

Economic instability

1. Create a housing trust fund.
2. Create a low-interest loan fund accessible by island residents, including preferential programs for manufactured and floating home residents.

3. Consider a port buyout of residential properties near the development site, particularly for land that hosts manufactured homes.

EMPLOYMENT

Occupational safety

1. Work with Oregon OSHA to ensure that workplace safety best practices are strictly adhered to in the design and operation of future port facilities.
2. Use the Federal Highway Administration's Highway Safety Manual when designing transportation improvements related to the development scenario.

Economic opportunity

1. Implement a local hiring agreement to give North Portland residents priority for jobs on West Hayden Island created by the development. The agreement should include specific outreach to Hayden Island residents.
2. Give preference to minorities and minority-owned firms when hiring workers and contractors.

Limitations of the analysis

Like any assessment project, this analysis has its strengths and its shortcomings. There is additional discussion of specific limitations in each assessment factor section. This section describes the overall limitations of this analytical approach.

Lack of a specific development proposal

The ability to estimate the potential health impacts is limited by lack of detail about possible future development. The types of goods passing through the terminal also matter in estimating health impacts. For example, the movement of grain is associated with increased dust, while the movement of autos is associated with increased noise during unloading. The movement of some goods may require more handling and therefore produce more jobs. Some goods net a higher profit which may more positively impact the regional economy. While this analysis provides a reasonable summary of the potential outcomes of the annexation and zoning decision being made at this time, additional analysis would be appropriate at the time of future development, to evaluate the specific development plans.

Evaluating only one development scenario

The development scenario is just one vision for how Hayden Island may develop, so using it as the template for assessment may overlook health impacts that would occur under different development scenarios.

Data shortcomings

In many cases, information that would help answer questions about the health impacts of development was unavailable. In addition, data was limited about the effect of other future projects on Hayden Island.

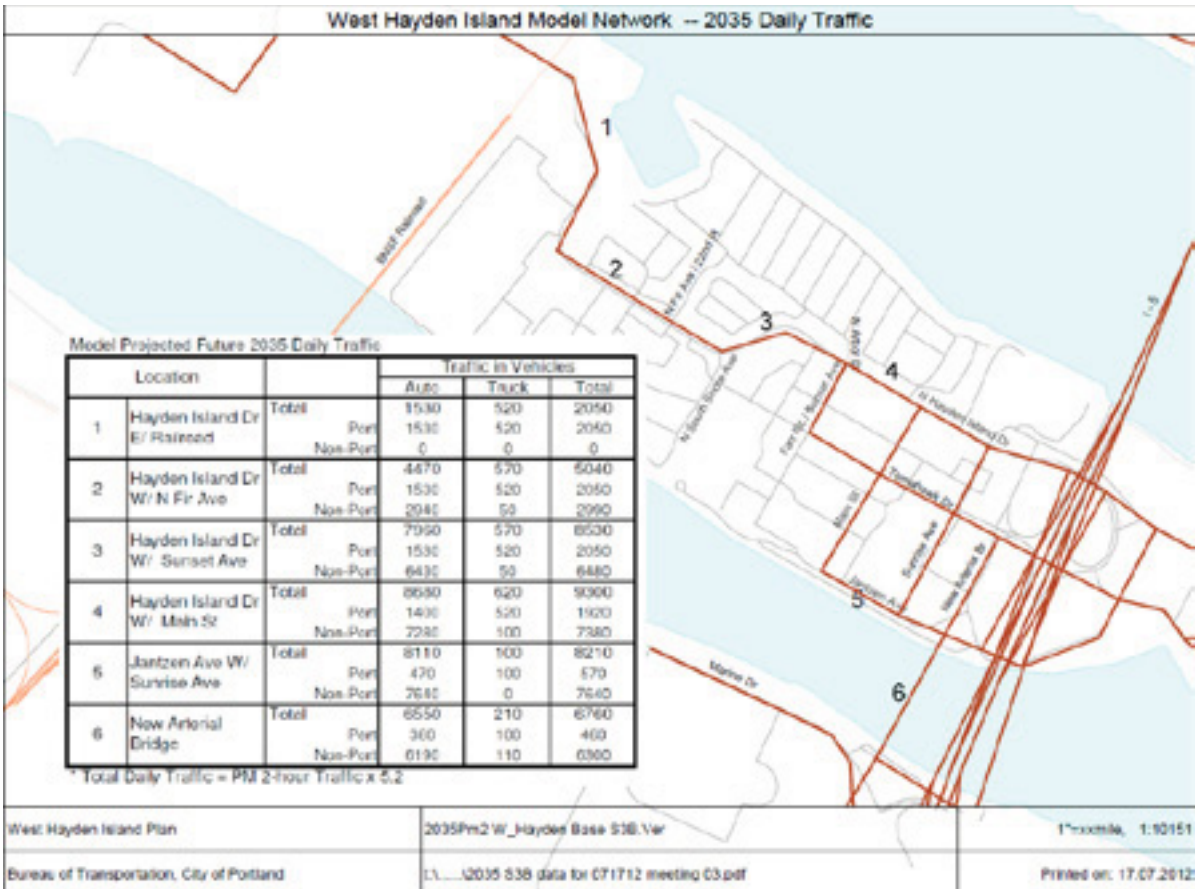
Lack of local health outcome data -Another limitation is the lack of health outcomes data at small geographic scales. It is virtually impossible to know what proportion of residents, in a small area, are affected by specific health conditions. When these data do exist, confidentiality considerations often prevent reporting them for small communities like Hayden Island. Further, while there are inequities in disease burdens among social groups (Bhat, 2011), data to compare these groups at a small geographic scale are often unavailable or invalid because they misclassify people; this is especially problematic when attempting to research health issues in groups such as Native Americans (Curry-Stevens & Cross-Hemmer, 2011).

Population projections in the future -Estimates about the future population of the island are based on expected land uses in 2035. The projections do not classify this estimated population by age group or by race/ethnicity. This is problematic because there are significant health and social differences based on these variables. Not having this demographic information may hinder our ability to identify vulnerable populations and accurately gauge potential health impacts.

Time and resource constraints

Lastly, the depth of this analysis and the detail with which it is presented were limited by time and resource constraints. The timeline of the West Hayden Island planning process required completing the project very rapidly and with personnel who were committed to work on multiple other projects that serve public needs. Developing the project scope and conducting the analysis was particularly challenging given the uniqueness of the project and the necessity of developing a collaborative process for an assessment approach that was new to all of the partners involved.

Answering many of the questions about health identified by stakeholders would require very sophisticated measurement and computation that goes beyond the expertise available at, or affordable to, local governments and community-based organizations. This analysis represents an innovative collaboration between government agencies and nonprofit organizations to assess the health impacts of a proposed development project. It provides a health perspective on decisions related to the potential annexation and development of West Hayden Island, but it is beyond the project scope to provide quantitative estimates of health impacts or conclusive recommendations about how development should proceed.



Summary of PBOT traffic project, Greenhouse Gas and Traffic Safety Analyses

Traffic Analysis

The plot above displays projected daily traffic volumes for year 2035. For various locations on Hayden Island the estimated traffic volumes for both automobiles and trucks are provided for both the WHI Port generated traffic and the non-Port traffic.

These daily volumes were derived from modeling output which is produced from a two hour PM peak period base. For modeling purposes daily traffic = PM 2-hour traffic x 5.2. Or to determine the 2 hour peak from the volumes listed in the plot above divide each figure by 5.2.

This data is based on a "high impact" scenario for WHI development that assumes two automobile processing terminals and one bulk terminal. The current WHI concept plan is instead proposed to include 1 auto/2 bulk terminals. This will produce about 34% fewer truck trips and 30% fewer auto trips for the Port generated traffic. So for each location on the above plot the current concept plan volumes can be determined by reducing the Port truck volumes by 34% and the auto volumes by 30%.

VI. APPENDIX A

Under the "high impact" scenario approximately 50% of the trucks from WHI development would be heavy trucks. Under the current WHI concept plan approximately 60% of the trucks from WHI development would be heavy trucks.

The total daily traffic volumes for autos and trucks for all streets on Hayden Island are expected to increase from 28,800 currently to 58,800 by 2035. This is a 104% increase. With development of the WHI concept plan daily volumes are expected to increase to 61,800 by 2035, a 115% increase over current volumes.

The total daily truck volume estimate for all streets on Hayden Island in 2035 without WHI is 1,330 trucks based on existing traffic counts and Regional Transportation Plan data. The truck volumes added by WHI is estimated to be 516 for all truck types under the high impact development scenario.

The traffic analysis was prepared to be consistent with the Regional Transportation Plan, the adopted Hayden Island Community Plan and the Environmental Impact Statement for the Columbia River Crossing project.

The transportation modeling analysis conducted for the WHI concept plan process and resulting findings has been determined to be in compliance with the State Transportation Planning Rule (TPR) as confirmed by the Oregon Department of Transportation (ODOT).

This information is primarily summarized from the WHI Transportation Modeling Analysis: Phase 1 Planning Level Network Analysis by PBOT dated 12/9/11. The WHI Supplemental Traffic Assessment prepared by DKS, dated 7/16/12 is also used as a source.

VMT and GHG Assessment

The vehicle miles traveled (VMT) and Greenhouse Gas (GHG) assessment conducted for the WHI concept plan process is based on the same data as was used for the Traffic Analysis described above.

The purpose and appropriate interpretation of the VMT and GHG assessment is to provide an order of magnitude comparison of differences of the scenarios evaluated not the specific model output. Meaningful data would not be produced by calculating VMT or GHG on an individual street or for a small geographic area.

Three scenarios were evaluated for the VMT/GHG assessment: (1) a 2005 base, (2) a 2035 future base without WHI development, and (3) a 2035 with WHI development. Overlaid on these scenarios are two geographic areas for analysis: (1) local island streets and freeway ramps, and (2) the local island streets plus the freeway and the Marine Drive interchange and adjacent street.

Unlike the traffic analysis it is not technically valid to adjust the model output from the VMT and GHG analysis to determine the reductions which may occur as a result of the current WHI concept plan based on 1 auto/2 bulk terminals.

The WHI development produces 8% more VMT than the 2035 base case on the local island streets and 2% more VMT on the area-wide network.

The WHI development produces 12% more GHG than the 2035 base case on the local island streets and 3% more GHG on the area-wide network.

Traffic congestion relief from CRC project is the biggest factor in the difference between the 2005 base and either 2035 scenario for both GHG and VMT. GHG is more affected by vehicle congestion and speeds and ambient temperatures than VMT.

This information is summarized from the Technical Memo: Introduction of VMT and GHG Calculation for West Hayden Island Concept Plan by PBOT dated 9/5/12.

Safety Assessment

The transportation safety assessment conducted for the WHI concept plan process is based on the same data as was used for the Traffic Analysis described above. The analysis is based on Highway Safety Manual methodology.

The safety assessment evaluates both North Hayden Island Drive and the freeway ramp access street intersections. This assessment is based on street network improvements identified in the Hayden Island Community Plan and the CRC project.

Reduction in vehicle crashes are expected with the 2035 street network compared to the current network, even with WHI development. Surface streets improved by CRC and build out of streets by the Hayden Island Community Plan result in decreased crashes.

The WHI development will not significantly increase the projected number of crashes compared to the future 2035 base conditions. This is because the total traffic volume difference with and without the WHI development is small.

The increase in truck traffic with WHI development may affect safety conditions if North Hayden Island Drive if current condition is not improved. National Highway Traffic Safety Administration data trucks are not over represented in crashes. However, when crashes involving trucks occur they have higher rates of severity.

Improvements to North Hayden Island Drive over current conditions will be important for pedestrian and bicycle safety. Key factors for pedestrian and bicycle safety include improved facilities, separation from traffic, improved crossings, reduced crossing distances, traffic speed control and illumination.

The impact that high truck volumes and truck sizes have on the physical condition of roadways is a factor to be considered. If not appropriately designed and maintained the conditions of the roadway can deteriorate and cause driving hazards for other roadway users such as automobiles and bicycles.

The elderly population of island residents is an important consideration in decisions on roadway design. Issues such as limited personal mobility, reduced visual acuity and reduced hearing abilities need to be considered in both roadway network and the pedestrian network and facilities.

This information is summarized from the Technical Memo: ***Safety Assessment for West Hayden Island Concept Plan*** by PBOT dated 9/21/12 and the ***Transportation Safety Summary - Hayden Island Health Analysis*** by BPS dated 10/4/12.

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