FINAL ENVIRONMENTAL IMPACT STATEMENT
and SECTION 4(f) and 6(f) EVALUATIONS
SR 520 BRIDGE REPLACEMENT AND HOV PROGRAM

MAY 2011

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

Attachment 14
Health Impact Assessment

U.S. Department of Transportation
Federal Highway Administration

Washington State
Department of Transportation

SR 520 Health Impact Assessment

Tim Whelan

A bridge to a healthier community

September 2008

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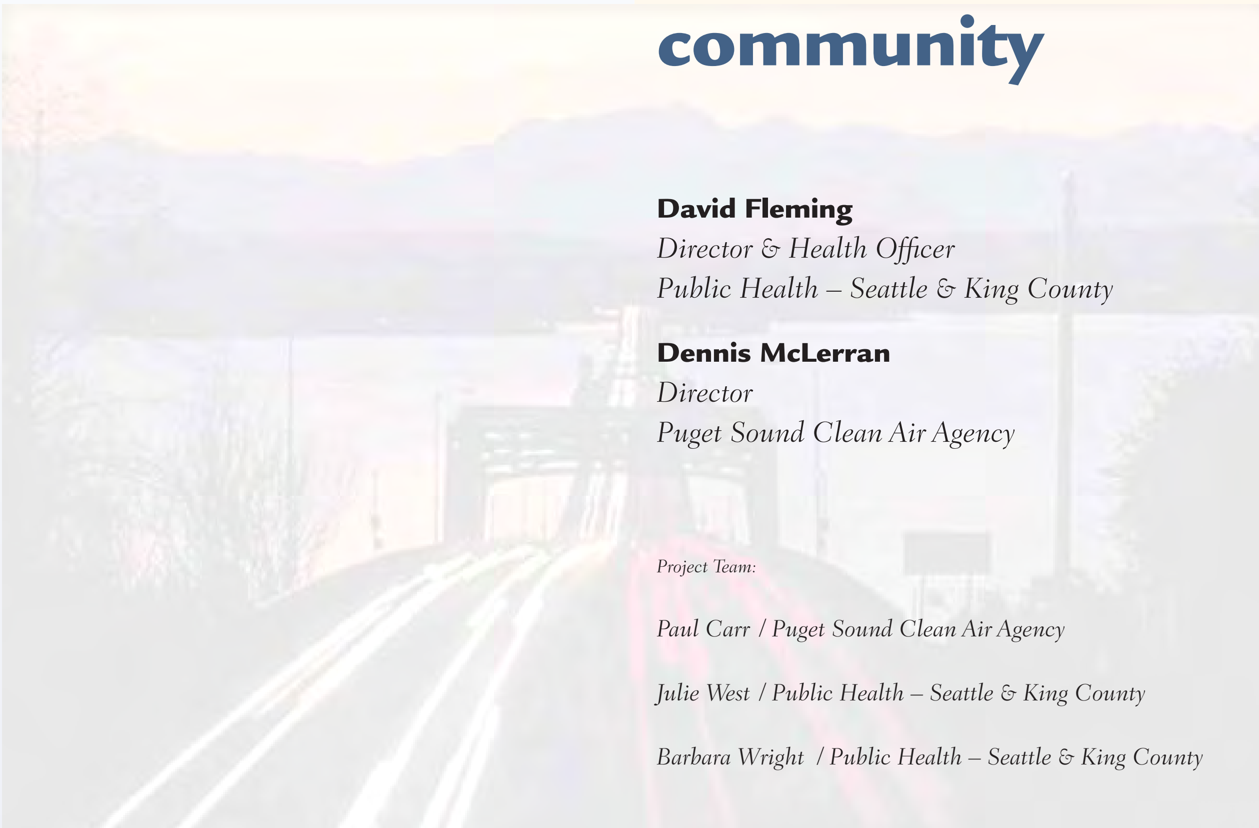
Kern Ewing

The SR 520 Replacement: A bridge to a healthier community



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Introduction

The Puget Sound region has a unique opportunity to build a transportation project that moves people throughout the region while helping to create healthy places to live, work, and play. State Route 520 (SR 520) was constructed in 1963 with little attention to the health problems associated with car emissions, neighborhood disruption, and degradation of the natural environment. Now the region has a chance to correct past oversights and approach the SR 520 Bridge Replacement and HOV Project in a way that embraces the region's commitment to providing a healthy community for all people.

Washington State Department of Transportation

Transportation planners must make decisions that will support individuals and communities in making good healthy choices. A well-designed transportation project can go much beyond its primary purpose of moving motor vehicles by positively influencing the futures of communities and the health of their residents.

DEFINING HEALTH HAS CHANGED

Just as transportation needs are much different today than they were in 1963, health concerns also have changed. With chronic diseases, such as diabetes and asthma, increasing, the social and physical environments are important aspects of health-promotion strategies. Today, health is viewed as not merely the absence of disease or infirmity, but as a state of physical, mental, and social well-being (WHO, 1946). This definition recognizes that numerous factors influence individual health and involves an examination not just of individuals, but of the larger community as well. Seen in this broader context, the SR 520 Project can be designed to support alternatives to the automobile, to reduce emissions that cause pollution, to create community connections, to provide amenities that improve mental well-being, and to contribute to a visually stimulating environment. All these actions help enhance individual health and contribute to healthy communities.

DEFINING TRANSPORTATION HAS CHANGED

The four-county Puget Sound region will gain two million people in the next 50 years, and while roads cannot accommodate all of these people, a transportation system that moves people and not just cars will be better equipped to meet their needs. In addition, a shift in how people travel is already occurring because of the rising cost of gasoline, concerns about global climate change, and the increasing use of non-motorized transportation. These changes are occurring at the same time that 76 million baby boomers reach retirement age and telecommuting and other work alternatives become more common. National reports indicate Americans are driving fewer miles, consuming less oil and using transit more. This supports the need to redefine how to plan transportation systems.

In the August 2006 *SR 520 Bridge Replacement and HOV Project – Draft Environmental Impact Statement*, the Washington State Department of Transportation (WSDOT) proposed many excellent infrastructure elements (e.g. landscaped lids, pedestrian and bicycling connections, visual design elements, and transit facilities) that would reduce vehicle emissions, create opportunities for physical activity and reconnect communities. The SR 520 mediation process and alternatives being considered continue to include these elements. To embrace the opportunity for creating healthy places to live, work, and play, it is critical that these elements be made integral to the project and not be viewed solely as mitigation or expendable amenities. This report presents the findings of the health impact assessment report and recommendations that can be incorporated into the mediation process and impact plan. These elements along with others discussed in this report would contribute to creating healthy communities for generations to come.

THE REPORT

This report provides background on why a health impact assessment was conducted for this transportation project and provides general information on the health impact assessment tool. The report explains how a transportation project can affect health and what measures can be taken to avoid unfavorable community health consequences. A more detailed looked at the research done to compile this report is included in the Appendix.

The report does not recommend one alternative over another since it is difficult to differentiate among the alternatives until the specific designs are developed. The report recommends elements that will be important in any alternative selected. The goal for this report is to help the SR 520 Mediation Group, WSDOT, and the Washington Legislature evaluate the alternatives based upon their potential health impacts.

This HIA is the latest in a series of coordination, collaboration, and partnership efforts to successfully complete the SR 520 Project. The measures recommended will require continued coordination, collaboration, and partnerships. WSDOT, Sound Transit, and King County Department of Transportation are the primary agencies responsible for implementing the recommendations, but other agencies and municipalities, such as the University of Washington and the City of Seattle are necessary partners. Community participation in the SR 520 Project has been part of its long planning history and continues today with the mediation process. This type of civic engagement and participation supports and adds to the long-term physical and social health of communities.

Washington State Department of Transportation

Executive Summary

Good health is defined as a state of complete physical, mental, and social well-being, not merely the absence of disease or infirmity. One of the great public health problems in the 21st century is chronic disease (e.g. diabetes, cardio-vascular problems, asthma). Many of the risk factors for these diseases can be traced to how our cities are built. It is clear from research that public projects impact health. With the SR 520 Bridge Replacement and HOV Project, the region has an opportunity it won't see again for at least a half-century to build communities that are healthy places to live, work, and play.

WASHINGTON GOVERNOR AND LEGISLATURE MANDATE HEALTH IMPACT ASSESSMENT

In 2007, Governor Gregoire signed Senate Bill 6099, a legislative directive to develop a SR 520 interchange design and plan for the Westside of Lake Washington through mediation for a more reliable replacement of the existing SR 520 Bridge. The directive also asked Public Health – Seattle & King County and the Puget Sound Clean Air Agency to conduct a health impact assessment (HIA) of the SR 520 Bridge Replacement and HOV Project, focusing on air quality, greenhouse gas (GHG) emissions, and other public health issues, with final recommendations to be incorporated into the Mediation Group's Project Impact Plan. The HIA research and the following report indicate that choosing the right set of features for the SR 520 Project – regardless of which of the three plans under consideration is adopted – can contribute significantly to improving the health of people in communities adjacent to the corridor and the livability of their neighborhoods.

WHAT IS A HEALTH IMPACT ASSESSMENT?

A HIA is a tool to help decision-makers recognize the health consequences of the decisions they make and provide a healthier living environment. HIAs use a combination of procedures and methods by which a policy or project may be evaluated regarding its potential effects on the health of the population, and the distribution of those effects within the population. A HIA is much like an Environmental Impact Statement, but it focuses on population health.

In the early steps of the SR 520 HIA, analysis identified nine health focus areas for research, including air quality, water quality, green space, physical activity, noise, mental well-being, safety, social connections, and emergency medical services. The research showed these nine areas are closely interrelated and connected. What happens in one of these areas has identifiable effects on other areas, so it is critical that decision-makers consider them together. To organize the findings, the report is divided into four elements that are recommended for inclusion in whatever alternative is selected. More specific information on the original health focus areas is available in the Appendix.

RECOMMENDATIONS

The SR 520 Bridge Replacement and HOV Project Draft Environmental Impact Statement published in August 2006 proposes many excellent elements that would contribute to a healthy community. These elements include pedestrian and bicycling amenities, transit improvements, design improvements, landscaped lids and green spaces, and noise reduction strategies.

No single action will solve our chronic disease challenges. Multiple actions are needed to create healthy communities. For this reason, it is critical that these elements are integral to the project and that they are supported, despite challenging budget times, for optimal health benefits.

CONSTRUCTION PERIOD

1) Reduce construction-related pollution
2) Increase traffic management
3) Provide for construction noise control

TRANSIT, BICYCLING AND WALKING

1) Increase and improve transit service to meet increased demand, attract more riders, and reduce air pollution
2) Install connected walking and bicycling facilities throughout the corridor
3) Create a common wayfinding system

LANDSCAPED LIDS AND GREEN SPACES

1) Include six landscaped freeway lids
2) Use landscaping materials throughout the SR 520 corridor, along adjacent trails and roadways and at transit stops
3) Improve and preserve the integrity of the Washington Park Arboretum, and the ability of visitors to enjoy it and other green spaces and naturals areas
4) Preserve access to the waterfront for water-related activities

DESIGN FEATURES

1) Reduce noise throughout the corridor
2) Add to the adjacent communities' visual character with art and design
3) Utilize innovative storm water management practices

Project Guiding Principles:

» Ensure health elements are integral to the project plan.

» Support all recommendations in difficult budget times for optimal health benefits.

Health Impact Assessment Background

The SR 520 Replacement and HOV Project has the potential to affect the health of individuals and communities from the beginning of construction through its entire existence.

The SR 520 Health Impact Assessment (HIA) examines these effects from a human health perspective. An example is the effect that environmental pollutants have on human health, such as toxic air emissions' link with cancer. This is a different focus than examining and mitigating environmental impacts.

GOAL OF SR 520 HEALTH IMPACT ASSESSMENT

The goal of the SR 520 HIA is to protect public health by raising the awareness of the Mediation Group and other decision makers about the relationship between health and transportation systems. This will help ensure health consequences are considered in their decision-making process for the development of an environment that supports healthy people and communities.

This section of the report outlines the HIA procedures and health focus areas investigated, then moves on to the recommendations that Puget Sound Clean Air Agency and Public Health – Seattle & King County put forth to the Mediation Group for review. The report does not recommend one alternative over another because it is difficult to determine impacts among alternatives until the specific designs are developed. The report does recommend elements that would be important in any alternative selected.

Modified from Dahlgren G & Whitehead M. (1991)

DEFINING HEALTH

The long-term goal of Public Health – Seattle & King County and Puget Sound Clean Air Agency is for the SR 520 corridor design to support healthy people and healthy, sustainable communities. The World Health Organization has defined "health" as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Defining health this way recognizes that numerous factors influence the health of individuals and the community, from individual traits to external factors such as interpersonal relationships and social-economic, cultural and environmental conditions stemming from political and community decisions (WHO, 2003) (as shown at left).

THE HEALTH IMPACT ASSESSMENT MANDATE

Senate Bill 6099, passed by the Legislature and signed by Governor Gregoire in 2007, directed the Office of Financial Management to hire a mediator to work with interested parties directly affected by the SR 520 Bridge Replacement and HOV Project (SR 520 Project) to develop a SR 520 interchange design and plan for the Westside of Lake Washington. This plan (due December 2008) is to address the effects of the project on Seattle neighborhoods and parks, including the Washington Park Arboretum, and institutions of higher education. The bill also directed Public Health – Seattle & King County and the Puget Sound Clean Air Agency to conduct a HIA of the SR 520 Project's effects on air quality, greenhouse gas (GHG), and other public health issues, with recommendations to be incorporated into the mediation project impact plan.

WHAT IS A HEALTH IMPACT ASSESSMENT?

A HIA is similar to the more familiar "environmental impact assessments" conducted for more than three decades under the National Environmental Policy Act (NEPA) and in Washington, the State Environmental Policy Act (SEPA). The key difference is that while NEPA and SEPA evaluations focus on the environmental effects of a project, HIAs focus on how a project is likely to affect human health.

> **"Health…a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."**
>
> *World Health Organization*

HIA is a combination of procedures and methods by which a policy or project may be judged as to its potential effects on the health of the population, and the distribution of those effects within the population. It is a tool to help decision-makers recognize the health consequences of the decisions they make so they can contribute to a healthier living environment. HIAs have been used widely internationally, in places such as Europe, Canada, and Australia. HIA methodology is still evolving in the United States. Because the nature of the action being analyzed influences the HIA, detail in these assessments can vary from a simple checklist to a more extensive review of research and other relevant information. HIA strives to anticipate potential consequences for decision-makers and to deliver a set of recommendations intended to minimize health risks and maximize health benefits.

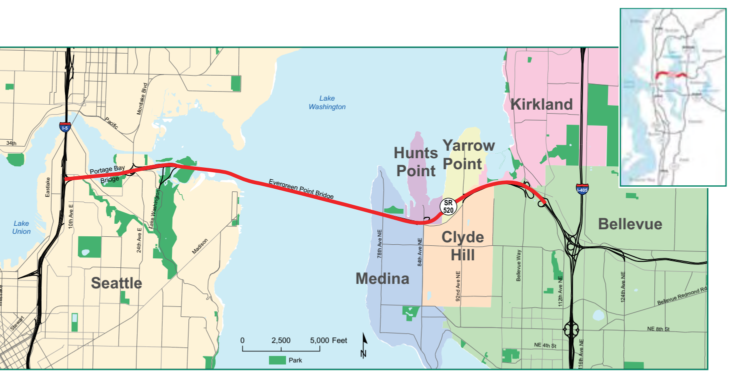
The SR 520 Project is currently undergoing NEPA/SEPA analysis. A *SR 520 Bridge Replacement and HOV Project – Draft Environmental Impact Statement* (DEIS), completed in August 2006, provided information on 17 environmental disciplines. A Supplemental DEIS (SDEIS) studying new design options from the project's mediation process is underway and planned for publication in late 2009. A Final EIS in 2010 will respond to public comments on the DEIS and SDEIS.

The SR 520 HIA made use of relevant data from the DEIS analysis, and although the DEIS and HIA processes have different goals and are independent in their conclusions, the use of the previously prepared DEIS data provides the two analyses with a consistent information base.

Health Impact Assessment Background
Continued

HEALTH IMPACT ASSESSMENT PROJECT AREA DESCRIPTION

The SR 520 Project impacts neighborhoods, the Washington Park Arboretum, the University of Washington, and the movement of goods and people in the Puget Sound region. Currently, SR 520, spanning Lake Washington from I-5 in Seattle to just west of I-405 in Bellevue, consists of four total lanes with HOV lanes existing only east of the floating bridge. The SR 520's Evergreen Point Bridge is one of two east-west bridges across Lake Washington in King County. Approximately 155,000-160,000 vehicle drivers and passengers cross the bridge each day.



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The HIA focused on the project design mandated by the Legislature in which the SR 520 will be a "4+2" configuration – six lanes, with two general-purpose lanes and one carpool lane in each direction. The bridge will be designed to withstand major earthquakes and windstorms up to 95 mph. The new SR 520 will have increased transit service that will make bus trips more frequent and reliable. It is also planned to have a bridge pathway for walking or bicycling across the lake, shoulder lanes to keep traffic flowing in the event of stalled vehicles, and new interchanges to reduce traffic impacts on communities near the corridor.

THE WORK OF THE SR 520 MEDIATION GROUP

The 33-member Mediation Group representing parties interested in the SR 520 Project began meeting in September 2007. Since that time, it has developed three design alternatives specific to the Westside – known as A, K and L – for further evaluation in the SDEIS.

COMMON ELEMENTS OF THE ALTERNATIVES INCLUDE:

- A six-lane corridor including two general-purpose and one HOV lane in each direction.
- Lids at I-5, at 10th Avenue and Delmar Drive East, and at Montlake Boulevard on the Westside.
- Bicycle and pedestrian connectivity (across the bridge and to adjacent communities).
- Exclusion of a median freeway transit stop.
- Reversible direct access to and from the I-5 express lanes.

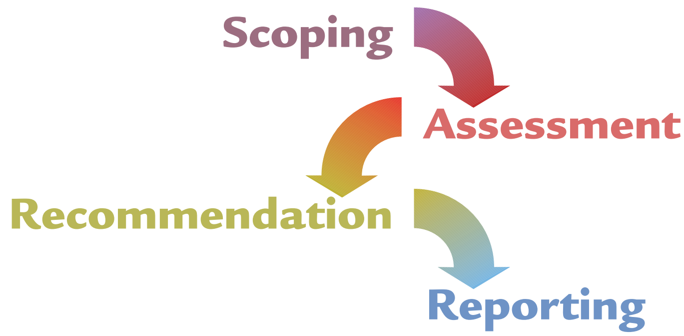
Baseline design information provided by WSDOT for each of the alternatives is outlined below (the summary is from June 17, 2008 Mediation Group work session).

ALTERNATIVE	BASE DESIGN ELEMENTS
A	» Includes an interchange at Montlake Boulevard, similar to the configuration of the existing interchange » Does not include Lake Washington Boulevard ramps » Adds a second Montlake bridge parallel to the existing Montlake Bridge » Includes a westbound transit-only off-ramp to Montlake Boulevard
K	» A low roadway profile » Includes quieter pavement » Includes a berm over the roadway at Foster Island » Includes a single-point urban interchange under the mainline SR 520 located in the east Montlake area near the existing Museum of History and Industry » Includes a tunnel under the Montlake Cut » Separates freeway and local traffic across the Montlake Cut, allowing Montlake Boulevard to be a local traffic access roadway » Includes access to and from SR 520 and the Arboretum with a roundabout at the terminus of a new roadway parallel to the existing Lake Washington Boulevard
L	» Includes a single-point urban interchange over the SR 520 mainline at the east Montlake area near the existing Museum of History and Industry » Includes a second draw bridge over the Montlake Cut » Includes Lake Washington Boulevard ramps

The three alternatives are similar in many ways, except for how the Westside interchange is designed and the consequent cost of construction. The health impact differences are difficult to estimate until the specific designs are developed. For these reasons, the SR 520 HIA review focused on a broad view of the SR 520 Project's design features (including the alternatives' common elements) as indicated in Senate Bill 6099. The specific design decisions will have important implications for individual and community health.

THE RESEARCH STEPS

Although HIA's level of detail can vary, generally the analysis is done in a step-wise manner. The SR 520 HIA was completed in the following stages:



1) SCOPING to identify health focus areas to be researched in the analysis: Through a review of previous HIA reports, the SR 520 DEIS, and public and Mediation Group comments, the SR 520 HIA team selected the following nine health focus areas to review air quality, water quality, green space, physical activity, noise, mental well-being, safety, social connections, and emergency medical services.

2) ASSESSMENT of how population health could be affected by the transportation project: As the HIA progressed, literature and report reviews and discussions with stakeholders were summarized in background papers for the nine health-focus areas. A greenhouse gas analysis was also completed. These reports demonstrated that the initial focus areas were highly interrelated and connected.

3) RECOMMENDATION development to identify project features that benefit population health: The recommendations were organized into the following critical health elements: Construction Period; Transit, Bicycling and Walking; Landscaped Lids and Green Spaces; and, Design Features. Specific recommendations were then developed within each of these categories.

4) REPORTING of the assessment findings and recommendations to the Mediation Group and other decision makers through this report

When determining the nine issues for the assessment review, influential community behaviors and social and environmental conditions were considered. The nine background papers were prepared by reviewing research that linked the issue to the SR 520 Project. These reports, provided in the Appendix, are not intended to replace discipline reports required through the NEPA/SEPA process, but rather to complement and provide information focused on population health outcomes.

The general premises used when reviewing the areas were:

AIR QUALITY – Clean, healthy air is important for public health, quality of life, and climate protection.

WATER QUALITY – Clean water is essential to protecting human, plant, and animal health.

NOISE – Reducing community noise decreases related annoyance levels and may play a positive role in other health areas.

GREEN SPACE – Parks, gardens, arboretums, bicycle and walking paths, trees, and urban landscaping all provide a respite from the urban landscape and contribute multiple health benefits.

MENTAL WELL-BEING – Positive mental well-being can be realized from physical activity, stress reduction, feelings of safety, and exposure to natural areas.

PHYSICAL ACTIVITY – Regular physical activity can improve quality of life as well as reduce the risk of numerous chronic diseases.

SAFETY – Feeling safe and secure at home, work, and play and in the community is basic to a sense of well-being.

SOCIAL CONNECTIONS – Social networks, trust, reciprocity, and civic engagement develop through community interactions affect health and well-being.

EMERGENCY MEDICAL SERVICES – Emergency medical services increase survival and reduce disability from out-of-hospital emergencies.

HEALTH IMPACT ASSESSMENT RECOMMENDATIONS

The reviews highlighted that many of these topics are interrelated and interdependent, and that SR 520 Project design elements have the potential to influence several focus areas. In the discussion that follows, the recommendations are grouped into four categories:

- Construction Period
- Transit, Bicycling and Walking
- Landscaped Lids and Green Spaces
- Design Features for Healthy Communities

Health Impact Assessment Recommendations

Construction Period

Washington State Department of Transportation

INTRODUCTION

The SR 520 Project is expected to require seven or more years to build. The construction period can produce detrimental effects on health due to exhaust emissions, congestion, and longer travel times in the corridor. Project sponsors, such as WSDOT, have considerable experience at reducing impacts during construction, by controlling construction-related dust, working in travel lanes only during evening hours, and raising public awareness of the project through media campaigns. Many of the measures recommended in this report are also included in the SR 520 Draft Environmental Impact Statement. All of these actions have potential health benefits.

CONSTRUCTION AND AIR QUALITY

Unless avoided or reduced, air emissions associated with project construction can affect people in and near the corridor. Construction vehicles and equipment, and vehicles hauling materials and equipment through residential neighborhoods and commercial areas can expose equipment operators, pedestrians, bicyclists, and residents to fine particle and diesel particulate matter emissions. They can also cause traffic congestion, which can result in additional air pollution.

WSDOT follows accepted industry practices to control dust on its construction sites and from the vehicles working on the project. Readily available technology can be purchased or installed on equipment to reduce harmful emissions. Altering construction practices, such as eliminating engine idling when vehicles and equipment are not in use, can also reduce harmful emissions. On some projects, construction companies have provided shuttle services for workers, which reduces harmful emissions. Shortening the total construction period can reduce total emissions.

“Unless avoided or reduced, air emissions associated with project construction can affect people in and near the corridor.”

CONSTRUCTION NOISE AND LIGHTING

Controlling construction noise will be especially important throughout the project construction period. Because of the project’s multi-year duration, construction noise could potentially have more than temporary negative effects on communities near the project. Coordination among all agencies responsible for noise along the project corridor, including WSDOT, Public Health – Seattle & King County, and municipal governments will be necessary to ensure that noise impacts from construction are minimized.

Readily available technology can be purchased or installed on construction equipment and vehicles to reduce noise. Altering construction practices, such as changing when certain activities occur and how long they occur, are common practices by builders to reduce noise.

> **“Controlling construction noise will be especially important throughout the project construction period.”**

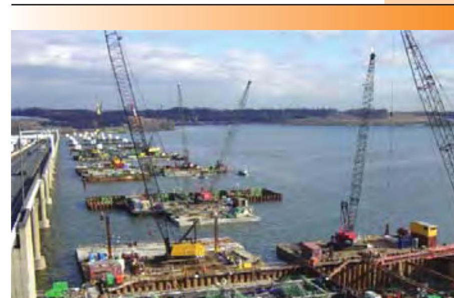
Washington State Department of Transportation

While working during off peak times will have benefits, it is also necessary to ensure that artificial lights used for construction crews do not interfere with residents' ability to have restful nights.

CONSTRUCTION AND EMERGENCY MEDICAL SERVICES

An important service reviewed in the SR 520 HIA is the ability of emergency medical services (EMS) to rapidly respond to incidents and reach residents in a timely manner 24 hours a day. This issue was brought forward in early community discussions.

Several factors are critical for successful emergency medical service response, including response times, trained first responders, effective communication, and community education. King County's geographically based EMS system allows for rapid responses without units, in most cases, crossing the SR 520 bridges. However, EMS providers do need to access SR 520 neighborhoods via arterial roads for emergencies and may need to transport patients to medical facilities using the SR 520 corridor. Coordination and communication during the construction period will be essential to providing critical emergency services. Timely and consistent communication regarding traffic congestion and road closures, specifically in regards to access points into corridor neighborhoods and to and from the bridge, is a key element.



Washington State Department of Transportation

Health Impact Assessment Recommendations

Construction Period

Continued

Washington State Department of Transportation

If the SR 520 Evergreen Point Bridge failed because of a catastrophic windstorm or earthquake, WSDOT has a SR 520 Catastrophic Failure Plan in place to manage traffic and communications. The plan builds upon existing emergency management procedures and incorporates additional input from local agencies and jurisdictions. It represents a toolbox of strategies that can be implemented during a long-term recovery from a bridge failure, and will also be useful for managing SR 520 construction traffic impacts.

CONSTRUCTION AND COMMUNITY INTERACTION

Maintaining physical connections between corridor neighborhoods during construction can help maintain social interactions among people. Choosing construction truck haul routes that avoid neighborhood streets can reduce residents' exposure to diesel emissions. Maintaining traffic flow and providing information on construction activities and progress can help people cope with the changes to their existing activities, such as the routes and times they take to go to work. A wayfinding signage system can help pedestrians and bicyclists avoid construction sites and identify quieter routes.

The following specific construction period recommendations will help reduce potential health impacts:

1) REDUCE CONSTRUCTION RELATED POLLUTION
by implementing the following actions:

a) Use new or retrofit diesel powered construction vehicles and equipment.

b) Implement an idling reduction program for construction vehicles and equipment.

c) Designate a HOV lane on the bridge to maintain or increase transit ridership.

d) Increase transit service to attract new riders and reduce congestion.

e) Increase transit opportunities and incentives (such as free or subsidized transit passes) and trip reduction programs (such as carpooling and shuttle services) for construction workers, University of Washington students and staff, and adjacent neighborhood residents.

f) Provide financial incentives for the contractor to accelerate construction.

g) Schedule construction activities that can delay traffic during the lowest traffic periods to minimize congestion.

2) IMPROVE TRAFFIC MANAGEMENT
by implementing the following actions:

a) Develop safe and clearly marked alternative routes for pedestrians and bicyclists during the construction period.

b) Conduct a public education program to reduce traffic on the facility, and increase distribution of the information before beginning construction activities that are likely to increase congestion.

c) Provide clearly identified temporary lane configurations to maintain traffic flow in the corridor.

d) Install traffic calming devices, such as traffic circles, curb bulbs, and speed humps, and limit construction traffic routes in the affected neighborhoods.

e) Provide access to construction schedules so Emergency Medical Services can provide uninterrupted service in the corridor, especially where access is limited.

f) Provide real time traffic and road construction information in an easily accessible way so area residents, transit, freight, Emergency Medical Services, and other users can change routes and travel times as needed. Some possible strategies include increasing the number of traffic cameras and providing reader boards in the corridor.

g) Ensure Emergency Medical Services can quickly reach all construction areas (including water access).

3) PROVIDE FOR CONSTRUCTION NOISE CONTROL
by implementing the following actions:

a) Use OSHA approved broadband back-up warning devices on all construction vehicles and equipment.

b) Use approved noise control devices for generators, compressors, and similar equipment.

c) Limit the operating periods for equipment that produces loud noise, such as pile drivers and concrete cutters, particularly during nighttime periods.

d) Maintain construction equipment in good working condition so that it does not create additional noise.

e) Notify residents of potentially affected areas prior to construction activities and provide a complaint hotline and web site.

f) Coordinate with agencies responsible for controlling noise during planning and construction and when responding to complaints.

Health Impact Assessment Recommendations

Construction Period

Continued

The following table summarizes the link between the construction period recommendations and potential health benefits:

RECOMMENDATIONS	ACTIONS	HEALTH RELATED EFFECTS
1) Reduce construction related pollution	» Less polluting vehicles and equipment operating in area » Less construction during peak travel times » Increased transit opportunities	» Reduce asthma exacerbation and respiratory disease risk factors » Decrease cardiovascular disease risk factors » Decrease cancer risk factors
2) Increase traffic management	» Clearly marked lanes on bridge » Rapid access to SR 520 communities during emergencies » Decreased traffic congestion and delay » Safe and clearly marked alternative routes for pedestrians and bicyclists creating increased sense of safety » Easily accessed information on construction schedules	» Decrease cardiovascular disease risk factors » Decrease stress and stress-related health effects » Reduce pedestrian/bicyclist injury risk factors
3) Provide for construction noise control	» Quieter vehicles and equipment operating in community » Reduced noise in surrounding communities	» Decrease noise-related annoyance, stress, and stress-related health effects » Reduce risk of sleep disturbances » Decrease mental fatigue

Health Impact Assessment Recommendations

Transit, Bicycling and Walking

INTRODUCTION

Increasing and improving transit service and providing bicycling and walking facilities in the corridor will provide multiple health benefits by reducing greenhouse gas emissions and other air pollutants through the use of alternatives to single-occupant vehicles, increased opportunities for physical activity, and improved social connections.

AUTOMOBILES, TRANSIT, BICYCLING AND WALKING AND AIR QUALITY

Exposure to air pollutants is associated with a wide range of health effects – from throat irritation and respiratory ailments to heart disease and cancer. These health impacts are often greater among more sensitive and vulnerable populations, including children, older adults, and those with compromised immune systems (EPA, 2008).

CARS, TRUCKS, AND OTHER MOBILE SOURCES, such as construction equipment, contribute approximately half of all the air pollution in the region (PSCAA, 2005). They are major sources of:

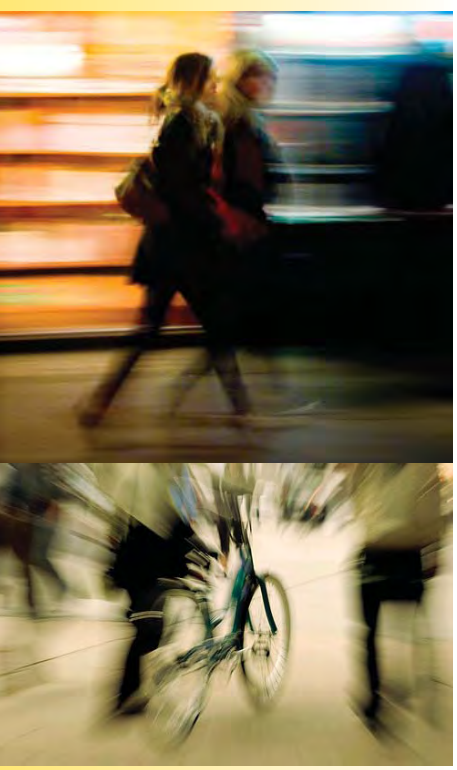
FINE PARTICLES (PM 2.5) – Diesel exhaust is the most significant fine-particle emission because of its toxicity.

AIR TOXICS – Key chemicals/mixtures of concern are diesel particulates, benzene, 1,3-butadiene, acetaldehyde, and formaldehyde.

OZONE – Volatile organic compounds, a main contributor to ozone pollution, are emitted primarily from mobile sources.

GREENHOUSE GASES – Major greenhouse gases include ozone, carbon dioxide, methane, nitrous oxide, and hydrofluorocarbon.

People who live within 300 meters of major roadways such as SR 520 experience higher concentrations of certain air pollutants, especially fine particles, than people who live at greater distances. This can affect the health of people living close to the roadway. Roadways with high volumes of diesel vehicles pose more concern because chronic exposure to diesel particulates has been associated with a number of health risks (Houston et al., 2006). Traffic emissions also contribute to ambient levels of air pollution outside of this 300-meter distance. The health effects of pollutants on those closest to the highway may be best addressed through project design, while the broader effects of background pollutants are more appropriate to address on a regional or national basis. Potential measures to reduce the impact of air pollution on health include:



(Top) Flickr: Justin Keery

(Bottom) Flickr: QuiDam Espelitiea

Transit, Bicycling and Walking

Continued

- Keeping travel lanes, bridges, tunnels, tunnel vent stacks, and ramps away from homes, daycare facilities, schools, and other facilities where sensitive populations are staying.
- Providing vegetation buffers that include trees and shrubs between vehicle travel elements, such as ramps and lanes, and where people live, work, and play.
- Promoting less polluting travel modes, such as transit and bicycling, and traffic management strategies to reduce congestion.

(Above) Unknown

(Right) Complete the Streets

(Far right) Preliminary concept design for Metro's RapidRide Service to be implemented beginning in 2010

AUTOMOBILES, TRANSIT, BICYCLING AND WALKING AND GREENHOUSE GAS EMISSIONS

The six-lane replacement, including the three design alternatives under consideration by the SR 520 Project Mediation Group, supports multiple travel modes. The provision of HOV lanes will improve transit speed and reliability and provide an attractive alternative to driving alone. The bicycle and pedestrian pathway will allow bicyclists to ride across SR 520 rather than load their bicycles onto buses. In addition, design features, such as pathways and lighting that create walkable environments in the corridor, and provide safe and convenient connections to destinations such as the University of Washington campus, will contribute to positive health consequences. Connections between SR 520 corridor transit services, local and express transit service, and Sound Transit's light rail station at Husky Stadium, are likely to produce more opportunities for transit ridership, less single-occupant vehicle use, and fewer air pollutants.

The Puget Sound Clean Air Agency reviewed the greenhouse gas emissions associated with the three alternatives under consideration. The full Greenhouse Gas Analysis Report is available in the Appendix. The agency investigated the effect that changing key factors such as transit service, tolls, and parking fees in the corridor would have on greenhouse gas emissions. Because Alternatives K and L have similar lanes, grades, interchange designs, and total distances they were evaluated as one alternative.

All three alternatives result in similar levels of greenhouse gas emissions. Additionally, changing the key factors has a similar effect on greenhouse gas emissions. Increasing transit service, tolls, and parking fees leads to a shift to more transit activity and lower levels of greenhouse gas emissions for the alternatives. Decreasing transit service, tolls, and parking fees leads to higher levels of greenhouse gas emissions for the alternatives. The amount of the change in greenhouse emissions is also similar for each of the alternatives.

TRANSIT IMPROVEMENTS AND HEALTH

Increased access to public transit may help promote and maintain active lifestyles. Walking to and from public transportation can help physically inactive

populations attain the recommended level of daily physical activity (Besser et al., 2005). Increased walking or bicycling to and from transit can have a positive impact on many health concerns, including cardiovascular health, subsequent medical costs, and overall well-being.

Reliable, rapid, frequent, comfortable, safe, and easy-to-use service is important for people to choose transit. Transit becomes even more attractive as driving becomes more costly (through fuel prices, parking fees, and tolls) and as congestion increases.

The Westside of the SR 520 corridor has high-density neighborhoods and high levels of daily travel to the University of Washington and the Eastside. This land use pattern is conducive to successful transit (Cervero, 1993). Development patterns on the Eastside vary in density and will benefit from park-and-ride opportunities and transit transfer points to encourage transit use.

Nationally, an increased interest in public transportation is evident. A telephone survey by the National Association of Realtors and Smart Growth America in October 2007 found that three-fourths of Americans believe that being smarter

Transit, Bicycling and Walking

Continued

about development and improving public transportation are better long-term solutions for reducing traffic congestion than building roads.

Preserving opportunities for new transit solutions, such as bus rapid transit (BRT), is important. A successful BRT system relies on frequency, reliability and speed and can operate on bus lanes, HOV lanes, expressways, or ordinary streets. King County Metro Transit will operate the RapidRide program, which includes two projects – the Pacific Highway South BRT and the Bellevue-Redmond BRT. The new Bellevue-Redmond BRT program utilizing the SR 520 corridor will provide an opportunity to connect walking, bicycling, and transit.

Complete the Streets

PEDESTRIAN AND BICYCLE IMPROVEMENTS AND HEALTH

Transportation projects by nature provide greater mobility and safety of movement, but they also connect people and places. Increased connectivity between areas allows residents to be more physically active. Connections also bring people together, making them feel part of the larger community.

The present SR 520 corridor separates several Seattle and Eastside neighborhoods, making walking and bicycling a challenge or impossible. Pedestrian and bicycle connections with transit are not intuitive or easy to understand. And, the existing corridor makes social connections between neighborhoods difficult.

The SR 520 Project provides an opportunity to restore the connections between neighborhoods north and south of the SR 520 corridor that were lost when the project was built in1963 and to provide a cross-lake bicycling and walking connection between the Eastside and Westside neighborhoods. The improvement and creation of trail systems will increase access to areas, such as playfields, local businesses, and the Washington Park Arboretum.

Flickr: tofu_minx

As indicated in the SR 520 DEIS, the bicycle and pedestrian paths have the potential to connect the region's longest and most popular trails and routes (Burke-Gilman Trail, Washington Park Arboretum Waterfront Trail, Lake Washington Loop Route, Sammamish River Trail, and East Lake Sammamish Trail) as well as many on-street bicycle routes. The project area is also near many recreational facilities, community sites, retail, and education establishments that are destinations for pedestrians and bicyclists and areas for physical activities.

The SR 520 Project can increase connectivity by providing a safe, continuous, and well-designed multimodal facility that capitalizes on adjacent neighborhoods and makes walking, bicycling, and transit travel efficient and enjoyable.

Flickr: Alan Murray

Because of the increase in available facilities, such as the trails, an increase in pedestrian and bicyclist activity is expected in this corridor. This increased physical activity will bring health benefits to the users. By walking or bicycling to work, school, or other destinations, individuals can reach the recommended 30+ minutes of moderate physical activity level, five days a week (DHHS, 2008). As energy prices rise and environmental concerns increase, more people may make a combined bicycle/pedestrian and transit trip in the corridor. When making connections is easy, convenient, reliable and quick, more people may choose alternatives to single-occupancy vehicle trips and may incorporate physical activity into their travel. This increased regular physical activity improves people's quality of life as well as reduces risk for numerous chronic diseases.

Creating a wayfinding signage system that includes information on destinations, routes, and other tips for pedestrians and bicyclists is important in providing the knowledge and confidence necessary for efficiently using the connections and paths. The signage design should be coordinated among municipalities, the University of Washington, transit agencies, and others within the corridor to give pedestrians and bicyclists a system that is easy to recognize. The system should also include information about transit to enable quick understanding a nd selection of the appropriate transit routes so people can reach their destinations efficiently.

Many of the elements critical to supporting connectivity are included in the SR 520 Project alternatives. Having the ability to be physically active, to freely move through the corridor in pleasing natural surroundings and to reconnect neighborhoods will contribute to a healthy community.

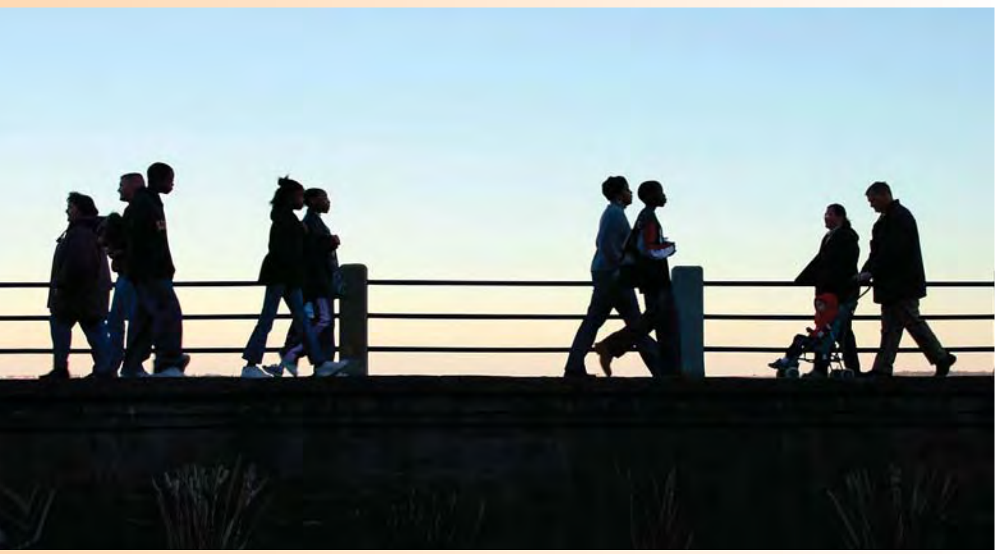
Transit, Bicycling and Walking

Continued

FEELING AND BEING SAFE IN THE CORRIDOR

Feeling and being safe in one's neighborhood is critical for community vitality and a basic goal for all communities. People out for a casual walk in their neighborhood will choose the safest, most pleasant route, and possibly one where they are likely to run into a neighbor. Visual aids, such as long sight lines (being able to see what is around the corner) and adequate signage indicating the way is important for both walking and bicycling.

Lighted paths with long sight lines are likely to be used frequently by more people. Design features, such as separation and barriers between motorized and non-motorized routes can reduce the likelihood of accidents and can result in more people walking and bicycling. Many communities also designate a lane for bicyclists and rollerbladers, and another for pedestrians on heavily used paths to reduce the potential conflict between people traveling at different speeds. Addressing these concerns and ideas in the design phase will be critical in creating walking and bicycling opportunities that feel and are safe.



Flickr: Lyn Adams

The following specific transit, bicycling, and walking recommendations will help produce positive health effects:

1) INCREASE AND IMPROVE TRANSIT SERVICE to meet increased demand, attract more riders and reduce air pollution, by implementing the following actions:

a) Provide a significant increase in the number of buses operating in the peak periods over the projected service described in the SR 520 DEIS.

b) Enhance transit and park-and-ride facilities serving the corridor with better weather protection, drop off areas, and more bicycle and pedestrian facilities.

c) Ensure that transit transfer points and light rail facilities are located as near each other as feasible, and connected by pedestrian and bicycle paths.

d) Promote the corridor as an area for implementing pilot programs, such as bus rapid transit, that have the potential to reduce single occupant vehicle travel.

e) Provide facilities and designs that make it easy for users to change modes without delaying their trips in the corridor.

2) INSTALL CONNECTED WALKING AND BICYCLING FACILITIES
throughout the corridor, including:

a) To, from, and across the corridor to adjacent neighborhoods.

b) To and through parks, green spaces, regional trails, and the Washington Park Arboretum.

c) To bus stops, bus transfer points, and the light rail station.

3) CREATE A COMMON WAYFINDING SYSTEM
in the corridor that includes these features:

a) Information on destinations and all mode choices that provides pedestrians and bicyclists a quick understanding in selecting non-motorized or multi-mode transportation routes.

b) Coordination of the design with municipalities, the University of Washington, transit agencies, and others within the corridor.

Flickr: Daryl Bridges

4) PROVIDE SAFE MOBILITY
on pedestrian and bicycling paths, and at transit stops and transfer points, by implementing the following actions:

a) Create lighted paths that are safe and perceived to be safe with high visibility.

b) Provide appropriate barriers and traffic calming features between shared paths and roadways where pedestrian, bicyclist, and traffic activity will be high.

c) Mark shared paths for bicyclists and pedestrians to minimize possible conflict.

d) Program the traffic monitoring cameras on the bridge to also monitor pathway use.

Health Impact Assessment Recommendations

Transit, Bicycling and Walking

Continued

The following table summarizes the link between the transit, bicycling, and walking recommendations and potential health benefits:

RECOMMENDATIONS	ACTIONS	HEALTH RELATED EFFECTS
1) Increase and improve transit service	» More frequent transit service with improved accessibility » Decreased roadway congestion and time spent in single occupancy vehicle » Reduced emissions and improved air quality » More alternatives to vehicle use available » Increased mobility options	» Reduce asthma exacerbation and respiratory disease risk factors » Decrease cardiovascular disease risk factors » Decrease cancer risk factors
2) Install connected walking and bicycling facilities	» Improved pedestrian and bicycle flow via safe and continuous pedestrian and bicycle paths » Decreased motor vehicle use » More opportunities for physical activity with improved pedestrian and bicyclist environment » More alternatives to vehicle use available » More walking and bicycling to local destinations	» Decrease risk factors associated with inactivity, including cardiovascular disease, diabetes, obesity, and osteoporosis » Reduce asthma exacerbation and respiratory disease risk factors » Decrease cancer risk factors
3) Create a common way finding system	» More easily understood opportunities for physical activity on clearly identified pedestrian/bicycle paths and natural areas » Coordinated routes and signs that are easily understood	» Decrease risk factors associated with inactivity, including cardiovascular disease, diabetes, obesity, and osteoporosis
4) Provide safe mobility	» Reduced barriers to walking/bicycling along a pathway » Paths shared by bicyclists and pedestrians are marked to minimize possible conflict	» Decrease risk factors associated with inactivity, including cardiovascular disease, diabetes, obesity, and osteoporosis » Reduce pedestrian/bicyclist injury risk factors » Decrease stress for pedestrians/bicyclists » Increase sense of safety and personal security

Health Impact Assessment Recommendations

Landscaped Lids and Green Spaces

INTRODUCTION

The landscaped freeway lids proposed over SR 520 can provide multiple health benefits to communities in the project area. When first opened in the 1960s, SR 520 dramatically altered and separated many communities. The proposed landscaped lids will reconnect these neighborhoods and provide easy and safe connections between these communities for all users, especially pedestrians and bicyclists. In addition, by their design they can help reduce noise pollution in the adjacent areas. The landscaped lids will also contribute to improved air quality directly through the inclusion of trees and vegetation that traps air pollution and indirectly by encouraging more walking and bicycling for short trips to local destinations. Restoring and preserving the corridor's parks and natural areas is critical, as is finding opportunities to enhance the area with landscaping along roadways, trails and at transit stops.

CONNECTING COMMUNITIES BENEFITS HEALTH

Health benefits are realized when people feel connected to their environment. People who engage socially with others and are involved in their community live longer and are physically and psychologically healthier. Community interactions, even in casual ways, provide a sense of connectedness, an important factor for promoting health and well-being (Putnam, 2001; Kawachi et al., 2001; Berkman, 1995).

(Above) Vollmer & Associates

(Right) Minnesota Department of Transportation

The SR 520 Project proposes six freeway lids to reconnect communities. The 10th and Delmar lid would partially reconnect the Roanoke/Portage Bay and North Capitol Hill neighborhoods, and the Montlake lid would partially reconnect the Montlake neighborhood. The proposed lids also provide connections in Medina, Hunts Point, Yarrow Point, and Clyde Hill over SR 520 at Evergreen Point Way, 84th Avenue Northeast, and 92nd Avenue Northeast. The freeway lids are places that can bring diverse people together with different interests that typically make up a neighborhood (Skjaeveland et al., 1997).

The use of landscaped lids started in 1939 when Robert Moses designed the Franklin D. Roosevelt Expressway along Manhattan's East River and tunneled

Landscaped Lids and Green Spaces

Continued

under the Mayor's home, constructing a 14-acre park on top. In 1976, Seattle expressed great vision when public-spirited individuals and the City, County and State officials created a 5-acre landscaped lid (Freeway Park) over the below-grade portion of I-5 separating the First Hill neighborhood from Downtown Seattle. Projects are underway in many U.S. cities to create parks and open space on the top of transportation projects to save important connections.

The landscaped lids and other public spaces support social connections in a neighborhood by creating places where residents and visitors can gather and interact. Public areas that offer attractive walking destinations are more likely to provide opportunities for informal interaction (Wood et al., 2008; Lund, 2002). The landscaped lids will be destinations for area residents and visitors. Amenities and design in these spaces, such as benches and shaded areas, will encourage users to stay and interact with others. Design strategies can improve safety and the perception of safety and make the spaces more likely to be used (Forsyth et al., 2007).

Amy Shumann

Being able to easily and quickly access nearby places, such as grocery stores, community centers, parks, transit stops and neighboring communities can make people's daily life less stressful. The ability to reach these places on foot, bicycle, or short bus ride may free up time for other important or satisfying activities (Public Health – Seattle & King County, 2005). Adding to this benefit is evidence suggesting that the amount of time people spend driving in their cars alone impacts their engagement in community life and interferes with developing strong neighborhood ties – each additional 10 minutes in daily commuting time cuts involvement in community affairs by 10 percent (Putnam, 2000).

The new lid connections also will provide non-motorized transportation opportunities for people to readily travel between neighborhoods and increase the likelihood of meeting physical activity recommendations (Powell et al., 2003). This can in turn have a positive effect on air quality in the corridor with the reduction in vehicle miles driven for short neighborhood trips.

GREEN SPACES PROMOTE WELL-BEING

"Many of the best places are neither home nor work, but 'third places' in the public realm… Such public places are important venues for a wide variety of activities, such as social interaction and physical activity, which have clear health implications" (Frumkin, 2003).

Green spaces are essential to the health of communities as they connect residents with the natural world. Exposure to natural environments enhances the ability to cope with and recover from stress, and observing nature can restore concentration and improve productivity. The increase of landscaped and green public spaces can also lead to improved mental well-being and increased physical

Freeway Park

activity. Having nature in close proximity or just knowing it exists is important to people regardless of whether they are regular users (Maller et al., 2005).

Studies also indicate that landscaping in urban living areas is positively correlated with more use of the space and more vitality and interactions in the space (Sullivan et al., 2004). Green spaces become centers that bring a diverse group of individuals of different ages, socio-economic levels, and cultures together to enjoy an escape from everyday stresses. Research shows that residents of neighborhoods with access to greenery in common spaces are more likely to enjoy stronger social ties than those who live surrounded by barren concrete (Gies, 2007).

Kern Ewing

In addition to including green spaces on the freeway lids, the rich natural environment and the existing park property around Portage Bay and Union Bay in the SR 520 corridor provide a unique opportunity for thousands of people to enjoy and find renewal in a dense urban setting. Opportunities to visually enjoy wetlands, open water, the Washington Park Arboretum, and wildlife abound in the SR 520 Project area. It is also a wonderful visual relief from urban congestion for those who transverse the area.

Helen Vihn

Parks play an important role in promoting a sense of well-being and happiness, as well as in promoting social support and physical activity. Outdoor activity is widely thought to enable one to escape from the pressures of modern living, achieve an enhanced state of relaxation and refreshment, tackle new challenges, and reduce anxiety and stress levels. The proposed paths described in the SR 520 DEIS will connect bicyclists and pedestrians to numerous green spaces along the corridor. The green spaces themselves can also become corridors that link travelers to shops, transit stops, places of employment, and schools.

The inclusion of green spaces with trees, shrubs, and turf also has important implications for air quality. Emissions from automobile and truck exhaust contain significant pollutants, including carbon monoxide, volatile organic compounds, nitrogen oxides, and particulate matter. Trees and other plants make their own

Landscaped Lids and Green Spaces

Continued

food from carbon dioxide in the atmosphere, water, sunlight and a small amount of soil elements. In the process, they release oxygen for us to breathe and reduce warming of the atmosphere. Also, trees alter their proximal environment by moderating climate, improving air quality, conserving water, and harboring wildlife (Burden, 2006).

Freeway Park

Taking opportunities to include and enhance the essential green spaces in the SR 520 corridor is a critical element for healthy communities. With development of new landscaped areas and preservation of current parks and green spaces, the SR 520 corridor can be an oasis for renewal, social interaction, and physical activity.

The following specific landscaped lids and green space recommendations will help enhance positive health outcomes:

1) INCLUDE SIX LANDSCAPED FREEWAY LIDS that connect SR 520 communities (i.e. on the Westside at I-5, 10th Avenue and Delmar Drive East, and at Montlake Boulevard; and, on the Eastside at Evergreen Point Way, 84th Avenue Northeast, and 92nd Avenue Northeast).

a) Design lids with landscaping, green spaces, and amenities, such as benches, bike racks, public restrooms, and shaded areas, to attract more public use.

b) Design lids with good visibility and sightlines and that avoid isolated areas.

c) Install emergency call boxes on the lids to provide for personal security.

2) USE LANDSCAPING MATERIALS THROUGHOUT THE SR 520 CORRIDOR, along adjacent trails and roadways, and at transit stops to soften the concrete footprint.

3) IMPROVE AND PRESERVE THE INTEGRITY OF THE WASHINGTON PARK ARBORETUM, and the ability of visitors to enjoy it and other green spaces and natural areas.

4) PRESERVE ACCESS TO THE WATERFRONT FOR WATER-RELATED ACTIVITIES, such as currently available at the University of Washington's Waterfront Activity Center.

The following table summarizes the link between the landscaped lids and green space recommendations and potential health benefits:

RECOMMENDATIONS	ACTIONS	HEALTH RELATED EFFECTS
1) Include six landscaped freeway lids	» Increased walkability and bikeability of neighborhoods with increased connectivity » Increased proximity of residents to green spaces and destinations » Increased recreational opportunities » Increased access to the waterfront for waterfront activities » Increased social connections of neighborhood with opportunity for neighbor interactions » Decreased use of motor vehicles for short trips (shops, school, library, transit stops, parks) » Provision of an environment where people can relax, discuss concerns, and exchange ideas » Increased perception of safety with enhancement of lids with lighting, benches and good visibility	» Decrease risk factors associated with inactivity, including cardiovascular disease, diabetes, obesity, and osteoporosis » Improve mental well-being (increase sense of belonging and social support)
2) Use landscaping materials throughout the SR 520 corridor	» Addition of green spaces into an urban environment » Increased opportunity for contact with natural surroundings » Increased number of trees and vegetation capable of trapping air pollutants » Decreased noise pollution through vegetation dampening sound » Increased shade which reduces urban heat island effect	» Reduce stress » Reduce recovery time from illness » Reduce asthma exacerbation » Decrease respiratory disease risk factors » Decrease noise-related annoyance, stress, and stress-related health effects » Reduce risk of sleep disturbances » Decrease mental fatigue
3) Improve and preserve the integrity of the Washington Park Arboretum, and the ability of visitors to enjoy it and other green spaces and naturals areas	» Increased opportunity for contact with natural surroundings » Increased number of trees and vegetation capable of trapping air pollutants » Increased recreational opportunities » Increased social connections » Promotion of environmental stewardship » Decreased noise pollution through vegetation dampening sound » Increased shade that reduces urban heat island effect	» Decrease risk factors associated with inactivity, including cardiovascular disease, diabetes, obesity, and osteoporosis » Increase mental well-being » Reduce stress, depression, and anxiety » Reduce recovery time from illness » Decrease mental fatigue » Increased concentration and productivity » Decrease noise-related annoyance, stress, and stress-related health effects
4) Preserve access to the waterfront for water-related activities	» Increased opportunity for contact with natural surroundings » Increased recreational opportunities » Increased social connections » Promotion of environmental stewardship	» Decreased risk factors associated with inactivity, including cardiovascular disease, diabetes, obesity and osteoporosis » Increase mental well-being » Reduce depression and anxiety » Reduce stress » Reduce recovery time from illness

Health Impact Assessment Recommendations

Design Features for Healthy Communities

INTRODUCTION

Conventional street and roadway design has historically been driven by traffic demand and level of service. Environmental regulations have helped to avoid adverse impacts on the environment, but little attention has focused on how design features can impact health. The SR 520 Project is an opportunity to create a transportation project that protects the environment and provides a healthy community.

In this section, roadway design effects on health are explored. One of the biggest annoyances produced by roadways today is the noise experienced in neighborhoods adjacent to roadways. The visual character of a community and the experience one has while in it also impacts health. And, finally storm water runoff from roadways can impact health in ways that need to be considered.

NOISE AFFECTS QUALITY OF LIFE

The noise level influences the experience residents and visitors have in a community. Researchers have examined the relationship between noise and human health for several decades. Regulations to control noise began to be enacted in the United States in the seventies based on the findings of such research. Annoyance is the often-cited consequence of noise, and it is widely agreed that annoyance detrimentally affects an individual's well-being and state of mind. However, attempts to link annoyance to specific health indicators, such as stress or blood pressure, have not yielded uniform results. Annoyance can certainly result in social discontent in neighborhoods affected by noise. A more thorough discussion on how noise impacts hearing loss, sleep disturbances, cardiovascular disease and other issues is found in the Noise Issue Paper in the Appendix.

(Above and Right) Washington State Department of Transportation

Households near the proposed landscaped lids will experience a reduction of noise below the Federal Highway Administration (FHWA) action level of 67dBA. The level of 67 dBA (an acoustical unit of measurement) is within the range of normal conversation. This is the level at which long-term noise reduction strategies like landscaped lids, quieter pavement, and noise walls must be evaluated. The landscaped lids will reduce noise for nearby residents and the hundreds of pedestrians, bicyclists, and transit riders who will use these areas for shopping, recreation, socializing, or traveling to and from

work. It will be important during design to ensure that any proposed noise walls do not create additional problems. Safety issues could arise by creating areas of entrapment or isolation along the corridor. Noise walls could increase unsightly concrete surfaces interfering with views of water or natural areas. They can also isolate neighborhoods and interfere with social interactions of community members. As the project proceeds, emerging noise-reduction technologies and strategies need to be evaluated and considered. Funds for these features should not be compromised as this project moves forward.

© *Stacy Levy, Watermap, 2004 / Fannie Cox Center for Science, Math and Technology / Friends' Central School, Wynwood, PA*

COMMUNITY CHARACTER CREATES VITALITY AND GOOD HEALTH

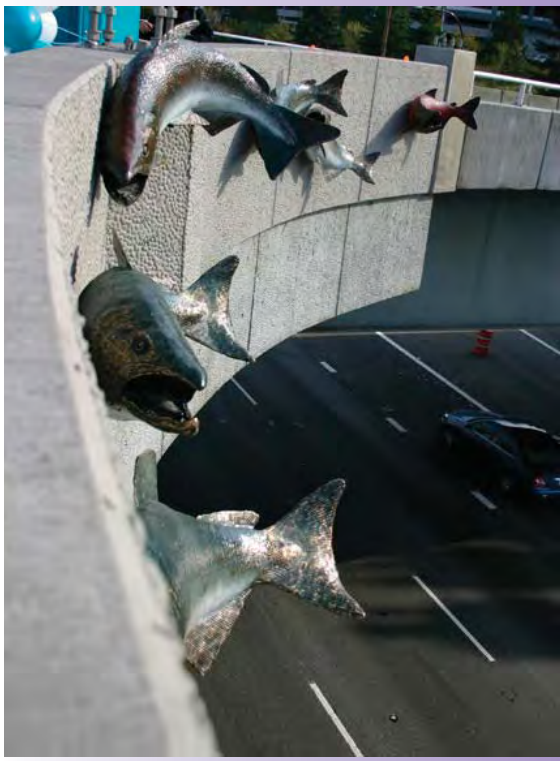
How communities are designed also impacts the overall daily experience of residents and visitors. An area's visual character and perceived safety are important factors for drawing pedestrians and bicyclists from point to point. People are more likely to walk or bicycle longer distances when they anticipate something of interest ahead and when they feel safe.

Designing these features on a human scale is also important, since people will feel more comfortable in the space. Destination walkers may often be walking out of necessity and the most direct and pleasant routes will be used more frequently. An integrated design approach that incorporates architectural features, landscape forms, art, textures, and color can add to a community's visual character. In the SR 520 Project, opportunities for an integrated design approach exist along pedestrian and bicycle paths, on landscaped lids, and at transit stops.

Design Features for Healthy Communities

Continued

Residents value specific attributes of their community, whether it is the economic vitality of their neighborhoods, its history, ease of mobility and safe streets, the quality of schools, natural resources, scenic qualities, or the local system of parks. A successful transportation project must be in harmony with the community and preserve resources of the area. WSDOT is working with communities using a process called Context Sensitive Solutions to make transportation investments that improve the way people live and work together. It is a collaborative, interdisciplinary approach that involves stakeholders in developing transportation facilities that fit their physical settings and preserve scenic, aesthetic, historic, and environmental resources, while maintaining safety and mobility.



(Above) © Carolyn Law, Evanston Plaza, *2003 / Seattle, WA*

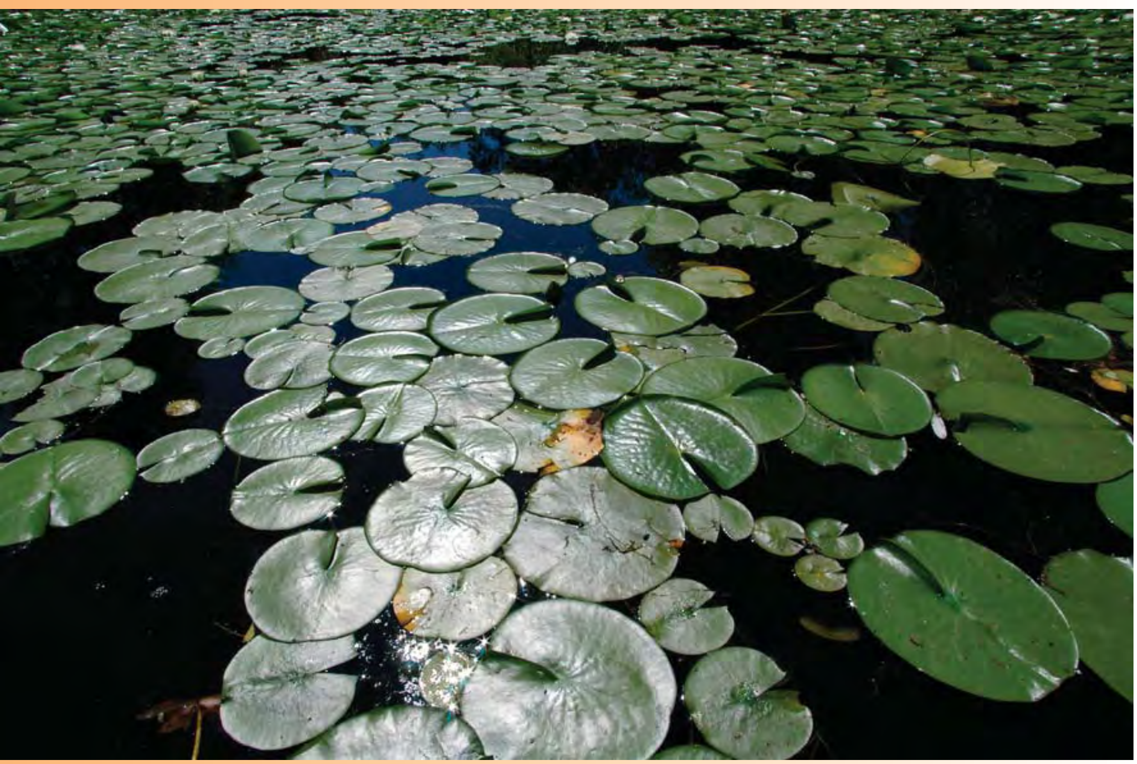
(Right) Washington State Department of Transportation

In 2006, WSDOT convened the Design Advisory Group, a committee of volunteers from communities along the SR 520 corridor, to discuss the future character of the project. *The SR 520 Corridor Aesthetics Handbook – Ideas for Urban Corridor Design* was created as a result of these efforts and will be used to develop aesthetic guidelines for the facility and corridor. The guidebook outlines WSDOT's philosophical principles that: (1) aesthetics and engineering are good partners and they challenge each other to be better; (2) aesthetics will be an integral part of good engineering design; (3) aesthetic treatments do not have to be expensive or a maintenance burden to be successful; and (4) the SR 520 communities will be an integral part of the future interdisciplinary team. WSDOT has been working with Eastside communities to develop design ideas for the eastern portion of the project and will begin this work with Westside communities. This is great step in creating a sense of community and vitality that will be important to the community's health.

PUBLIC ART AND DESIGN HUMANIZE A ROADWAY

The SR 520 corridor has a rich natural environment with unique opportunities to view the lake and adjacent natural lands whether traveling by automobile, transit, bicycle or on foot. The addition of art enhances this experience. Public art is a way to humanize large infrastructure projects. Arts can be valuable to civic renewal and can nurture social connections by helping communities to understand and celebrate their heritage. Incorporating artistic elements can soften the otherwise monotonous expanse of concrete. Involving artists early in the SR 520 Project design process can provide for unique and creative solutions to gathering spaces, signage, noise walls, and many other aspects of the project.

Adding artistic elements and designing for them early in the project can reduce construction-related costs. Maintenance of these elements does not have to be expensive or burdensome to be successful. Opportunities to partner with other local jurisdictions and neighborhood communities to fund and incorporate art into the project should be explored. Federal funding sources are also available for artistic elements.



(Above) © Valeri Otani and Fernanda D'Agostino, Bridge Between Cultures, *2001 / Weller Street Pedestrian Bridge, Seattle, WA*

(Left) The Washington Park Arboretum: photoskye.com

WATER QUALITY IS VITAL TO THIS REGION

Maintaining and improving water quality is essential to protecting public health and creating healthy sustainable communities. Water quality can affect the health of people who drink from or swim in a water body and those who eat fish caught in it. Lake Washington and the creeks in the project area are not used as sources of public drinking water, but the lake is used for swimming and for recreational, commercial, and tribal fishing.

Although the water quality of Lake Washington has improved dramatically in the last 50 years thanks to the elimination of sewage discharges, the lake is still affected by pollution. A significant source of pollutants is storm water runoff, which contains heavy metals, petroleum products, and plastics from roads and

Design Features for Healthy Communities

Continued

parking lots as well as pesticides and herbicides from landscaping and agriculture. Traffic accidents near or over the water can produce "spikes" of organic pollutants, like gasoline and diesel from spills, and add to higher water pollution level near the roadway. In addition, air toxics from vehicles can settle into the lake, adding to pollutant loads. Animal wastes and occasional sewage overflows contribute to bacterial pollution.

Storm water runoff from the existing SR 520 is not treated. It discharges directly into Portage Bay, Lake Washington, and streams that enter the lake, carrying petroleum products and metals with it. Water quality treatment on the floating bridge presents some special problems, because weight and buoyancy concerns make it technically infeasible to store large volumes of water on a floating structure. WSDOT is working with the Department of Ecology on a special study to identify "all known and reasonable technologies" for the floating bridge and to determine the most effective methods of water quality treatment.

WSDOT currently proposes storm water treatment systems for the Evergreen Point Bridge and, in preparing the project alternatives, is analyzing the degree to which those systems can remove significant loadings of contaminants. A specific storm water treatment system for the new bridges' center floating spans has not been selected, but the current plan includes regular high-efficiency sweeping of the floating bridge road surface prior to rain in addition to dilution in Lake Washington. WSDOT will review strategies while preparing alternatives for the Supplemental EIS and Final EIS to determine how effectively the method ultimately selected for the bridge will improve water quality.

(Top) © *T. Ellen Sollod,* From the Laws of Man to the Laws of Nature, *2004 / Olympia Gateway Corridor, Olympia WA*

(Bottom) © *Gary Moore,* 9th Street Pedestrian Mall Historic Overtown District*, 2005 / Miami-Dade County Public Art Program*

Lake Washington is an extraordinary natural resource that helps define the essence of this region, and it is critical that it be protected from pollution that can affect its health and the health of those who use it. The SR 520 is not the only polluter of the lake, but reducing contaminant runoff would be a strong beginning to reducing lake pollution levels and preserving a most valuable regional asset.

The following specific design feature recommendations will help reduce potential health impacts:

1) REDUCE NOISE THROUGHOUT THE CORRIDOR
by implementing the following actions:

a) Incorporate multiple solutions (e.g. freeway lids, noise walls, quieter pavement, landscaping) to reduce noise in the corridor for the lifespan of the project.

b) Design sound walls that decrease noise but do not result in additional problems (e.g. isolated areas, unsightly concrete structures, interference of natural views).

2) ADD TO THE ADJACENT COMMUNITIES' VISUAL CHARACTER WITH ART AND DESIGN
by implementing the following actions:

a) Incorporate architectural, art, and design solutions into all elements of the project (i.e. landscaped lids, trails, noise walls, transit infrastructure, bicycle storage areas, signage, and structural components of the bridge) that harmonize with adjacent neighborhoods and natural surroundings and conceal the roadway footprint.

b) Design landscaped lids, walking and bicycling paths, transit infrastructure, and other elements within a human scale to make the user feel more comfortable and not overwhelmed by the adjacent large concrete structures.

c) Identify areas and opportunities for art early in the WSDOT design process that reflect and build upon strategies in the SR 520 Corridor Aesthetics Handbook – Ideas for Urban Corridor Design and partner with local jurisdictions, neighborhood organizations or others to collaborate on these projects.

3) UTILIZE INNOVATIVE STORM WATER MANAGEMENT PRACTICES
along the SR 520 corridor to substantially reduce vehicular pollution from entering Lake Washington.

(Top) © Jill Anholt, Uncoverings, *1999 / Downtown Vancouver, City of Vancouver, British Columbia*

(Bottom) © Vicki Scuri, Trilobite Tot Lot, *1991 / Evergreen Park, Bellevue, WA*

Design Features for Healthy Communities

Continued

The following table summarizes the link between the design feature recommendations and the potential health benefits:

RECOMMENDATIONS	ACTIONS	HEALTH RELATED EFFECTS
1) Reduce noise through out the corridor	» Quieter road surfacing, road screening and landscaping » Decreased noise pollution in surrounding communities » Designed sound walls that blend into the adjacent areas and infrastructure	» Decrease noise-related annoyance, stress, and stress related health effects » Reduce risk of sleep disturbances and subsequent effects » Decrease mental fatigue
2) Add to the adjacent communities' visual character with art and good design	» Increased neighborhood aesthetics » Increased sense of community culture » Added public art and design to humanize the large concrete infrastructure » Designed lids, paths, transit infrastructure and other elements with architectural, art, and design solutions that harmonize with the surroundings and conceal the roadway footprint » Increased use of community public spaces, especially by pedestrians and bicyclist	» Reduce stress and stress-related health effects » Decrease risk factors associated with inactivity, including cardiovascular disease, diabetes, obesity, and osteoporosis
3) Utilize innovative storm water management practices along the SR 520 corridor	» Decreased polluted runoff into waterways » Improved water quality in Lake Washington and surrounding wetlands and streams » Improved recreational opportunities Increased quality of edible fish	» Reduce exposures to water toxics » Increase opportunity for physical activity

Conclusion

This region has the opportunity of a generation with the SR 520 Project to build healthy places to live, work, and play. Interest is growing around the world on how to move people differently. Additionally, a movement is underway in the United States and internationally to conceal highways with parks and green materials and to reconnect neighborhoods and natural features separated by past transportation projects.

The region continues to face budget constraints, but it is critical that these recommendations remain integral to the project to gain optimal benefits. Unfortunately, in past public projects, landscaping, walking and bicycling opportunities or other important healthy features were reduced or eliminated to decrease costs or to meet budget restrictions. Many times these elements are seen as extras or amenities. They are not extras or amenities. They are critical for healthy communities.

No single action is going to solve the chronic disease challenges of today, but through many actions creating healthier communities is achievable. Public projects do have an impact on health. This is the time to do everything possible to create healthy communities.

Project Guiding Principles:

- **» Ensure health elements are integral to the project plan.**
- **» Support all recommendations in difficult budget times for optimal health benefits.**

> “This region has the opportunity of a generation with the SR 520 Project to build healthy places to live, work, and play.”

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Appendix:

Appendix A: SR 520 Project Area Demographic and Health Information

September 2008

DISCUSSION OF HIA SOCIAL AND HEALTH INDICATORS

Recognizing that risk of disease and injury can be mitigated through the built environment, relevant health indicators were examined as part of the SR 520 Health Impact Assessment (HIA), including general health status, weight control, social connection, physical activity, mental health, education, and household income. The HIA project area was compared to King County as a whole:

DEMOGRAPHICS

The SR 520 study area tends to have less diversity in race/ethnicity, a higher proportion of whites, and a higher income as compared to King County. Fewer children and more young adults reside in this area. This can influence the health conditions of the area.

ECONOMIC INDICATORS

A strong association exists between the level of wealth and positive health status. The SR 520 study area had more households making $75,000 or more a year and fewer households making $50,000-$75,000 as compared to King County. Additionally, study area residents were more likely to have received some college education or have a college degree.

HEALTH INDICATORS

General health status is one measure of quality of life that factors in a person's physical and social environments and of a person's perceived health (DHHS, 2000). Individuals experiencing poor physical and/or mental health may be less likely to engage in positive health behaviors. The SR 520 study area has similar rates of poor general health and poor mental health status as compared to King County.

Lack of exercise and being overweight are risk factors for serious illnesses such as coronary heart disease, hypertension, and diabetes, and contribute to premature death. Residents of the study area have significantly lower rates of obesity than the King County average. Leisure time physical activity gives a picture of people who engaged in no physical activity in the past month in their non-work time. The major barriers most people face when trying to increase physical activity are time, access to convenient facilities, and safe environments in which to be active (DHHS, 2000). The SR 520 study area is similar to King County in terms of individuals who are leading a sedentary lifestyle.

While the difference is not significant, a higher proportion of people living in the SR 520 study area have jobs that are more sedentary. Sedentary jobs can lead to an increased need to participate in leisure time physical activity.

Social connection examines the relationship that residents have with their community and neighborhood. Many factors can influence this connection, including disconnects of the natural and built environment, such as where a major road may hinder access to parks or services for some neighborhood residents, street structure, locality (urban or rural), and the neighborhood population make-up.

Appendix A:

(Continued)

Survey respondents were asked if they felt their neighbors could be trusted. No significant differences could be determined in the study area as compared to King County.

Life expectancy is the number of years the average person can expect to live and reflects risk of death at all ages. An infant born in the SR 520 study area in 2006 has a slightly higher life expectancy (84.2 years) than King County (81.1 years). Life expectancy at 50 years is more strongly affected by chronic disease and injury, the major causes of death for older people. Residents of the SR 520 study area have a longer life expectancy at 50 (86.6 years) than the King County average (83.3).

Heart disease, diabetes, and asthma are health conditions in which changes in the built environment can impact through encouraging increased physical activity. Residents of the study area are less likely to be hospitalized or to die from heart disease or diabetes as compared to King County.

Asthma is the most common chronic childhood illness, and is often used as an indicator of environmental health. Asthma morbidity and mortality are closely related to both indoor and outdoor air quality. Outdoor air pollutants that can exacerbate asthma include pollen, mold, and pollutants such as nitrogen dioxide, sulfur dioxide, ozone, and diesel exhaust particles (Pandya et al., 2002; AAP, 2004). Rates of childhood asthma hospitalization are higher in the study area (207.7 per 100,000) than in King County as a whole (157.6 per 100,000).

HIA AREA DEMOGRAPHIC AND HEALTH INDICATOR RATES

DEMOGRAPHICS	SR 520 AREA	KING COUNTY AVERAGE
POPULATION, 2006 ESTIMATES [2]		
White alone	83.9%	77.8%
Black alone	3.1%	5.8%
American Indian/ Alaska Native Alone	0.7%	1.0%
Asian/PI alone	9.6%	12.2%
Multiple race	2.8%	3.3%
Hispanic as Ethnicity	4.1%	6.1%
Age 0-17	12.3%	21.3%
Age 18-44	51.8%	41.6%
Age 45-64	24.7%	26.5%
Age 65+	11.1%	10.7%

SOCIO-ECONOMIC INDICATORS (PERCENT, 3 YEAR AVERAGE, 2005-2007) [3]

	SR 520 AREA	95% CI [4]		KING COUNTY AVERAGE	95% CI	
	Estimate	LB	UB	Estimate	LB	UB
Household Income						
<$10,000	2.5	1.4	4.5	2.5	2.1	3.0
$10,000-$25,000	12.2	9.3	15.9	14.5	13.4	15.6
$25,000-$35,000	11.9	8.8	15.8	9.5	8.7	10.3
$35,000-$50,000	12.8	10.6	15.4	14.1	12.9	15.5
$50,000 -$75,000	12.7	10.7	15.1	17.4	16.4	18.4
$75,000+	47.9	43.6	52.1	42.0	40.6	43.4
Education						
Less than High School	4.0	2.2	7.3	5.6	5.0	6.4
HS graduate	7.8	6.0	10.0	17.7	16.5	18.9
Some College	21.0	17.5	24.9	26.4	25.2	27.7
College Graduate	67.2	62.9	71.2	50.3	27.7	51.6

Appendix A:

(Continued)

HIA AREA DEMOGRAPHIC AND HEALTH INDICATOR RATES						
DEMOGRAPHICS	SR 520 AREA			KING COUNTY AVERAGE		
HEALTH INDICATORS (PERCENT, 3-YEAR AVERAGE, 2005-2007) [3]						
		95% CI			95% CI	
	Estimate	LB	UB	Estimate	LB	UB
General Health						
Poor or Fair	8.2	6.7	10.1	10.5	9.7	11.2
Poor Mental Health						
More than 14 days	7.8	6.4	9.6	9.6	8.9	10.4
Weight Control						
Overweight (BMI > 25)	44.3	40.7	48.0	54.6	53.2	56.0
Obese (BMI > 29)	11.0	9.0	13.4	20.0	18.7	21.3
Social Connection						
Most people can be trusted	67.5	58.8	75.2	60.6	57.7	63.4
Physical Activity (PA)						
Sedentary job	74.6	69.3	79.3	69.9	67.7	71.9
No leisure time PA	11.8	9.8	14.1	14.8	13.7	16.1
Life Expectancy (2006)						
At birth	84.2	83.8	84.6	81.1	81.0	81.2
Age 50	36.0	35.7	36.3	33.3	33.1	33.4
HEALTH INDICATORS (AGE-ADJUSTED RATE PER 100,000, 3-YEAR AVERAGE, 2004-2006)						
		95% CI			95% CI	
	Estimate	LB	UB	Estimate	LB	UB
Hospitalizations [5]						
Heart Disease	614.3	594.8	634.4	781.5	773.9	789.3
Asthma	70.4	62.3	79.3	80.6	78.1	83.1
Childhood Asthma (age 1-17)	207.7	176.5	243.0	157.6	150.3	165.2
Diabetes	45.5	40.1	51.6	90.4	87.9	93.0
Mortality [6]						
All Causes	517.0	499.6	535.1	653.2	646.2	660.2
Cancer	136.1	127.0	145.9	163.0	159.5	166.6
Diabetes	14.0	11.3	17.5	20.2	19.0	21.5
Diabetes-Related	36.6	32.1	41.9	61.7	59.5	63.9
Heart Disease	114.4	106.4	123.0	146.8	143.5	150.2

Analysis area includes ZIP codes 98102, 98103, 98105, 98109, 98112, 98195, 98004, 98005, 98033, 98039.

[2] Washington State Department of Health, Vista Partnership, and Krupski Consulting. (December 2007). Population estimates for public health assessment.

[3] Washington State Department of Health, Center for Disease Control. Behavioral Risk Factor Surveillance System.

[4] Confidence Intervals tell how likely the rate is to vary due to chance and is used to compare rates between different groups. For each estimated rate, one would expect the rate to fluctuate, but to remain within the confidence interval upper bound (UB) and lower bound (LB) 95% of the time. When comparing two rates, if the confidence intervals do not overlap, the difference between the two rates is considered "statistically significant," where random variation can be ruled out as the reason for the difference.

[5] Washington State Department of Health, Comprehensive Hospital Abstract Reporting System. Hospitalization discharge data.

[6] Washington State Department of Health, Center for Health Statistics. Death certificate data.

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Air Quality

Appendix B:
Air Quality Issue Paper

September 2008

Clean, healthy air is important for public health, quality of life, and climate protection.

INTRODUCTION

Exposure to air pollutants is associated with a wide range of health problems – from throat irritation and respiratory ailments, to heart disease and cancer. These effects are often greater among sensitive populations, including children, older adults, and those with compromised immune systems. Top air quality health concerns in the Puget Sound Region include:

FINE PARTICLES AND DIESEL PARTICULATE MATTER

» Exposure to fine particles is associated with reduced lung function, asthma exacerbation, irritation, chronic obstructive pulmonary disease, heart attack onset, increased hypertension, and stroke onset (EPA, 2005).

» Diesel exhaust is a significant fine-particle emission source because of its high carcinogenicity and toxicity and likely long-term increase in risk of lung cancer (California Air Resource Board; EPA, 2003).

AIR TOXICS

» Top air toxics of concern include diesel particulate matter, formaldehyde, benzene, 1,3-butadiene, and acetaldehyde (PSCAA, 2003).

» Many air toxics are linked with increased potential cancer risk, as well as respiratory irritation and nervous system effects (EPA, May 2008).

OZONE

» Exposure to ozone is linked with respiratory irritation and reduced lung function, as well as adverse cardiac (heart) effects (EPA, 2007).

» Volatile organic compounds, a main contributor to ozone pollution, are emitted primarily from mobile sources (PSCAA, 2005).

GREENHOUSE GASES

» Climate change refers to the various impacts of an ever-warmer planet, brought on by increased levels of greenhouse gases in the atmosphere (PSCAA, June 2008).

» The major greenhouse gases include ozone, carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons (PSCAA, June 2008).

» Climate change may increase the risk of infectious diseases, exacerbate respiratory disorders and prolong disease transmission seasons (EPA, June 2008).

DISCUSSION

Cars, trucks, and other mobile sources, such as construction equipment, contribute approximately half of all the air pollution in the region (PSCAA, 2005). For some pollutants of concern such as diesel particulate matter, mobile sources contribute much more than half. Vehicle type, engine type (such as gas or diesel), travel speed, travel time, and miles traveled all affect the quantity and type of emissions.

Landscaped lids over SR 520 can improve air quality directly through the tree canopy and indirectly by providing easy access to transit and light rail stops and neighborhoods.

Urban trees can help improve air quality by absorbing, binding, intercepting, and storing pollutants including ozone, particulate matter, nitrogen dioxide, and carbon monoxide; by sequestering carbon dioxide; and, by helping to counteract the urban heat-island effect (Nowak et al.; Center for Urban Horticulture; U.S. Forest Service).

Design alternatives that create walkable environments and locate the light rail station and the transit transfer centers near each other are likely to produce more transit ridership, less single-occupancy vehicle use, and fewer mobile-source air pollutants.

A study by Frank et al. (2006) found that an increase in walkability is associated with fewer vehicle miles traveled and less nitrogen oxides and volatile organic compounds per capita. Research shows the majority of residents living within one-quarter mile of a transit station arrive by foot or bicycle (Cervero, 2004). Culture, weather, topography, and urban environment, such as barriers like wide busy roads, also influence how far people are willing to walk (Cervero, 2004; Alfonzo, 2005).

Construction impacts air quality and public health in the project site, and in roads, pathways, parks, residences, daycare facilities, and neighborhoods near the project site.

TYPICAL EMISSIONS DURING CONSTRUCTION INCLUDE:

- Dust (particulate matter) from excavation, grading, loading, and unloading and demolition of structures and pavement.
- Particulates, air toxics, volatile organic compounds, oxides of nitrogen and greenhouse gases from construction vehicles, worker vehicles, diesel construction equipment, and increased congestion on the roads in and near the project site.

The Washington State Department of Transportation (WSDOT) reduces construction emissions by following practices specified in a memorandum of agreement with the Puget Sound Clean Air Agency such as:

- Covering dirt, debris, and gravel piles to reduce dust.
- Restricting traffic on the construction site to minimize soil disturbance and transport onto roadways (WSDOT, 2006, p 8-28).

The effect of construction vehicle and equipment emissions on air quality and public health can be reduced through readily available mitigation measures including:

- Using all new diesel equipment and vehicles or installing emission reduction equipment on existing diesel vehicles and equipment.
- Implementing idling reduction programs.

Diesel powered vehicles and construction equipment can be retrofit with emission reduction devices that can reduce particulate emissions from 25 percent to 85 percent, depending on the technology used (EPA, May 2008).

Construction activity can increase congestion thereby increasing air pollution and its impact on drivers, passengers, pedestrians, cyclists, residents, nearby parks and neighborhoods, and the region.

Construction-related lane closures, detours, and buses traveling in general purpose lanes can result in reduced travel speeds, increased congestion and increased air pollution. The SR 520 DEIS identifies numerous measures to reduce congestion and the associated increase in air pollution including:

- Increasing bus service.
- Providing temporary lane configurations.
- Providing incentives for the contractor to accelerate construction.
- Scheduling construction during the lowest traffic periods.

WSDOT has proposed construction staging areas that do not expose many residents or neighborhoods to air pollutants.

The proposed construction equipment and project materials staging areas are mostly located in or near the right-of-way where construction is occurring (WSDOT, 2006, p 8-9). Only the staging area in the westbound HOV lane on the Eastside of the bridge is near residences and a school.

Vehicles hauling materials and equipment will travel through residential and commercial neighborhoods, exposing equipment operators, shoppers, pedestrians, and residents to fine particulate and diesel particulate matter emissions.

The land side haul routes will occur on approximately a dozen streets in both commercial and residential areas and average 2-5 truck trips per hour with increases to 3-12 trips per hour during periods of peak activity (WSDOT, 2006, p 8-15).

Traffic on the SR 520 facilities will contribute to emissions and increase concentrations in areas approximately 300 meters on either side, which will affect the health of the drivers, passengers, pedestrians, bicyclists, and nearby residents.

Vehicle-related pollutants such as fine particles are highly concentrated immediately downwind from major roadways. People who live within 300 meters of major roadways such as SR 520 experience higher concentrations of certain air pollutants, especially fine particles, than people who live at greater distances.

Air Quality

This can affect the health of people living close to the roadway. Roadways with high volumes of diesel vehicles pose more concern because chronic exposure to diesel particulates has been associated with a number of health risks (Houston et al., 2006). Traffic emissions also contribute to ambient levels of air pollution outside of this 300-meter distance. The health effects of pollutants on those closest to the highway may be best addressed through project design, while the broader effects of background pollutants are more appropriate to address on a regional or national basis. The illustration identifies land uses with sensitive and vulnerable populations, including daycare centers and schools within a 300 meter corridor along SR 520.

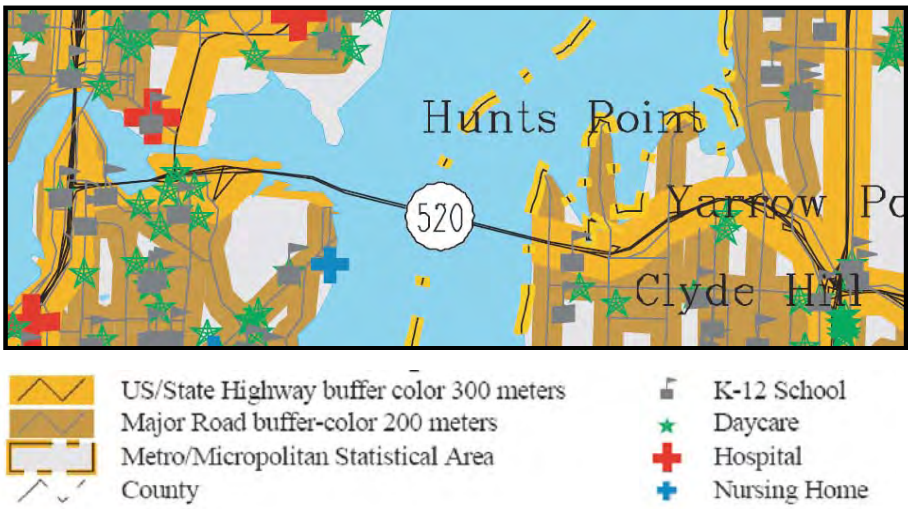

Illustration:
Sandlin G. Department of Ecology,
Air Quality Program, July 2006

The ventilation stacks for the anticipated Montlake Cut tunnel, which would be 20' x 40' x 70'high, appear to be in the parking lot south of Husky Stadium and in East Montlake Park, which are not near residential neighborhoods (J Young, personal communication, May 16, 2008).

The project will reduce emissions compared to not building it because it will reduce future travel times for buses, carpools, and single-occupant vehicles.

Currently, the peak period trip is severely congested, with stop-and-go travel and takes about 13 minutes in a single-occupant vehicle and 11 minutes in a bus or 3+ person carpool. Under free-flow traffic conditions, the trip takes about 8 minutes (WSDOT, 2006, p 4-6). Emissions rates are higher during stop-and-go, congested travel than free flow travel operating at the same average speed (EPA, Sept 2003).

Transit, carpool, and single occupancy vehicle travelers will be able to move through the corridor quicker in 2030 than if the project is not built. Transit and carpool travelers will generally see travel times increase over their current 2008 levels, but still below the 2030 forecasted travel times if the project is not built. However, even with construction of the project, single-occupant vehicle travelers will spend approximately twice as much time traveling in the corridor as is currently done (WSDOT, 2006, p 4-6).

The project will be able to reduce emissions compared to not building it because more people will be traveling in buses and carpools.

Currently, during the peak period, approximately 11 percent of people crossing the bridge ride in buses. This percentage is predicted to rise to 27 percent if the project is built (J Young & M Horntvedt, personal communications, June 4, 2008). The percentage is predicted to rise to 25 percent in 2030 even if the project is not built (WSDOT, 2006, p 4-11). The increase in person trips relative to the increase in vehicle trips indicates a shift to carpools and buses primarily due to tolls and congestion (WSDOT, 2006, Transportation Discipline Report p 4-8).

Approximately 30 percent more buses would be needed to accommodate the projected growth in demand for bus service in the morning. The six-lane project design will have available roadway capacity to serve transit service demand (WSDOT, 2006, Transportation Discipline Report p 7-16).

SUMMARY

Because air pollution produces some of the most significant adverse health effects associated with major transportation projects, it is essential that air quality be a central focus of the SR 520 Project. Readily available technology and WSDOT's existing procedures and practices can help reduce air quality concerns during the seven-year construction period. The vegetation on landscaped freeway lids can directly contribute to lower air pollution, help provide easier access to neighborhoods on both sides of the SR 520 corridor, and help encourage more walking, bicycling and transit use, which also can contribute directly to lower air pollution. These features of the project should be viewed not as optional, but as essential to promoting the health of residents and their communities.

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Water Quality

Appendix C:
Water Quality Issue Paper

September 2008

Clean water is indicative of a healthy ecosystem and essential to protecting human, plant, and animal health

INTRODUCTION

Within the natural environment of the SR 520 corridor, Lake Washington is an extraordinary resource that helps define the region. Lake Washington is an important cornerstone of the Cedar and Sammamish river watershed in King County. This fresh water body is home to a complex aquatic life system and a source of recreation and beauty. In the last 50 years, it has come under enormous stress from waste disposal, development, and a rapidly growing population.

Storm water is the leading contributor to water quality pollution of urban waterways in Washington (Ecology). Currently, the SR 520 Evergreen Point Bridge does not have a storm water treatment system and roadway pollutants are carried directly into the lake and associated wetlands. The SR 520 Bridge Replacement and HOV Project will create new impervious surface, generating additional storm water runoff; and, construction will remove vegetation, increasing the potential for erosion into surface waters. The proposed project includes storm water treatment facilities such as water quality vaults, storm water wetlands, bridge column treatment wetlands, and other techniques to treat storm water before it enters Lake Washington, all of which can help to reduce the pollutants that enter Lake Washington (WSDOT, 2006).

DISCUSSION

Seattle began discharging raw sewage into Lake Washington around 1900, and as early as 1926 sewage was diverted from the lake to the Duwamish River and Puget Sound. Suburban growth contributed to the lake's pollution. Ten sewage treatment plants were built around the lake between 1941 and 1953, which released a total of 20 million gallons effluent a day. Researchers studying the lake's biology and chemistry predicted that the increased nutrients would stimulate nuisance algal conditions. In 1958, a referendum passed to fund a major trunk sewer to treat and divert all wastewater effluents, excluding storm water, from the lake into Puget Sound. As the system diverted effluents to the Sound, Lake Washington's deterioration slowed, and then stopped by about 1964. By 1965, there were signs that the lake was improving (KCDNRP).

Lake Washington has, however, had a slow decline in water quality since the late 1970s as measured by nutrient content, water transparency, bacteria, and toxics. Direct storm water deposition and air deposition are two known contributors to water pollution. Direct storm water contamination comes from improper uses at shoreline properties, normal vehicle use, and vehicular accidents on the roadways. Vehicle operations leave heavy metals, petroleum products and plastics on the roadways. Accidents can cause water pollution from gasoline and diesel spills. In addition, air deposition of toxics from vehicles onto the water is potentially a major contributor to water pollution in the lake.

The Puget Sound Partnership, a community-led effort of residents, governments, tribes, scientists, and businesses working together to restore and protect Puget Sound, was charged by Governor Gregoire and the Legislature to determine the problems leading to the poor health of the Puget Sound and create an agenda for restoring its health (www.psp.wa.gov). Although this effort is focused on Puget Sound the problems and their effects are likely applicable to Lake Washington. One of the discussion groups created is the Human Health Topic Forum (PSP, 2008). An initial draft discussion paper identified water quality threats to human health including pathogens, biotoxins, and toxic contaminants including metals, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), petroleum compounds, endocrine-disrupting compounds, and others.

Among the most serious potential threats to human health identified by the Puget Sound Partnership was consumption of fish, which concentrate in their tissues such toxics as PCBs and mercury. Human consumption of these fish can lead to chronic health problems, and children are at the greatest risk for developmental effects from such exposure. Native American tribes and some immigrant populations are at particular risk because they tend to consume more of what they catch and eat more bottom fish than the general population. They may also experience serious health, social, and economic consequences if traditional marine food sources become scarce or unavailable because of contamination.

As in the Sound, recent studies have documented the presence of toxics in Lake Washington fish, including heavy metals and PCBs (WSDOE, 2007). The Washington State Department of Health has issued a fish-consumption advisory (for northern pikeminnow, yellow perch, and cutthroat trout) for Lake Washington due to this contamination (WSDOH). Little is known about sources of PCBs in Lake Washington, but other jurisdictions in Washington have found untreated storm water to contain high loads of PCBs (WSDOE, 2007).

A storm water runoff study of SR 520 Evergreen Point Bridge found high concentrations of zinc (Wilson, 2005) which was later determined to be from corrosion of iron downspouts (WSDOT, 2005). The runoff study also found elevated levels of:

- Barium, copper, and lead – found in brake-wear dust.
- Phthalate compounds – found in a variety of consumer products, including plastics and car parts.
- Total petroleum hydrocarbons.
- 4-nonylphenol – a degradation byproduct and surfactant use in detergent gasoline and lubrication oils.
- Bisphenol-A – plasticizer used in a wide variety of consumer product including automobiles.
- Nitrogen, ammonia, and fecal coliform bacteria – vehicle traffic is a source of nitrogen compounds and bird droppings from roosting birds on the west high rise structure appear to be likely source of nutrients and bacteria.

Public Health – Seattle & King County works with King County Department of Natural Resources and Parks to monitor public beaches on Lake Washington for safety of swimmers and other recreational activity. Matthews Beach, north of the SR 520 Evergreen Point Bridge, is one of the more frequently closed sites due to bacterial pollution. Madison Park, less that one mile south of the Evergreen Point Bridge, has had moderately high levels of bacteria but no closures (KCDNRP).

Discussion with the Washington Department of Ecology (WSDOE) indicated that the SR 520 Project will be required to acquire and abide by numerous permits to regulate storm water. For example, WSDOE requires WSDOT and other large jurisdictions to manage storm water through compliance with the municipal storm water National Pollutant Discharge Elimination System (NPDES) permit. This permit prohibits discharge of toxics at levels that would violate water quality standards and requires the use of "all known, available, and reasonable methods of prevention, control and treatment to prevent and control pollution of waters."

NPDES permits for storm water will be required during demolition of the existing bridge and construction and will include regulations for upland construction to meet state water quality standards. In addition, at least one federal permit for water quality standards will be required. The WSDOT also has its own storm water management program, known as the "Highway Runoff Manual," that it follows during construction and implementation of transportation projects, and which the WSDOE has approved.

Storm water treatment systems are currently proposed at either end of the Evergreen Point Bridge. Storm water treatment(s) for the new bridges' center floating spans are still being considered; the current plan includes regular high-efficiency sweeping of the bridge's road surface prior to rain events in addition to dilution in Lake Washington, as indicted in the SR 520 Draft Environmental Impact Statement (EIS). While preparing for the Supplemental EIS and Final EIS, WSDOT plans to review these strategies and analyze the degree to which the systems can remove significant contaminant loadings for the new project alternatives.

SUMMARY

The SR 520 bridges have had minimal storm water management since built that will change drastically with the replacement. SR 520 is not the only facility that contributes pollutants to the lake, but an innovative storm water management system can be an important part of the solution to reducing lake pollution levels and preserving a valuable regional asset.

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Noise

Appendix D:
Noise Issue Paper

September 2008

Community noise is a source of annoyance and may cause health problems. Reconstruction of SR 520 could affect neighboring communities both during construction and operation

INTRODUCTION

Noise is a nuisance that can have negative effects on the health of individuals and communities. Transportation sources such as motor vehicles are major sources of community noise, particularly in urban and industrialized areas.

The SR 520 corridor was built in the 1960s, prior to the establishment of noise regulations for federal highways. The proposals for the reconstruction of the SR 520 corridor integrate noise-reducing design features along all sections of the project area that affect surrounding communities. This includes most of the project, except possibly the middle section of the bridge over Lake Washington. This report discusses what is known about the relationship between noise and health for individuals and communities and the noise effects of the SR 520 Bridge Replacement and HOV Project as outlined in Washington State Department of Transportation's (WSDOT) Noise Discipline Report submitted with the SR 520 Draft Environmental Impact Statement (DEIS).

The reconstruction of SR 520 could affect nearby neighborhoods both during construction and during operation as a consequence of its design.

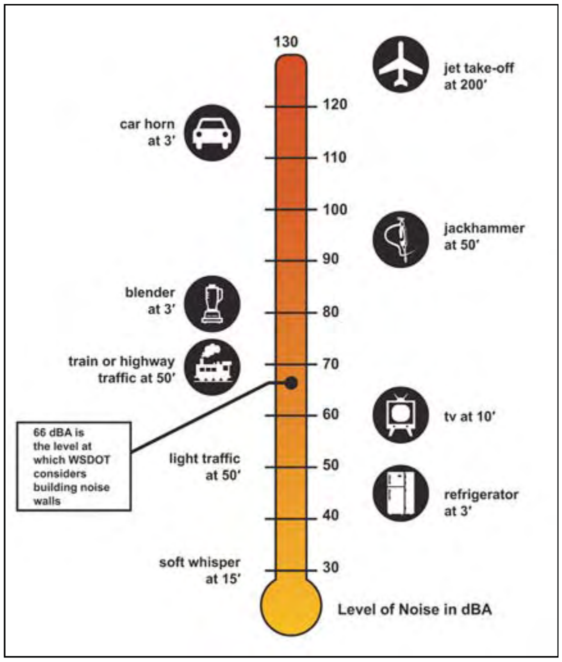
CONSTRUCTION - The activities and equipment associated with the various phases of highway construction can create significant noise within a community. Construction vehicles are often louder than passenger vehicles, and construction equipment can generate noise characterized as either "impact" or "impulse" noise. Such noise is often repetitious and may have low-frequency components, characteristics more often associated with annoyance (EPA, 1981).

In the case of the SR 520 Project, construction is expected to take seven years or longer and potential for detrimental effects on surrounding communities is great.

DESIGN -WSDOT has conducted extensive studies on the effects various bridge designs would have on community noise. The SR 520 DEIS Noise Discipline Report focuses on four-lane and six-lane design options. Though both options would reduce the effects of traffic noise on nearby communities, the six-lane option provides for lids that would benefit more residences in the project area by reducing noise levels below the FHWA action level of 67 dBA (WSDOT, 2006). At certain sections of the corridor, particularly within Seattle at the west side of SR 520, traffic noise from local streets appears to influence noise levels to a greater extent than the proposed project (WSDOT, 2006).

Noise

Currently, more design options are being considered within the six-lane configuration. As part of federally required mitigation, noise walls are included in these discussions. The placement and design of the roadway have also been designed to help minimize noise impacts to the surrounding neighborhoods. Mediation team members have requested that other technologies, such as the quieter pavement currently being researched by WSDOT, be considered for minimizing noise effects.



Researchers have examined the relationship of noise to human health for several decades. Regulations to control noise began to be enacted in the United States in the 1970s based on research findings. The typical measure of noise used in regulations is the decibel, which measures pressure levels in the atmosphere resulting from sounds against a standard reference sound at a specified distance. The scale is logarithmic. Figure 1 demonstrates some common sounds or noises and their relative strength. (Timmerson, 1999)

The importance of efforts to mitigate the noise of construction and operation of a SR 520 replacement is underscored by extensive, ongoing research. These are some of the main findings.

ANNOYANCE – An often cited consequence of noise is annoyance. It is widely agreed that annoyance has a detrimental effect on an individual's well-being and state of mind. Attempts to link annoyance to specific health indicators, such as stress or blood pressure, have not yielded uniform results. However, annoyance can certainly result in social discontent in neighborhoods affected by noise, as evidenced by the prevalence of noise regulations in many urban areas.

HEARING LOSS OR DEGRADATION – The loss or degradation of hearing following exposure to excessive amounts of sound is the most documented and well-understood connection between noise and health. Standards have been developed in the United States and other industrialized countries for protective noise-exposure levels in industrial settings. Studies of community noise exposure and hearing loss have not demonstrated a clear link between the two. Guidelines developed by the World Health Organization state that a lifetime of regular exposure of 70 dBA could produce negligible hearing loss (Berglund et al., 2000).

CARDIOVASCULAR DISEASE – While little convincing evidence of a link between traffic noise and blood pressure has been shown, recent studies indicate potential links between ischemic heart disease, a commonly occurring type of heart disease, and long-term exposure to high levels of road traffic noise (Babisch, 2006). While these relative risks are low, the ubiquity of noise and prevalence of ischemic heart disease make it a potentially important public health issue. Researchers are also examining the combined role of air pollution and noise pollution (which have the same sources) to cardiovascular disease.

COMMUNICATION INTERFERENCE – Humans discriminate among sounds and focus on those related to a certain task, even when background noise levels are high. Speech becomes more difficult to understand at higher levels of background noise which in turn makes communication more difficult. Older adults, children in the process of language acquisition, those with hearing impairment, and those not familiar with the spoken language are particularly vulnerable to speech interference effects (Watkiss et al., 2000).

SLEEP DISTURBANCE – Community noise regulations place a value on lower aggregate noise levels at night. Noise can cause sleep disturbance, but it is difficult to correlate increasing aggregate noise exposures to sleep disturbance. This may be because individuals can become accustomed to noise levels. The long-term health effects from sleep disturbance may result in lowered performance and physiological effects.

WORK AND LEARNING PERFORMANCE – Researchers have long sought to characterize how noise might affect the performance of tasks in working and learning environments. Performance degradation is often linked to other potential effects of noise, such as hearing loss, communication interference, sleep disturbance, and annoyance. As a result, most studies have not demonstrated direct links between noise exposure and performance degradation. A notable exception was shown in a study that found a statistically significant linear relationship between noise levels in neighborhoods adjacent to busy airports and reading comprehension among children (Clark et al., 2006). This relationship was not observed for children exposed to high levels of noise from nearby roadways in this particular study, though the authors themselves indicate more research is needed in this area (Clark et al., 2006).

SUMMARY

The detrimental effects of noise on individuals and communities reviewed argue for vigorous efforts to mitigate construction noise and traffic noise on the SR 520 structure. Construction noise control is needed for the duration of project construction. Construction will last several years and its noise could potentially have more than temporary negative effects on communities near the project. Consequently, great care will be needed in controlling construction-related noise. Coordination among all agencies responsible for noise along the project corridor, including WSDOT, Public Health – Seattle & King County, and municipal governments, will be necessary to ensure that noise impacts from construction are minimized to the extent possible along the entire project corridor. This coordination is recommended in addition to noise control measures that WSDOT uses during typical construction projects. Planning will be particularly important, given the length of time that construction will occur.

Design considerations could include new materials and designs for noise walls and the development of comprehensive maps of transportation and community noise, which could help in planning the SR 520 replacement and assist in ensuring compatible uses for neighboring properties.

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Appendix E:

Physical Activity Issue Paper

September 2008

Regular physical activity can improve people's quality of life as well as help prevent numerous chronic diseases.

INTRODUCTION

Physical activity is more than just exercising and playing sports; it also includes household and yard work, occupational activity, and bicycling or walking for transportation. This paper examines how the design of the built environment and transportation systems can affect individual and community health through increased opportunities for physical activity.

DISCUSSION

Physical inactivity is one of the top modifiable risk factors for chronic disease, premature death, and injury (CDC, 1996). Physical activity has numerous health benefits, including reduced risk of cardiovascular disease, ischemic stroke, non-insulin-dependent (type 2) diabetes, colon cancer, osteoporosis, depression, and fall-related injuries (Kahn, 2002). Despite these benefits, only about 25 percent of Americans currently meet the minimum recommended goal (Kahn, 2002; Wen, 2007) of 30 or more minutes of moderate physical activity five days a week, or 20 minutes of vigorous activity three times a week (DHHS, 2008).

Sedentary lifestyles are considered a major contributor to the obesity epidemic in the United States (CDC, 1996). In 2005, approximately 60 percent of American adults were overweight, of whom nearly 24 percent were obese (Blanck, 2006). Approximately 33 percent of children and adolescents are overweight or obese (RWJF, 2007). It is estimated that the obesity epidemic costs the nation more than $117 billion each year in medical expenses and lost productivity (RWJF, 2006).

Two objectives of the U.S. Department of Health and Human Services' *Healthy People 2010* initiative are to increase the amount of moderate or vigorous physical activity performed and to increase opportunities for physical activity through access to places and facilities where people can be active (Kahn, 2002). Research is finding associations between the design of neighborhoods, city centers, and roadways and residents engagement in physical activity for recreation and utilitarian purposes (Canepa, 2007; Ewing, 2006; Frank, 2006). For example, one study found that just a 5 percent increase in neighborhood walkability was associated with a 32 percent increase in time spent in physically active travel, a 0.23-point reduction in body mass index (a measurement of weight in kilogram/height in meter2), and 6.5 percent fewer vehicle miles traveled (Frank, 2006).

Research shows that the built environment has an impact on walking behavior even after accounting for attitudes and preferences (Handy, 2006). In one study participants drove less when living in a more walkable environment regardless of their demographic characteristics and neighborhood preferences (Frank, 2007).

Community design and transportation options affect population groups differently. For example, 21 percent of Americans age 65 and older do not drive and more than 50 percent of non-drivers age 65 and older stay home each day partially because they lack transportation options. More than half of older Americans make walking a regular activity, and nearly two-thirds walk a half mile at least once a month. Safe and inviting walking and bicycling environments provide them the necessary support and the subsequent health benefits (Bailey, 2004).

Neighborhood characteristics also influence children's daily physical activity levels. Research shows that fewer kids are getting regular physical activity in schools, and parents' concerns about traffic safety, crime, or both is a significant barrier to physical activity (RWJF, 2007).

Connectivity of streets (Frank, 2006; Heath, 2006) and trails (Suminski, 2005) is important for pedestrians and bicyclists. Studies reinforce the idea that if it is easy to walk or bicycle in a neighborhood, people are more likely to do it. Distance to (Krizek, 2006; Moudon, 2006), number of (Heath, 2006; Hoehner, 2005), and types of (Frank, 2006; Moudon 2006) amenities within walking and biking distance from home are important. One study found that residents of walkable neighborhoods engaged in 70 more minutes of moderate to vigorous physical activity per week compared to residents of neighborhoods where it was difficult to walk (Saelens, 2003). Other research found that those having a place (such as neighborhood streets or sidewalks or public parks) to walk to less than 10 minutes from home were more likely to meet physical activity recommendations than those who reported having no place to walk (Powell et al., 2003). Other studies indicate that individuals will generally choose to walk/bike .12 mile to retail (Krizek, 2006), .16 mile to restaurants, and .27 miles to a grocery store (Moudon, 2006).

Access to public transportation encourages alternative modes of transportation, like walking and bicycling, and is associated with increased levels physical activity. Research found that transit users spent a median daily time of 19 minutes walking to and from transit (Besser, 2005). Conventional theory is that individuals will walk .5 miles to rail and .25 miles to bus; however, recent evidence demonstrated that "pedestrians are prepared to travel more than .5 mile if an accommodating atmosphere prevails" (Canepa, 2007; Hoehner, 2005).

Researchers have found that streets and public open spaces are common places for physical activities (Giles-Corti, 2002). One study found that two-thirds of people who were physically active engaged in activities on neighborhood streets, nearly 30 percent reported using parks, and 25 percent used walking trails (Brownson, 2001).

Bridges that provide for walking and bicycling can help encourage physical activity and non-vehicular commuting. The Arthur Ravenel Jr. Bridge, also known as the Cooper River Bridge, is a cable-stayed bridge over the Cooper River in South Carolina, connecting downtown Charleston to Mount Pleasant. The bridge has a bicycle/pedestrian lane that travels along the outer edge of the bridge's tower piers and offers observation sites with benches. The bicycle/pedestrian lane is 2.7 miles long and is limited to a 4.1 percent maximum slope (SCDOT, 2004). In a recent survey of 393 users, 67 percent indicated that their activity levels had increased since the opening of the bridge path, and 10.4 percent said they are using the bridge to commute to work. Bike commuters identified the chance to be outside and the scenery as strong reasons for the bridge use. Users also indicated safety, lighting, scenery, parking, convenience, location, and easy access as important path qualities (Quick, 2008).

With more sedentary jobs and more reliance on motorized transport, leisure-time physical activity is important in meeting the recommended levels of physical activity (Bedimo-Rung, 2005). Parks play an important role in increasing physical activity by providing areas for walking, sports, and other activities, as well as being a pedestrian destination (Cohen, 2007). The exposure to natural beauty in parks can improve the experience of users and encourage greater use (Giles-Corti, 2005).

A safe environment with absence of crime, traffic, accidents, and injury for pedestrians and bicyclists is a basic goal for communities. Traffic-calming devices, such as vertical and horizontal deflections, road narrowing, medians, and traffic circles (Loukaitou-Sideris, 2006) are important for walking and bicycling (Lee, Loukaitou-Sideris, 2006; Heath, 2006). The presence (Moudon, 2006; Rodriguez, 2004; Heath, 2006; Krizek, 2006) and quality of (Heath, 2006; Loukaitou-Sideris, 2006) bicycle lanes and footpaths (Lee, 2004) is also important for promoting walking and bicycling (Hoehner, 2005; Loukaitou-Sideris, 2006; Wendel-Vos, 2007).

The SR 520 Bridge Replacement and HOV Project indicates plans for a bicycle/pedestrian path across the Evergreen Point Bridge, trail connections within the communities, and connections to lids over the freeway. The paths will connect the region's longest and most popular trails and routes (Burke-Gilman Trail, Washington Park Arboretum Waterfront Trail, Lake Washington Loop Route, Sammamish River Trail, and East Lake Sammamish Trail) as well as many on-street bicycle routes. Additionally, the SR 520 Project site and vicinity include "a total of 17 recreational facilities located along the Seattle and Eastside project corridor" which provide destinations for pedestrians/bicyclists. These areas include trails and play areas and are important community assets for increasing physical activity. Many other destinations are in or nearby to the project area such as the University of Washington campus, Seattle library, community centers, and local retail.

An increase in residents engaging in physically activity is expected, although it is difficult to determine the number of pedestrians and cyclists who will use the SR 520 floating bridge path and other trails. The paths and recreation areas increase opportunities and choices and marketing of these facilities with wayfinding signs that indicate preferred routes, destinations, and distances can encourage current and new users.

SUMMARY

Recent collaborative and multidisciplinary initiatives can provide additional guidance for future design plans. The Seattle Bicycle Master Plan's goals are to increase use of bicycling in the Seattle area for all trip purposes and improve the safety of bicyclists throughout Seattle. And, the Pedestrian Master Plan, while still being developed, strives to get more people walking while reducing the number and severity of crashes involving pedestrians. These plans can provide recommendations and guidance on improvements for the SR 520 Project to increase the volume, enjoyment, and safety of bicyclists and pedestrians.

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Safety

Appendix F:
Safety Issue Paper

September 2008

Feeling safe and secure at home, work, and play and in the community is basic to people's sense of well-being.

INTRODUCTION

The SR 520 Bridge Replacement and HOV Project proposes walking and bicycling paths across the Evergreen Point Bridge with connections to surrounding neighborhoods, and landscaped lids that can encourage people to enjoy opportunities to be physically active. These proposed changes are expected to result in an increase of pedestrian and bicycle traffic on and in the vicinity of the SR 520 corridor. It is important to consider how these improvements can promote the safest environment for all users. This report reviews pedestrian and bicyclist collision and other safety data on a regional, state, and national level, and ways to improve safety for pedestrians and bicyclists with the SR 520 Project proposed changes.

DISCUSSION

Healthy People 2010's which establishes national goals for significant preventable health threats has as a target, reducing pedestrian fatalities by one per 100,000 people. King County's pedestrian fatality rate is 1.4 per 100,000 people. On average, 26 pedestrians are killed in King County every year (Lim, 2005). Also, Healthy People 2010's goal for injuries resulting from motor vehicle crashes or falls is 17.5 per 100,000, while King County's 2003 rate was 26.5 per 100,000 (PHSKC, 2006).

A report on King County pedestrian fatalities in 2000-2003 provided information on the environmental and human factors that contributed to pedestrian deaths (Lim, 2005). Pedestrians made up nearly 20 percent of motor vehicle crash fatalities, and the darkest winter months, particularly when it was raining, were the most dangerous times for pedestrians. Sixty-two percent of pedestrians killed were attempting to cross a roadway.

In 2006, the King County Medical Examiner's Annual Report indicated traffic fatalities involved 33 pedestrians and eight bicyclist deaths (PHSKC, 2006).

Although a path for pedestrians and bicyclists does not currently exist on the SR 520 Evergreen Point Bridge, four pedestrian and bicyclist collisions were documented in the corridor (I-405 to I-5) during 2002-2007. On a similar path, the I-90 pedestrian and bicyclist shared path between Seattle and the Eastside, two collisions were reported in the past five years (D. Giles, WSDOT, personal communication, March 7, 2008).

The preceding data demonstrates a relatively low incidence of pedestrian and bicyclist injuries and fatalities in the region. However, strategies to reduce the risks for pedestrians and bicyclists are needed. Several planning efforts are underway to develop and implement safe walking and bicycling statewide.

Safety

The built environment design can influence the choice for active transportation such as walking and bicycling and the outcomes related to improved safety, including increased physical activity. Critical to maximizing the health benefits is managing the proximity of pedestrians and bicyclists to traffic, managing the volume and speed of traffic at crossings, and increasing the knowledge and attitudes people have about the rules of the road.

Research has looked at bicycle ridership factors on pathways in the Central Puget Sound region. Of the 29 locations reviewed in the project area, six locations containing paths of designated bike lanes carried half of all the bicycle traffic entering and leaving downtown, suggesting that a majority of bicyclists prefer to ride on facilities designed for exclusive bicycle use (PSRC, 2001). In an April 2007 statewide telephone survey, 57 percent of responders said no sidewalks in their community made it difficult for them to walk and 23 percent indicated busy roadways deterred them from walking. Also, 37 percent said no bike lanes and too narrow or no shoulders were reasons not to bicycle (Wilbur Smith Assoc., 2007).

Final design elements of the SR 520 Project will increase the safety of pedestrians and cyclists, especially as their numbers increase. Traffic-calming techniques that aim to reduce speed and aggressiveness of drivers near the trails, transit shelters, or on the project corridor will be needed to protect bicyclists and pedestrians in the project vicinity. For example, reducing speeds in neighborhood areas can prevent pedestrian fatalities (pedestrians have a 5 percent chance of death when hit by a car traveling 20 mph or less, a 40 percent chance of death at 30 mph, an 80 percent risk at 40 mph, and 100 percent risk of death at 50 mph or more) (Ross, 2007).

The Bicycle Alliance of Washington anticipates a high volume of ridership across the SR 520 shared path and have suggested key safety features that will assist these riders, such as, smooth and gentle transitions to and from the SR 520 to neighborhood routes; good lines of sight; signage to clearly define distances and routes for cyclists crossing the bridge; and adding visual cues, such as color striping, to separate pedestrians from bicyclists and avoid possible collisions on the shared path (G. Black, personal communication, June 5, 2008).

New solutions like rubber sidewalks, currently being tested in Bellevue and Seattle, provide a surface that is easier on the joints of pedestrians and have minimized injury to those who may have fallen (Holly, 2006). This concept may be a creative option for some of the pedestrian and bicycle paths if it can withstand the environmental elements and wear and tear from daily use.

Sound walls and jersey barriers aid in minimizing noise levels from vehicles and provide a layer of safety for bicyclists and pedestrians from the fast moving traffic. Residents have raised concerns about the visual appearance of sound walls and retaining walls.

Other important options that can increase the safety and health of pedestrians and cyclists are emergency 9-1-1 call boxes and cameras to monitor activity and increasing awareness of motor vehicle drivers of pedestrians and bicyclists through signage and reflective lights.

Safety considerations during construction will be critical for allowing pedestrians and bicyclists to continue with their active transportation modes and enjoy their time in safe environments. Clear signage indicating detour routes will be helpful as well as education campaigns to provide education on safe walking, bicycling, and driving practices (Gomez, 2006).

Finally, the issue of crime and safety is only briefly discussed here but is an important consideration when designing the SR 520 Project. The proposed landscaped lids provide numerous health benefits, but parks and green space can also attract undesirable behavior. Applying the principles of Crime Prevention through Environmental Design (CPTED) and other strategies will assist in balancing necessary visibility with pleasing design (www.cpted-watch.com). Ensuring clear sightlines for users and avoiding the creation of secluded areas is important. The walkways should be free of barriers and ample lighting should be available, as well as emergency call boxes. It is also important for neighborhoods to self-police their community; some local neighborhoods already have neighborhood watch programs.

SUMMARY

Designing for pedestrian and bicycle safety will be important during both construction and operation of the SR 520 Project. Critical elements include easy transitions to and from the SR 520 corridor, good lighting and signage, safe pedestrian and bicyclist facilities (such as benches, bike racks, public restrooms, and shaded areas), appropriate barriers between the shared bicycle and pedestrian path and the roadway, traffic-calming techniques in congested areas, and emergency call boxes. During construction, safe and clearly marked alternative routes for pedestrians and bicyclists will be needed.

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Safety

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Social Connections

Appendix G: Social Connections Issue Paper

September 2008

The social networks, trust, reciprocity, and civic engagement that develop through community interactions can improve health and well-being.

INTRODUCTION

Social interaction is the basis of human society, and research is finding that promoting ways for individuals to associate, even in a casual ways, may build social connections and in turn promote better health and well-being.

When built during the 1960s, SR 520 divided neighborhoods in Seattle and on the Eastside. The SR 520 Bridge Replacement and HOV Project alternatives being considered include elements that help reconnect communities. The SR 520 Project proposes to add landscaped lids across SR 520 to reconnect communities along its path. New bicycle and pedestrian paths are proposed that would connect existing trails in the area and another will extend across Lake Washington, creating a link between Seattle and Eastside neighborhoods.

This report defines important concepts for building social connections, explains the link to population health, and proposes ways the SR 520 Project can enhance neighborhood connections.

DISCUSSION

"Communities are strong when people are engaged in activities that benefit more than themselves as individuals. Working together for the common good of neighborhoods, faith communities, schools, or a political cause creates civic responsibility and a sense of reciprocity" (PHSKC, 2005). Interactions at a community level provide a sense of belongingness and general social identify, which is relevant for promoting health and well-being (Putnam, 2001; Kawachi et al., 2001; Berkman, 1995). Societal resources and the physical environment affect the social cohesion and civic engagement in communities, which can in turn affect the level of community health (Anderson et al., 2003).

"Friendship, good social relations, and strong supportive networks improve health at home, at work, and in the community." (World Health Organization, 2003)

Social cohesion is an ongoing process in which "a community has shared values and objectives and residents are willing to share, adapt to, and collectively address challenges and opportunities in the environment" (Anderson et al., 2003). Neighborhood ties enhance social cohesion because they often bring together diverse people with different interests that typically make up a neighborhood (Skjaeveland et al., 1997).

A related concept, social capital, is the degree to which people feel that they live in and belong to a socially cohesive local environment (GIT, 2007). The central premise of social capital is that social networks have value, and circumstances that limit networking can have negative effects on the well-being of community members.

A number of studies have linked the social environment to community well-being. People who engage socially with others and are involved in their communities live longer and are healthier both physically and psychologically. A study comparing those in an area with low social connectedness found an increase in death from all causes, stroke, and ischemic heart disease compared to those with high connections (Kaplan et al., 1988). Residents in neighborhoods with a higher degree of sense of community have higher ratings of perceived health and higher physical activity levels (Kawachi et al., 1997). One study showed that lower levels of trust were associated with higher rates of total mortality, coronary heart disease mortality, malignant neoplasms, stroke, and infant mortality (Kawachi et al., 1997).

Children and older adults are particularly sensitive to the social structure of their neighborhoods. Child development is shaped through exposure to models of networks and norms within their family, peer groups, and community (Putnam, 2000). The area outside of the home where parents feel comfortable letting their children play unsupervised has shrunk by 90 percent since the 1970s; an important fact as play is essential physical activity in children's lives (Louv, 2005). In socially connected neighborhoods, adults may take more efforts to create environments for children to play and be more active (Cohen et al., 2006). Older adults are at highest risk for morbidity and mortality. Decreased social participation and networks is a predictor of cognitive decline in men and women over age 65 (Kawachi et al., 2001). Members of this group may have less physical mobility and rely on close ties (e.g. neighborhood) for social interaction (Seeman et al., 1987).

The built environment affects community social connections. Built environment factors contribute to a sense of community and support opportunities for neighborhood interaction through interesting design, availability of public space, and presence of neighborhood facilities (Lund, 2002). Important factors for increasing public space use include: size of space, maintenance, presence of natural elements, street furniture, and views of and from the space (allowing people to discover that others are present). If residents prefer a place, they are more likely to stay for some time, to feel well, and interact with neighbors (Skjaeveland et al., 1997). These moments of interaction, whether for the exchange of pleasantries or information, strengthen social networking bonds and can have real and substantial positive health outcomes (Ewing & Kreutzer, 2006; Baum & Palmer, 2002; Bedimo-Rung et al., 2005; Leyden, 2003).

Areas with attractive walking destinations, footpaths, or a safe and interesting walking environment are more likely to provide opportunities for informal interaction (Wood et al., 2008). Research suggests that a walkable environment facilitates a strong sense of community because it provides for casual interaction between neighbors.

"When pedestrians encounter each other outdoors they are sharing three immediate attributes: the time, the space, and the expectation that they are having the same experience. It is the basis for easy conversation, even if it's only to complain about the weather. People who walk their local streets are the agents of community life. Children who walk to school make friends with other children en route and those who walk to their local shops meet their neighbors more often. It is often in the course of these informal meetings that information is exchanged and news is disseminated. Because the streets are a service that everyone uses and a common experience for everyone they provide a unique opportunity for integrating different sections of the community" (Franklin).

Studies indicate that green space in urban living areas is positively correlated with more use of the space and more vitality and interactions in the space (Sullivan et al., 2004). For example, parks can provide a place where people interact and develop social ties and a setting where healthy behavior (e.g. physical activity) is possible (Bedimo-Rung et al., 2005).

Many factors, however, can take people away from spending time in their community. For instance, people are spending more time alone in the car. Evidence suggests that each additional 10 minutes in daily commuting time cuts involvement in community affairs by 10 percent (which possibly means fewer public meetings attended, fewer committees chaired, and less volunteering) (Putnam, 2000). Also, more drivers on the road lead to heavy traffic that can produce more stress for residents and less social interaction. In one study, individuals living on a street with light traffic (200 vehicles at peak hour) had three times as many friends and twice as many acquaintances among their neighbors compared to those living on a street with heavy street traffic (900 vehicles at peak hour). Individuals living on the light street perceived it to be friendly and those with children were less concerned of traffic dangers. The heavy street had little activity and was used only as a corridor from homes to destinations (Appleyard et al., 1972).

Finally, public participation in land use and transportation decisions can promote social connections and lead to planning decisions needed for healthier communities. Although public agency standards for achieving social cohesion in land use and transportation projects are not required, guidance on public participation process as a means to enhance civic participation is available. The National Environmental Protection Policy Act (NEPA) provides guidelines for consideration of social, cultural and economic impacts in federal projects. Participation of residents and community councils in the SR 520 Project has been part of its long planning history. As part of the SR 520 DEIS process a Public Comment Report was compiled ("the report") with information on 1,734 unique submissions gathered at fairs and festivals; through an online comment system, email, and U.S. mail; and, at public hearings. In addition, the current mediation process includes affected community representatives.

The SR 520 Project area communities are established and residentially stable. These communities have settings that support informal social interactions, such as parks on the Westside and the Eastside. In addition, several playfields are located in the vicinity. The project site also has several transit routes and stops that connect the east and west sides of Lake Washington as well as adjacent communities and downtown areas. The University of Washington campus is also the site for a future Sound Transit light rail station.

Several SR 520 Project elements support social connections. The project proposes to add six lids across SR 520. The 10th and Delmar lid would partially reconnect the Roanoke/Portage Bay and North Capitol Hill neighborhoods, and the Montlake lid would partially reconnect the Montlake neighborhood. The proposed lids also provide connections in Medina, Hunts Point, Yarrow Point, and Clyde Hill over SR 520 at Evergreen Point Way, 84th Avenue Northeast, and 92nd Avenue Northeast. The landscaped lids can provide multiple health benefits to communities in the project area. The lids would include landscaped spaces with increased accessibility to neighborhoods and an opportunity for people to readily travel between neighborhoods and to local destinations (like neighborhood centers, the library, parks, and transit stops), especially by foot or by bicycle. The lids can become neighborhood public spaces that support social connections by creating places where residents and visitors can gather and interact. The lids can be destinations that bring diverse people together and build neighborhood ties.

Additionally, the SR 520 Project proposes a new bicycle and pedestrian path to connect the existing Bill Dawson Trail, which runs from Montlake Playfield to the south side of the National Oceanic and Atmospheric Administration's (NOAA) Northwest Fisheries Science Center, to the northeast area of Montlake neighborhood and then south to the Arboretum. A new bicycle and pedestrian path would extend across Lake Washington, creating a link between Seattle and Eastside area neighborhoods. The improvement of the trail system can increase access to areas where residents can interact and engage in physical activity.

SUMMARY

Recommendations to support and encourage social connections in the SR 520 corridor need to be focused on creating an environment and places that support interactions of the community.

"Many of the best places are neither home nor work, but "third places" in the public realm: streets and sidewalks, parks and cafes, theaters, and sports facilities. Such public places are important venues for a wide variety of activities of which some, such as social interaction and physical activity, have clear health implications" (Frumkin, 2003).

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Appendix H:

Mental Well-being Issue Paper

September 2008

Physical activity, stress reduction, exposure to natural areas, and feeling safe all contribute to mental well-being.

INTRODUCTION

The SR 520 Bridge Replacement and HOV Project offers many opportunities to expand existing natural systems by creating additional and connected parks, trails, and green spaces that would increase the enjoyment of the environment and the area's great natural beauty. These enhancements can positively influence the mental and physical well-being of residents and visitors.

DISCUSSION

Americans have experienced denser urban land development, with its increased noise and other irritations, since the early 19th century. Dependence on the automobile dramatically increased as cities developed, bringing increased noise, highways dividing communities, frustration from traffic congestion, and fewer opportunities for physical activity. These environmental changes influence health.

Regular exposure to high traffic levels can impair health, psychological adjustment, work performance, and overall life satisfaction (Novaco et al., 1990). Traffic can also increase blood pressure and frustration, sometimes leading to aggression (Mayer et al., 1977).

Chronic noise is generally associated with auditory damage; however, possible non-auditory health effects of noise include increased stress and stimulation overload that interferes with relaxation and the ability to concentrate. Stress induced by noise can contribute to anxiety and a sense of helplessness in children (Evans et al., 2001). Exposure to high levels of traffic noise can produce disturbances of daily necessities such as sleeping and relaxation, and general well-being (Bjork et al., 2006).

Research suggests that a physically inactive person is twice as likely to have symptoms of depression as a more active person. Research also suggests physical activity may improve self esteem and cognitive functioning (DHHS, 1996). Modern development patterns have created barriers to walking or bicycling to work and to recreational activities, school, and other activities and allow fewer opportunities for physical activity or to escape, renew, and relax in a natural environment. Also, some natural areas and parks are not easily or safely accessible without a vehicle.

Safe and well-marked access between green space areas is important to promoting physical activity and sense of well-being in a natural environment. Connected trails will increase commuting opportunities throughout the region by providing access to the biking and walking lanes connecting Seattle communities with communities on the eastern shore of Lake Washington. Safe and accessible transit and pedestrian options offer choices for some of our most vulnerable populations, such as the elderly or others who do not drive. Reduced isolation promotes mental well-being and helps eliminate or reduce depression and loneliness.

Being in nature is associated with mental well-being. The stresses in modern urban life brought on by traffic congestion, lengthy commutes, noise, and other distractions can lead to mental fatigue. Mental fatigue can negatively affect work performance and overall life satisfaction. Parks, green spaces, and open natural areas can provide a reprieve. Visiting a park can leave one with increased abilities to cope with the many everyday stresses in modern life. Parks can reduce stress and depression and improve the ability to focus, be productive, and recover from an illness (Maller et al, 2005). Researchers in Chicago found associations between contact with natural environment and improvements in the functioning of children with Attention Deficit and Hyperactivity Disorder (Taylor et al., 2001). Research indicates that spending time in parks can reduce irritability and impulsivity and promote intellectual and physical development in children and teenagers by providing a safe and engaging environment in which to interact and develop social skills, language and reasoning abilities, muscle strength, and coordination.

Significant evidence indicates that green spaces serve a vital role in communities as a location for social interaction (Sullivan et al., 2004). Social interaction and neighborhood spaces have been identified as key facets of healthy communities, supporting social networks, social support, and social integration that have been linked to improvement in both physical and mental health (Berkman et al., 2000; Bhatia et al., 2006). Attention fatigue (a neurological symptom that occurs when the part of the brain that allows us to concentrate in the face of distractions becomes fatigued) can be reduced by spending time in a natural setting (Kaplan et al., 1989; Kaplan, 1995).

SUMMARY

The SR 520 corridor is centrally located in Seattle and is easily accessible by public transportation from all over the region. It is also easily accessed by bicycling and walking from adjacent neighborhoods. The vicinity around the Montlake Bridge is densely populated with residents, University students, and visitors enjoying the unique attractions (e.g. Washington Park Arboretum, Interlaken Park, Lake Washington Ship Canal walkway, the University of Washington's Waterfront Activity Center, and many other recreational opportunities).

By enhancing and incorporating additional green space and trail connections into the design, the SR 520 Project will provide residents adjacent to the corridor and others in the region more opportunities to enjoy the natural world and reduce the daily stresses of living in an urban environment. It will also provide for adjacent communities to increase their opportunities for social interaction with their neighbors and help encourage physical activity and contact with the natural environment.

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Green Space

Appendix I:
Green Space Issue Paper

September 2008

Parks, gardens, arboretums, public space, bicycle and walking paths, trees, and urban landscaping all provide a respite from the urban landscape and have multiple health benefits.

INTRODUCTION

The SR 520 Bridge Replacement and HOV Project proposes to build six landscaped lids across SR 520 to reconnect communities along its path. They are located in the following areas: on the Westside at I-5, 10th Avenue and Delmar Drive East, and at Montlake Boulevard; and on, the Eastside at Evergreen Point Way, 84th Avenue Northeast and 92nd Avenue Northeast. In addition, this project will add better access to the Washington Park Arboretum. The project also proposes a 14-foot-wide bicycle/pedestrian path that will be built on the north side of SR 520 through Montlake and to the Evergreen Point Bridge. It will also extend along the north side of SR 520 through the Eastside to 96th Avenue NE. The pathways can link bicyclists and pedestrians to numerous green space and trail opportunities along the corridor. The increase in landscaping, public spaces and trails has the potential to produce positive health outcomes such as increased well-being, stress relief, physical activity, and other benefits. The new connections also provide non-motorized transportation opportunities which will reduce vehicle miles driven and carbon emissions in the corridor.

DISCUSSION

Green spaces fulfill one of human beings' most basic needs – the need for interaction with the natural world and other people. They are places that bring a diverse group of individuals of different ages, socio-economic levels and cultures together to enjoy an escape from everyday stress.

In the late 1800s, one of America's earliest urban park planners, Frederick Law Olmsted, was convinced that visual contact with nature was beneficial to the emotional and physiological health of city dwellers (Hunt et al., 2000). He promoted the inclusion and design of public open space as a critical component of making cities healthier.

A wealth of literature exists on the effects of rural and urban environments on physical, mental and spiritual health of local populations. Outdoor activity is widely thought to enable one to escape from the pressures of modern living, achieve an enhanced state of relaxation and refreshment, tackle new challenges, and reduce anxiety and stress levels. Features of green space positively linked to health outcomes include providing opportunities to engage in physical activity, community interaction, having contact with natural environments, and improving environmental quality.

Green Space

While it is accepted that the natural environment and physical activity are positive influences in daily life, many people have moved away from everyday physical activities. The U.S. and other countries are now facing an obesity crisis that is complex and difficult to resolve. Increasing "active" transportation options is an important step in encouraging physical activity and addressing the obesity epidemic.

Incorporating parks, trails, and greenways into communities can support increased exercise and healthier lifestyles. Linear paths or trails for bicyclists and pedestrians have been shown in several studies to increase regular physical activity, particularly among people who live nearby. These green spaces can become transportation corridors to shops, transit, places of employment, and schools. Trail users in both Missouri and Indiana indicated they were exercising more since a trail was built in their communities (Brownson, 1999; Eppley Institute, 2001). Physical activity can reduce not only obesity, but anxiety and depression and it can improve mood and self esteem (CDC, 1996).

More information is becoming available on the importance of green spaces in our lives in other ways. Research shows people have a more positive outlook and higher life satisfaction when in proximity to nature. Exposure to natural environments enhances the ability to cope with and recover from stress and observing nature can restore concentration and improve productivity. Having nature in close proximity or just knowing it exists is important to people regardless of whether they are regular users (Maller et al., 2005).

Green spaces can make dense communities near regional transportation corridors more livable by providing visual relief from concrete and noise. Green spaces also improve social health and psychological health. Parks and recreation and leisure services play an important role in promoting a sense of well-being and happiness, as well as in promoting close relationships, social support, purpose, and hope. The natural environment has a positive effect on well-being through restoration from stress and attention fatigue. Research has shown a positive relationship between the amount of green space in the living environment and physical and mental health and longevity (Groenewegen et al., 2006).

Green spaces can become strong centers to bring people together and increase social connections. More social connections and cohesion leads to improvements in health conditions.

Using green spaces for non-motorized transportation can also serve other benefits by reducing air pollution and greenhouse gas emissions that are by-products of driving. With safe, convenient and attractive pedestrian, bicycle, and transit opportunities, people are more likely to make short trips without driving.

Air quality can be improved through the use of trees, shrubs, and turf. Emissions from automobile and truck exhaust contain significant pollutants, including carbon monoxide, volatile organic compounds, nitrogen oxides, and particulate matter. Impacts are reduced significantly by proximity to trees. Trees alter the environment in which we live by moderating climate, improving air quality, conserving water, and harboring wildlife. Trees and other plants make their own food from carbon dioxide in the atmosphere, water, sunlight and a small amount of soil elements. In the process, they release oxygen for us to breathe and reduce warming of the atmosphere (Burden, 2006).

As our population ages, active transportation options (i.e. walking, biking, and transit) are excellent opportunities for seniors to be active and to have alternatives to driving alone or being isolated if they cannot drive. Living in areas with walkable green spaces positively influences the longevity of older adults independent of their age, sex, marital status, functionality or socioeconomic status (Blair et al., 1989).

Green space is equally important to young people. Studies have shown that people who deeply care about the environment's future almost always enjoyed experiences in natural areas when they were children. Regular exposure to the natural environment in childhood is important for social development and influences future physical, mental and social well-being as adults (Sustainable Development Commission, 2007).

In the United States and internationally there is growing interest in ways to reduce the visual impact of large concrete structures in the environment through better design and landscaping changes. In addition, interest and investment is reconnecting communities isolated by major transportation corridors like interstate highways. More than 20 American cities have choosen to make substantial investments in landscaped lids, decks and tunnels to soften concrete structures, reduce noise, reconnect communities or other important natural features, and visually make the project more appealing. The Seattle region has two excellent examples of concealing transportation projects and providing physical activity opportunties: the Seattle Freeway Park and the covered freeway area on the Mercer Island I-90 corridor. Both areas have green spaces that serve as parks, corridors for non-motorized transportation, and bridges for neighborhoods that were divided by major highways.

SUMMARY

Taking opportunities to include and increase, preserve and enhance the essential green spaces in the SR 520 corridor will be critical to the health of our communities. The rich natural environment and the existing park property around Portage Bay and Union Bay provide a unique opportunity for thousands of people to enjoy and find renewal in a dense urban setting. Opportunities to visually enjoy wetlands, open water, views of the Washington Park Arboretum and wildlife abound in this small area. It is a wonderful visual relief from urban congestion by those who transverse the area by vehicle or transit. With careful planning and development of connected paths and green spaces, it can be an ideal oasis for renewal and physical activity for those who transverse by foot or bicycle.

Currently, it is difficult for bicyclists and pedestrians to transverse the SR 520 corridor on the Westside. The trails and sidewalk are not well marked and some

Green Space

connections are precarious and not welcoming. Without knowing the area, it would be challenging to make connections to transit, adjacent neighborhoods, the University, or other area attractions. It is important to provide information to pedestrians and bicyclists on how they can safely transverse the corridor and also on what interesting opportunities are nearby (similar to what is done on the roadways to guide or direct motorists to their destinations).

The potential health benefits of being physically active are many and those benefits along with reduced carbon emissions in the corridor will add to a healthy community.

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Emergency Medical Services

Appendix J:
Emergency Medical Services Issue Paper

September 2008

Efficient movement of emergency service staff, supplies, and patients, daily and during emergencies is critical to increasing survival and reducing disability from health incidents.

INTRODUCTION

The design, construction constraints, and operation plans for the SR 520 Bridge Replacement and HOV Project are important considerations for emergency medical services, specifically how the project relates to access points into corridor neighborhoods and to the bridges.

King County leads the nation in 9-1-1 medical responses with a tiered response strategy of basic life-support services by firefighters trained as emergency medical technicians, advanced care by paramedics when needed, and resident participation in lifesaving CPR (Doyle, 2008). In addition to daily services, emergency service during catastrophic incidents is critical.

In assessing the link between emergency medical services and the SR 520 project, literature on emergency medical service (EMS) indicators was reviewed and EMS stakeholders provided information and comments related to the SR 520 Project construction and operation.

DISCUSSION

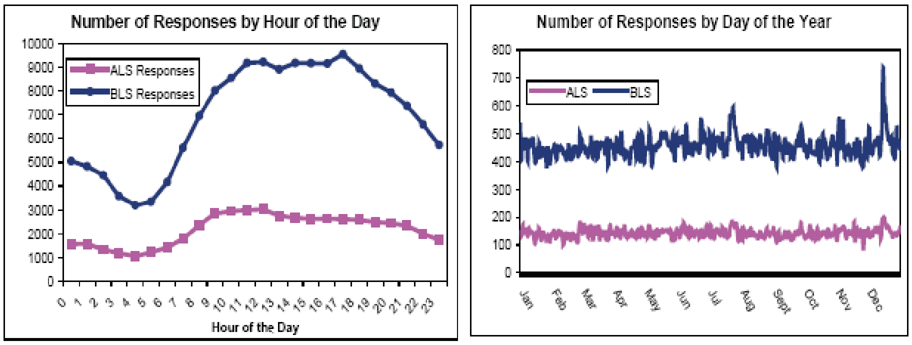
Several factors are critical for successful emergency medical service response, including:

- Rapid response times.
- Highly trained first responders providing quality patient care.
- Effective communication and dispatch systems.
- Community education (i.e. CPR training, seatbelt and helmet use).

SR 520 is used for emergency medical responses to the scene as well as for the transport of patients to medical facilities. King County's tiered and geographically based EMS system allows for rapid Basic Life Support (BLS) and Advanced Life Support (ALS) responses in most cases without units crossing the SR 520 bridges for the initial incident response. However, EMS providers do need to access SR 520 neighborhoods via arterial roads for emergencies and may need to transport patients to hospitals using the SR 520 corridor. For example, if hospitals and emergency departments on the Eastside are over capacity or if the severity of an illness or injury warrants transfer, patients may be diverted to Westside hospitals.

Emergency Medical Services

In 2006, the Seattle and King County EMS system responded to 166,941 calls for basic life support and 52,136 responses for advanced life support (EMS, 2007). The following graphs (from 2007 King County EMS Annual Report) show the number of those responses by hour of the day and day of the year (2006) for King County. Variation occurs in BLS and ALS response per day. Note the spike in BLS responses in December which represents the 'December 2006 windstorm.'



2007 EMS Annual Report

EMS provider data is based on where an EMS unit is located and the service area is located. Averaged data from 2003-2007, indicates that approximately 1,550 trips were made annually by fire and EMS services across the SR 520 bridges. With expected population growth in the project site, the numbers will likely increase to approximately 1,600 trips each year. In addition, American Medical Response, an ambulance company that provides transport services in King County, indicated approximately 4,618 EMS and hospital interfacility transports utilized the SR 520 bridge in 2007 (2552 bridge trips originating on the Eastside; 2066 bridge trips originating on the Westside of Lake Washington). This does not take into account trips for strictly vehicle deployment which could double the overall number each year. Another service, Tri-Med Ambulance, noted their vehicles travel 15 times a day on SR 520, including both BLS trips and wheelchair vans. This data indicates that the SR 520 corridor, ramps, and nearby arterials are critical daily travel links for EMS providers.

Various factors influence EMS response times (defined as the time from unit notification to unit arrival on scene). Minimizing delays is crucial to maximizing patient outcomes (Pons et al., 2005). No universally accepted response-time system requirement exists. "In urban areas, the most widely used ambulance response-time standard is 8 minutes and 59 seconds (with 90% compliance reliability). This standard was derived in the early 1970s when Seattle researchers noted dramatic cardiac arrest survivals with: reduced response times of less than eight minutes, first responders performing CPR, and resident CPR training (Fitch, 2005)." The Washington State Administrative Code (WAC 246-976-390) has indicated minimum agency response times for all major trauma responses (Washington Legislature):

A) To urban response areas: Eight minutes or less, eighty percent of the time;

B) To suburban response areas: Fifteen minutes or less, eighty percent of the time;

C) To rural response areas: Forty-five minutes or less, eighty percent of the time;

D) To wilderness response areas: As soon as possible."

Emergency Medical Services

Relevant to the SR 520 Project is the time needed to arrive at the scene and transport time which can be affected by multiple factors, including ambulance locations, time of day, and traffic flow patterns. These issues will be similar for daily EMS responses and for an emergency disaster situation. Despite a 6.9% increase in ALS calls in 2006, the average medic unit response time remained steady at 7.5 minutes, as indicated in the Average Unit Response Time graph.

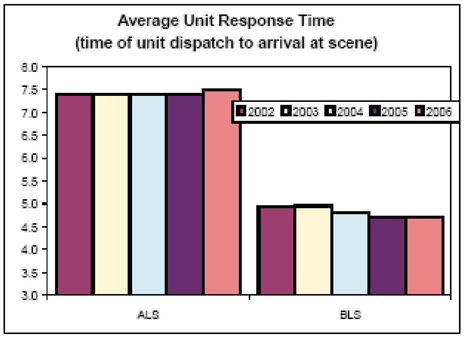
King County has one of the highest survival rates for out-of-hospital cardiac arrest in the United States, which is attributable to many factors, including quick EMS response (PHSKC). Cardiac arrest survival of patients in ventricular fibrillation in 2005 was 46%, in 2006 was 41%, and 45% in 2007. Other major cities have reported cardiac survival rates as low as 1-5%.

Representatives of the King County EMS system discussed possible scenarios that could potentially cause service impacts, such as:

» SR 520 lane and/or arterial road closures during construction.

» Traffic congestion due to tunnel closures on SR 520 (based on mediation alternatives being reviewed) and I-90.

» Traffic backups related to tolling operations.



2007 EMS Annual Report

Stakeholders also discussed topics and service elements that could be impacted by travel disruption on SR 520:

» Response time to emergencies on the SR 520 bridge and to communities in the vicinity.

» Emergency, non-emergency, and inter-facility transport of patients (with the increasing trend for hospital emergency department diversions to other hospitals).

» Access to regional specialty medical and trauma services (e.g. Burn Center at Harborview, hyperbaric chamber at Virginia Mason, and pediatric care at Children's Hospital).

» Moving medical supplies and equipment.

» Moving medical staff (e.g. EMTs, paramedics, on call physicians, and nurses) who travel back and forth across SR 520 for work (daily and in a disaster).

» Private ambulance contracts (fines can be associated with taking longer for patient transfer or not making as many transfers due to traffic congestion).

WSDOT representatives have indicated that current plans do not include complete SR 520 closure during construction (some ramp and lane closures may be necessary, primarily during off-peak hours). The SR 520 Project mitigation strategies (indicated in the Draft Environmental Impact Statement) for the construction period include ensuring that temporary road closures are minimized and detour routes are well signed. WSDOT has been engaged in SR 520 catastrophic bridge failure planning which includes a focus on communication strategies with emergency service stakeholders. The strategies developed for this planning effort will be useful during the construction stage of SR 520.

EMS representatives also provided feedback on service impacts when reduced freeway capacity was experienced (August 10-25, 2007) due to closure of several northbound lanes of the I-5 elevated bridge (south of downtown Seattle) for repairs. This was expected to cause significant traffic congestion. An after-action report by King County Medic One indicated that WSDOT's public information campaign and the public's cooperation helped to successfully minimize congestion. Also, with prior notice received and time to plan, an EMS Operational Plan was created that included: projected service impacts and delays, likely hospitals and types of patients to be most affected, other roadway constraints, strategies for traffic monitoring, and a contingency plan should a disaster occur during the closure. As a result of the careful planning, no major adverse delays in patient care, response time or transport times occurred.

Modeling results by King County EMS of a potential closure of SR 520 on the Eastside (between Lake Washington and I-405) showed no impacts to EMS accessibility or response time. An exception to this was for project vicinities North of SR 520, but the change noted was minimal.

SUMMARY

The SR 520 corridor, ramps, and nearby arterials are critical daily travel links for EMS providers. At present, EMS vehicles make about 1,550 trips across the SR 520 bridge. With expected population growth in the project site, the numbers will likely increase. Coordination and communication during the construction period will be essential to providing critical and timely emergency services. Timely and consistent communication regarding traffic congestion and road closures, specifically in regards to access points into corridor neighborhoods and to and from the bridge is a key element.

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Appendix K:
Summary: Green House Gas Analysis of SR 520 Project

September 2008

INTRODUCTION

Senate Bill 6099 directed Public Health – Seattle & King County and the Puget Sound Clean Air Agency to conduct a health impact assessment (HIA) of the SR 520 Bridge Replacement and HOV Project's effects on air quality, greenhouse gas (GHG), and other public health issues, with recommendations to be incorporated into the mediation project impact plan. Under that directive the Puget Sound Clean Air Agency investigated the greenhouse gas emissions associated with the three alternatives being considered by the SR 520 Project Mediation Group. The agency collaborated with Washington Department of Transportation, Sound Transit, Public Health – Seattle & King County, and the Puget Sound Regional Council in the design of the investigation and hired ICF Jones & Stokes to calculate the effects of the SR 520 Project on GHG emissions.

A single assessment of the project's effect on GHG emissions was not conducted because three alternatives were still being considered by the Project Mediation Group. Instead all three alternatives were investigated. Since all three alternatives contained four general purpose and two HOV lanes, the investigation focused on other key factors that could affect greenhouse gas emissions. These key factors included the level of transit service in the corridor, the amount of the toll charged to use the facility, and the cost of parking at major destinations in the corridor. The analysis also investigated the effect of higher gasoline prices and new fuel efficiency standards on GHG emissions.

Three scenarios were analyzed:

- A low GHG emissions reduction scenario that contained low values for the key factors, such as low tolls on the facility.
- A medium GHG emissions reduction scenario that contained values for the key factors that were similar to those contained in the 2006 Draft EIS for the SR 520 project.
- A high GHG emissions reduction scenario that contained higher values for the key factors such as much higher levels of transit service in the corridor.

The medium GHG reduction scenario provides a link to the analysis contained in the SR 520 Draft Environmental Impact Statement, while the high and low GHG reduction scenarios investigate the effects that different values for the key factors have on GHG emissions.

Alternatives K and L were analyzed as one alternative because of their similarities. The two alternatives have the same number of lanes, similar grades and interchange designs, and are about the same total length. These similarities were anticipated to produce similar traffic conditions and thus similar GHG emissions.

WHAT WAS LEARNED ABOUT THE ALTERNATIVES AND GHG EMISSIONS

This section presents the Puget Sound Clean Air Agency's summary of key points from the report prepared by the consultant ICF Jones & Stokes and is intended to facilitate consideration of GHG emissions in the project impact mediation process.

All three alternatives produce similar levels of GHG emissions. This result was not unexpected because each alternative has the same capacity - six lanes. Higher fuel prices and more fuel efficient vehicles reduce GHG emissions; another anticipated effect.

Key factors that can affect the amount of GHG emissions on a transportation project besides the number of lanes include the level of bus service, tolls, and parking fees. Even though the project had a fixed capacity of six lanes – four general purpose lanes and two HOV lanes, changes in the values of the key factors resulted in changes in the amount of GHG emissions for each alternative and scenario. Increasing transit service, tolls, and parking fees leads to a shift to more transit activity and lower levels of GHG emissions for the alternatives. Decreasing transit service, tolls and parking fees leads to higher levels of GHG emissions for the alternatives.

The bigger the change in the key factors the bigger the change in GHG emissions. The High Emissions Reduction scenario reduced larger quantities of GHG emissions than the other two scenarios and the Low Emissions Reduction scenario resulted in the smallest reduction in GHG emissions. This change in GHG emissions occurred for each of the alternatives analyzed.

The study area selected for analysis can influence the information obtained. Analyzing the area served by SR 520 provides a more complete picture of the magnitude of the GHG emissions that can be reduced by the scenarios. Analyzing the roadway network influenced by the project (i.e. roadway segments where the vehicle miles traveled varied by at least 5%) provides a clearer picture of the percentage reductions that the scenarios can produce.

Among similar alternatives, such as Alternatives A, L and K, changing the key factors has a similar effect on each alternative. Continued improvements in the tools used to analyze GHG emissions from a transportation project should provide more ability to distinguish the differences in GHG emissions from similar alternatives. Additionally, significantly different alternatives, such as eight lane and four lane alternatives, may not react the same when the key factors are changed.

ADDITIONAL INFORMATION IS PROVIDED IN THE ATTACHED REPORT

The GHG analysis report prepared by ICF Jones & Stokes follows this summary. The report consists of three documents. The Task 1 document identifies the most appropriate model and key factors for estimating GHG emissions from the SR 520 Project. The Task 2 document identifies appropriate values for the selected key factors and establishes the components of the three scenarios that are to be analyzed, such as the study area. The Task 3 document contains the summary results of the GHG emissions calculations for the selected scenarios and the alternatives being considered by the Project Mediation Group.

Task 1 Report—Analyzing Greenhouse Gas Emissions

State Route 520 Bridge Replacement and High Occupancy Vehicle Project ■ Puget Sound Clean Air Agency ■ August 2008

ICF Jones & Stokes
an ICF International Company

Task 1 Report: Identify the Most Appropriate Model and Variables for Estimating GHG Emissions

Analyzing Greenhouse Gas Emissions for the State Route 520 Bridge Replacement and High Occupancy Vehicle Project

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August 26, 2008

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Acronyms

Agency	Puget Sound Clean Air Agency
SR	State Route
HOV	High Occupancy Vehicle
Project	State Route 520 Bridge Replacement and High Occupancy Vehicle Project
CAT	Climate Action Team
HIA	Health Impact Assessment
mph	miles per hour
PSRC	Puget Sound Regional Council
EPA	U.S. Environmental Protection Agency
vmt	vehicle miles traveled
WSDOT	Washington State Department of Transportation
HOT	High Occupancy Toll
SOV	single-occupancy vehicle
HOV2	high-occupancy vehicle with 2 passengers
HOV3+	high-occupancy vehicle with 3 or more passengers

Introduction

The team of ICF Jones & Stokes and Fehr& Peers/Mirai Associates has been retained by the Puget Sound Clean Air Agency (Agency) to conduct the greenhouse gas (GHG) emission inventory to compare alternatives and operating scenarios for the State Route (SR) 520 Bridge Replacement and High Occupancy Vehicle (HOV) Project (Project). Washington State and King County have both enacted GHG reduction targets, and tailpipe emissions from commuters along the SR 520 corridor are a significant contributor to countywide GHG emissions.

Several significant pieces of legislation passed during the 2008 Legislative Session, including ESSHB 2815—creating a framework to reduce greenhouse gas emissions in Washington State. Part of this legislation calls for the Washington Climate Action Team (CAT) to continue to help the state develop strategies that reduce GHG emissions and expand the green economy and related jobs. In February 2008, the Washington State Department of Ecology issued *Interim Report: Leading the Way on Climate Change—the Challenge of Our Time*, outlining specific policy actions proposed to reduce statewide GHG emissions. Several of the policy actions call for reducing emissions by implementing trip reduction strategies including transit and tolling options. These policy options relate directly to the types of mode-choice options evaluated in detail in this report.

The Washington State Legislature has directed the Agency to prepare a Health Impact Assessment (HIA) for the Project (specifically the six-lane alternative). The HIA must include an evaluation of GHG emissions from the project.

The 2006 Draft Environmental Impact Statement (DEIS) for the Project included an Energy Discipline Report that made a rough estimate of fuel usage for project construction, and for vehicles driving along the corridor under each alternative. The discipline report indicated that annual fuel usage would be nearly identical under each alternative. However, that calculation was based on highly simplified assumptions. For example, it estimated vehicle fuel economy based on an average driving speed of 26 to 27 miles per hour (mph) for each alternative, without accounting for the drastic diurnal cycles of traffic congestion along SR 520. The average speed on SR 520 might indeed be 26 to 27 mph, but as any commuter along that route can attest the actual speed varies from nearly zero during rush hour to 65 mph during off-peak hours. Because the Energy Discipline Report used such simplified assumptions about diurnal traffic cycles, it was unable to distinguish fuel usage for the various alternatives. Additionally, consistent with environmental analysis practices the DEIS examined the worst case scenario. Under health impact assessment practices worst and best case scenarios can be examined. A best case scenario would involve project features and management programs that could produce the greatest reductions in greenhouse gases. The Puget Sound Clean Air

Agency elected to examine three scenarios: the "Low-Reduction" scenario, the "Mid-Reduction" scenario, and the "High-Reduction" scenario, with the Mid-Reduction scenario based upon the 6 lane alternative analyzed in the DEIS.

Defining a significance threshold for GHG emissions is especially challenging because no single project (not even a large project like SR 520) emits enough GHG, by itself, to affect global climate change. Environmental impact statements being produced today use a wide range of GHG assessment methods, from purely programmatic descriptions to sophisticated quantitative emission calculations. Regardless, it is important that the HIA for the Project include GHG emission calculations that are sophisticated enough to distinguish between the various operational scenarios.

ICF Jones & Stokes and Fehr & Peers/Mirai Associates will complete the following tasks as part of the SR 520 GHG analysis.

- Task 1. Identify the most appropriate model and variables for estimating GHG emissions. For this task, we will recommend the specific regional transportation modeling methods and tools to estimate future fuel economy and GHG emissions.
- Task 2. Advise the Agency in the selection of the model, key project variables, and their respective values. For this task, we will work with the interagency team to develop regional traffic parameters and mode-choice parameters to develop three representative scenarios:
  - High GHG Reduction Scenario (this scenario will include a subset called the "High2-Reduction" scenario, which models the GHG reductions that could result if fuel prices increase to future values higher than those considered for the "High-Reduction" scenario.
  - Low GHG Reduction Scenario
  - Most-Likely GHG Reduction Scenario
- Task 3. Calculate the GHG emissions. For this task, we will model regional traffic patterns and regional GHG emissions associated with each of the GHG reduction scenarios.

This report presents our recommendations for Task 1 to define the regional transportation modeling methods and GHG emission calculation methods to be used to evaluate the GHG emission reduction scenarios developed by the interagency team.

Task 1 Objectives

Task 1 aims at identifying appropriate models to quantify and evaluate GHG emissions associated with different alternatives and operating scenarios for the Project. Task 1 is divided into four sub-tasks:

- Task 1(a). (1) Recommend geographic area for regional traffic modeling (2) Review data quality objectives (3) Define required output of Puget Sound Regional Council (PSRC) regional traffic model to support GHG emission calculations.
- Task 1(b). Evaluate available GHG emissions models.
- Task 1(c). Define key regional traffic variables that could affect regional trip generation, regional congestion, and regional GHG emissions.
- Task 1(d). Based on previous subtasks, recommend the specific modeling procedures to predict GHG emissions from the Project.

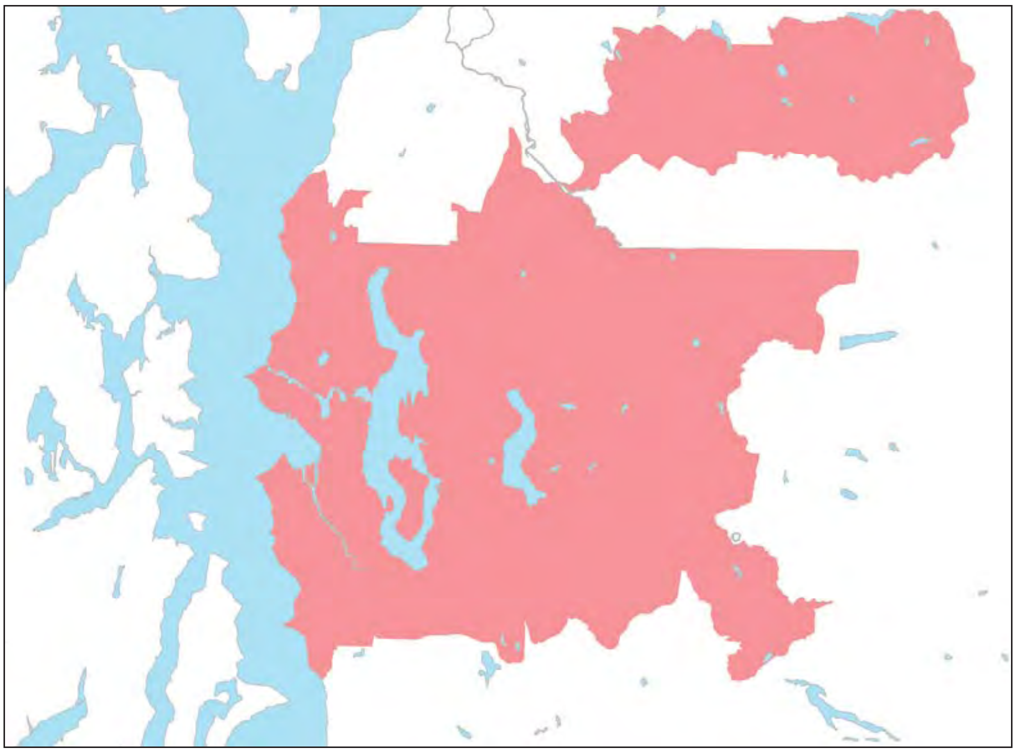
Task 1a. Recommend Geographic Area; Review Data Quality Objectives; Define Required Output of Regional Transportation Model

Subtask 1a(1). Recommended Geographic Area and Project-Influenced Roadways for SR 520 GHG Calculations

The study area for the GHG modeling consists of two related areas: the geographic study area, and project-influenced roadways. Figure 1 displays the recommended geographical area for the SR 520 GHG calculations. The red zones represent the PSRC Transportation Analysis Zones where 97% of the vehicles using the SR 520 Bridge originate or are destined in the PM peak period, for 2006. The "97% capture" roadway network was derived by Fehr & Peers/Mirai Associates, based on the PSRC Model Version 1.0B, for 2006. This recommended geographical area consists of central and northern Seattle and Shoreline in west King County. In the east King County region, the cities of Bellevue, Kirkland and Redmond are the key contributors to SR 520 demand. In Snohomish County, the City of Edmonds and the areas along SR 522 and SR 2 contribute to SR 520 demand. Traffic along the Interstate (I) 90 corridor between I-5 and I-405 will also be included in the modeled roadway network, to account for possible shifting of traffic away from the SR 520 Bridge as a result of various tolling options evaluated for this study.

Not all roadway segments within the geographical study area will be included in the GHG emission calculations. Instead, the calculations will be limited to "Project-Influenced Segments" within the study area. These are defined as roadway segments for which the ADT traffic volume varies by at least 5% between the High-Reduction scenario and the Low-Reduction scenario. The 5% criterion used to define "Project Influenced Segments" is the same value that has been used by the Federal Highway Administration to evaluate regional Mobile Source Air Toxics emissions for large regional freeway projects.

Figure 1.   Recommended Geographic Area for SR 520 GHG Calculations



Subtask 1a(2). Define Data Quality Objectives for Accuracy and Precision

The methods used to calculate SR 520 GHG emissions should satisfy data quality objectives for both accuracy and precision, which depend on the desired end uses of the calculations. A useful goal for the emission calculations will be to evaluate how various regional trip reduction strategies could reduce GHG emissions. The objectives for accuracy and precision, as they relate to that overall goal, are described below.

Objective for Accuracy

The SR 520 GHG emissions calculations should be accurate enough to determine if the resulting emissions reductions represent a meaningful fraction of regional reductions that could result from targeted regional and statewide emissions reduction programs. One useful benchmark to evaluate the significance of the SR 520 emissions reductions is the targeted statewide GHG emission reductions for the "Transportation Sector Policy Options" developed by the CAT Transportation Work Group. As listed in Table 1, several of the statewide policy options directly relate to SR 520 trip reduction programs being quantified for this study. The combined representative policy options call for a total statewide GHG emissions reduction of 11.4 mmtCO2-eq/year. The emissions calculation methods used for SR 520 should be accurate enough to allow users to compare the forecast SR 520 emissions reductions to the overall statewide targeted emission reductions set by the key policy options.

Table 1. Target Emission Reductions by Key Transportation Policy Options

Key Transportation Policy Option	Targeted State-Wide GHG Emission Reduction in Year 2020 (mmtCO2-eq/year)
T-1. Transit, Ridesharing, and Commuter Choice Programs	3.6
T-2. State, Regional, and Local VMT and GHG Reduction Goals and Standards	6.8
T-3. Transportation Pricing	1.0
Total Targeted Emission Reductions from Key Policy Options	11.4

Objective for Precision

The emissions calculations should be precise enough to quantify the differences in emission reductions provided under the three scenarios. Each of the scenarios will result in different forecasts for peak-hour traffic volume, peak-hour congestion, and diurnal traffic patterns. If forecasted congestion levels vary between scenarios, then the GHG calculation method should be precise enough to distinguish the resulting fluctuations in fuel economy and GHG emissions. The Energy Discipline Report presented in the DEIS used a highly simplified calculation procedure that assumed fuel economy was relatively insensitive to congestion levels. As a result, that report predicted the SR 520 fuel usage was nearly identical for all project alternatives. The GHG emission methods for this report should use refined modeling procedures to more accurately predict impaired fuel economy during highly congested conditions.

Subtask 1a(3). Required Output of Regional Traffic Model to Support GHG Emission Calculations

The required outputs from the PSRC regional traffic model to support the GHG emissions calculations are described under Task 1c.

Task 1b. Evaluate GHG Emissions Models

The selection of the GHG emissions model is based on the ability to differentiate emissions from varying levels of congestion resulting from the different alternatives considered. For the Project, the different alternatives for bridge replacement, transit use, tolling, and HOV lane configurations will affect GHG emissions in four ways:

1. Changes in traffic volumes. If all other factors remain constant (e.g., vehicle mix, vehicle occupancy, congestion levels), GHG emissions increase proportionally to traffic volumes. For example, traffic diversion due to higher tolling will change how traffic is distributed among different roadway segments, and will therefore change GHG emissions at each link.
2. Change in vehicle mix. Because emission rates depend on vehicle type, a change in the vehicle mix will affect GHG emissions. Incentives for transit use might have an impact on vehicle mix, by diverting personal automobile trips to transit.
3. Change in congestion levels. Emissions models have indicated that fuel usage, and consequently GHG emissions, can vary substantially depending on roadway congestion levels. Start-stop driving cycles with short bursts of acceleration generate higher per-mile emission rates than free-flow traffic. Therefore, the ability to adjust fuel economy and GHG emission factors according to congestion levels is important in the assessment of GHG emissions. Because alternatives with higher transit or HOV lane use have the potential to decrease congestion levels due to fewer vehicles on a roadway segment, they have the potential to affect congestion levels, and thus GHG emissions.

The combined set of models used to calculate GHG emissions each of the scenarios must be able to account for fluctuations in each of the above general parameters. The following sections evaluate currently available traffic forecasting models, fuel economy models, and GHG emission models relevant to the Project.

Comparison of Methods

ICF Jones & Stokes compared currently available GHG emissions models relevant the Project. Table 2 highlights their advantages and disadvantages.

Table 2. Evaluation of Available GHG Emission Models

Model	Ability to Estimate Fuel Economy or GHG Emission Factors	Conclusion
CAL3QHC	A line-source dispersion model that has been adapted for tailpipe emissions on queuing vehicles at congested intersections, CAL3QHC does not forecast traffic volume, LOS, or emission factors. It estimates vehicle queuing based on user-specified traffic volume and LOS. It does not calculate fuel economy or GHG emission factors.	A roadway dispersion model. Not suited for assessing GHG emissions from the Project.
MOBILE6.2	A tool to predict tailpipe emission factors for on-road vehicles, MOBILE6.2 does not forecast traffic parameters. It displays fuel economy for a specified year and vehicle fleet mix. However, its fuel economy data for future years are extremely limited and it does not vary fuel economy by speed or congestion level.	Not suited to evaluate variations in CO2 emissions according to congestion levels or vehicle speed.
Federal Highway Administration (FHWA) EMIT	A front-end interface for MOBILE6.2, developed by FHWA, EMIT is designed to facilitate calculation of regional criteria pollutant emissions and toxic air pollutant emissions. It calculates average vehicle speed for a user-specified set of roadway segments, based on user-specified roadway functional category, vehicles/hour traffic volume, and volume/capacity ratio. It interfaces with MOBILE6.2 to account for effects of vehicle speed on criteria pollutant and toxic air pollutant emission factors. The EMIT/MOBILE6.2 combination does not calculate CO2 emission factors, but can estimate average vehicle speeds, which can then be used to estimate fuel economy under a separate calculation.	A simple model that has been used on other freeway projects as a valuable starting tool in a simplified GHG emission analysis. It is not well suited to calculate variations in fuel economy and GHG emissions caused by the variation in congestion relief under the project scenarios.
MOVES (MOtor Vehicle Emissions Simulator) and PERE (Physical Emission Rate Estimator)	EPA is developing MOVES to replace MOBILE6.2. MOVES does not calculate traffic patterns; it relies on user-specified input data for traffic volume, fleet mix, and average travel speed. It displays fuel economy and GHG emission factors for CO2, methane, and nitrous oxide. It can use the PERE algorithm to calculate fuel economy for a user-specified driving cycle. The MOVES/PERE model has not yet been updated by EPA to account for future improvements in fuel economy mandated by the recently enacted Corporate Automobile Fuel Economy (CAFE) standards.	Even though MOVES/PERE is not currently configured to account for recent CAFE standards, it should be used as the primary tool to develop fuel economy estimates for the Project. Its fuel economy values for 2030 should be post-processed to adjust CAFE improvements.
Comprehensive Modal Emissions Model (CMEM)	Developed by UC Riverside, CMEM uses a parameterized physical approach that breaks down the entire combustion process into different components that correspond to physical phenomena associated with vehicle operation. It measures fuel and emissions rates on a second-by-second basis according to a set of input parameters that describe the vehicle, driving cycle, and road facility.	Its main advantage over MOVES/PERE is that it considers vehicle operational history effects (i.e., how the last second of operations affect fuel consumption/emissions). We will evaluate the influence of vehicle operational history effects on GHG emissions for a sample of roadway segments. If they prove relevant, we will rely on the CMEM model for the analysis.

Modal Emissions Models for Fuel Economy under Highly Congested Conditions

Modal emissions models, also referred to as instantaneous emissions models, are the only category of models that enable the differentiation of emissions among alternatives due to their ability to consider congestion levels. Modal emissions models take into account how different modes of vehicle operation affect emissions in unique ways. Instead of analyzing fuel consumption and emissions by assuming an average vehicle speed, modal emissions models quantify fuel consumption and emissions at each second, taking into account instantaneous speed, acceleration, and road grade, as well as vehicle and fuel characteristics.

We will evaluate the effects of the different alternatives and operating scenarios on congestion levels at different roadway segments. For roadways links where congestion levels vary substantially, we will rely on modal emissions models for the GHG assessment. For roadway segments where the variation in congestion levels is negligible (for example, at the mid-span of the bridge), we might rely on the intermediate method for the GHG assessment if the modeling efforts prove substantially lower than those required by the modal emissions model.

Previous research has indicated that fuel consumption is highly dependent on the specific vehicle operation mode, including idle, steady-state cruise (relatively constant speed), and different levels of acceleration and deceleration. By accounting for specific driving cycles (second-by-second instantaneous speed), modal emissions models can properly consider the effects of different vehicle operation modes. The two types of modal emissions models that are most relevant to this study are:

1. Speed-acceleration lookup tables
2. Micro modal emissions models

Speed-Acceleration Lookup Tables

This category of models consists of multi-dimensional tables that provide fuel or emissions rates based on a set of input parameters. The most common type of lookup tables are speed-acceleration tables. These lookup tables are generally created based on individual vehicles (or vehicle categories). Modal emissions models based on these lookup tables can convert a driving cycle to either fuel consumption or emissions by looking at many different sets of speed and acceleration combinations.

These models are relatively inexpensive to run due to low computational costs. However, they have two main drawbacks. First, they do not take into account the fact that instantaneous fuel consumption and emissions are highly dependent on the vehicle-operating history (i.e., last several seconds of vehicle operations). And second, it is not possible to account for load-producing effects such as road grade and accessory use (e.g., air conditioning) without the creation of numerous lookup tables or the application of correction factors.

Many traffic simulation models that incorporate emissions modeling rely on lookup tables, including FHWA's CORSIM (Corridor Simulation), a microscopic traffic simulation applicable to surface streets, freeways, and integrated networks with a complete selection of control devices (i.e., stop/yield sign, traffic signals, and ramp metering).

The U.S. Environmental Protection Agency (EPA) has developed a model called PERE (Physical Emission Rate Estimator), which was designed to support the new EPA energy and emissions inventory model, MOVES (Motor Vehicle Emissions Simulator). PERE can be used to generate speed-acceleration lookup tables. It uses physical principles to model vehicle propulsion systems and calculates fuel consumption on a second-by-second basis by considering a driving cycle. It also considers most variables that affect power demand, such as road grade, rolling resistance, aerodynamic coefficients, vehicle weight, and vehicle frontal area. It was validated to four conventional gasoline vehicles and several motorcycles, buses, and heavy-duty trucks; it predicts actual fuel consumption with 90% accuracy.

The MOVES/PERE model has not yet been updated by EPA to account for future improvements in fuel economy mandated by the recently enacted Corporate Automobile Fuel Economy (CAFE) standards. ICF Jones & Stokes is currently coordinating with EPA staff to determine practical ways to post-process the MOVES/PERE results to account for the CAFE improvements.

Micro Modal Emissions Models

Micro modal emissions models use a parameterized physical approach that breaks down the entire combustion process into different components that correspond to physical phenomena associated with the vehicle operation (for example, acceleration-deceleration cycles common during traffic congestion). They generally measure fuel and emissions rates on a second-by-second basis according to a set of input parameters to describe the vehicle, driving cycle, and road facility. The Comprehensive Modal Emissions Model (CMEM), developed by the University of California Riverside, under an EPA contract, is an example of a micro modal emissions model.

Micro modal models provide the advantage of taking into account all factors that have a strong influence on fuel consumption, including vehicle technology, fuel type, operating modes, accessory use, aerodynamic devices, and road grade. Additionally, transient operations can be properly modeled, including the time dependence of fuel consumption to vehicle operation.

Application of Modal Emissions Models

Our recommendation is that we use one of these two options for this study.

1. Develop speed-acceleration lookup tables in PERE and apply these tables to the input variables (speed, acceleration, road grade, vehicle type). We will evaluate the extent to which road grade variation is an issue on the SR 520 roadway system. Depending on our assessment, we will either disregard road grade from

the emissions assessment or we will consider a range of road grades in the development of lookup tables. Additionally, we will develop lookup tables for each vehicle type considered in the SR 520 roadway system.

2. Because option 1 lacks the ability to consider vehicle operational history effects (i.e., how the last second of operations affect fuel consumption and emissions), we recommend evaluating the influence of vehicle operational history effects on GHG emissions for a sample of roadway segments. If our evaluation indicates that such effects are irrelevant, we will rely on Option 1. Alternatively, we will rely on the CMEM model for the analysis.

Application of GHG Models to the SR 520 Roadway System

The alternatives and operating scenarios for the Project will certainly have an effect on the SR 520 Bridge, but they will also affect traffic on other roadway segments. As described in Task 1a(1), we defined the study area to include all roadway segments on which the project alternatives and operating scenarios would like have noticeable impacts.

Although modal emissions models provide the highest level of precision in the assessment of GHG emissions, they also require the highest level of effort. Because the main advantage of modal emissions models is the ability to differentiate emissions based on different levels of congestion, it is important that we determine the extent to which different alternatives and operating scenarios affect congestion levels on different roadway segments in the SR 520 roadway system. For example, we expect the congestion effects of different alternatives to be most noticeable along the SR 520 Bridge, and that such effects will diminish on roadway segments that are further away from the bridge. For roadway segments where congestion levels do not change as a result of the alternatives, modal emissions models are not required for the GHG assessment, and we might use a simpler model in the GHG assessment if it significantly reduces modeling efforts. In other words, we might utilize different emissions models depending on the roadway segment.

Task 1c. Define Key Traffic Variables

Design Options to Be Considered

The Washington State Legislature directed the Agency to conduct the HIA (including GHG emission calculations) for the six-lane configuration (the “4 plus 2” configuration) described in the DEIS. The Agency directed ICF Jones & Stokes to evaluate 2030 GHG emissions for three design options.

- Option A: Seattle City Council Resolution Application to the Six-Lane Alternative with No Montlake Transit Stop.

- Option K: Six-Lane Corridor with Tunnel through the Arboretum and Tunnel under the Montlake Cut.
- Option L: Six-Lane Corridor with Shallow Tunnel through the Arboretum (Foster Island Berm) and Bridge over the Montlake Cut.

Inspection of the roadway configurations for Option K and Option L indicates that the trip generation and regional vehicle miles traveled (VMT) should be nearly identical for those options. Therefore, this study will assume that the GHG emissions for Option K and Option L are the same.

Draft Environmental Impact Statement Review

ICF Jones & Stokes and Fehr & Peers/Mirai Associates consulted with the interagency team to identify the traffic-related variables most likely to affect GHG emissions in 2030. We also reviewed the relevant information included in the DEIS. In particular, we reviewed DEIS Appendix F (Energy Discipline Report), and DEIS Appendix R (Transportation Discipline Report). DEIS Appendix C (Air Quality Discipline Report) was not reviewed because it is limited to criteria air pollutants.

Appendix F: Energy Discipline Report

The transportation energy consumed under each alternative was estimated based on VMT and average speed estimates included in Appendix R. The report takes into account that fuel efficiency is reduced in congested conditions. Fuel efficiency, as a function of average speed, was determined based on U.S. Department of Energy and EPA data. Fuel efficiency certainly correlates to average speed, but it ultimately depends on congestion levels because instantaneous speed is the variable that determines fuel consumption on a second-by-second basis. Since different levels of congestion can be associated with the same average speed (and vice-versa), models that predict fuel consumption from second-by-second speed (rather than average speed) are necessary to differentiate energy consumption under different congestion scenarios.

Appendix R: Transportation Discipline Report

The DEIS provides a summary of key project variables that may influence trip generation, congestion, and travel time. Due to federal regulations, the DEIS analysis team was limited in the amount of variables it could modify. The key variables evaluated for the DEIS were:

- toll variations on the facility;
- level of transit service on the facility; and
- level of service assumptions (volume to capacity).

The toll rates used in the DEIS analysis were based on results from a 2003 "stated preference" survey of SR 520 users. This survey provided data to estimate the respondent's "value of time" according to the time of day (peak or off-peak), and requested the respondent to specify a reasonable bridge toll rate for each daily period. Table 3 shows the results of the DEIS survey for the year 2002..

Table 3. DEIS Survey of Acceptable Bridge Toll and "Value of Time"

Parameter	2002
Respondents' Acceptable Bridge Toll	
Peak period	$3.35
Off-peak period	$1.80
Respondents' "Value of Time"	
Peak period	$14.43/hr
Off-peak period	$12.20/hr

Since the DEIS was published, the Washington State Department of Transportation (WSDOT) and PSRC have continued to study the potential benefits of bridge tolling on trip reduction and congestion relief. The current WSDOT and PSRC study is looking at toll ranges for the SR 520 Bridge. The study has not yet been completed.

The transit service pattern assumed in the DEIS for 2030 is similar to the current pattern, but has enhanced service frequency during peak and off-peak periods. The assumed annual increase in service hours is approximately 2% a year, consistent with recent growth patterns and commonly used in many regional projects.

The combination of tolls on SR 520 and increased transit service contributes to a significant shift in mode choice on the SR 520 Bridge. According to the DEIS, in 2030, westbound PM person-trips would increase 23% while vehicular trips would increase only 4%. Peak demand is almost 2200 vehicles per hour in each general purpose lane along SR 520. While close to capacity, the six-lane facility evaluated in the DEIS was modeled to provide faster speeds in 2030 than the no-build alternative.

Key Mode-Choice Traffic Variables Input to the PSRC Regional Traffic Model

The PSRC regional traffic model will be used to develop regional traffic volume forecasts and GHG emissions estimates under each scenario for 2030. The following mode-choice parameters will be adjusted for a range of values to develop each scenario:

- parking cost
- transit fares
- tolling price
- transit frequency
- gasoline price and other passenger vehicle operating costs

- “value of time” for commuters (segmented by income quartile) and
- SR 520 operational management (e.g., potential use of high occupancy toll (HOT) lanes)

The range of values for each of these mode-choice parameters will be derived by the interagency team, before modeling begins, under Task 2 of this study.

Under Task 2 and Task 3 of this study, the interagency team could also choose to explore the effects that changes in long-range future land use and zoning restrictions (i.e., transit-oriented development) might have on trip generation and GHG emissions along SR 520. For example, Transportation Working Group Policy Option T-4, Promotion of Compact and Transit-Oriented Development, is forecasted to provide up to 3.8 million metric tons per year of statewide GHG reduction by 2020. However, revising the land use assumptions and trip generation factors in the PSRC regional model to reflect special transit-oriented development restrictions would require considerable coordination with local governments. Additionally, modifying land use would increase the scope of the analysis beyond that established by the legislature. Therefore, we consider modeling the benefits of transit-oriented development beyond the scope of this study.

Key Traffic Variables Input to the GHG Emission Calculations

Independent of the emissions model utilized on the GHG assessment, fuel economy and GHG emissions along any given roadway segment are governed by several general variables: traffic volume (which in turn depends on several mode-choice parameters for trip generation), micro-scale start-stop cycle in congested traffic, vehicle fleet mix, and vehicle occupancy.

Mirai Associates will execute the PSRC regional traffic model, using the previously described regional mode-choice input assumptions. ICF Jones & Stokes and Mirai Associates have performed an initial evaluation of the PSRC model to assess how its outputs will feed into the GHG emissions model. The following traffic model output parameters are required to calculate GHG emissions along each roadway segment. The discussions also address some of the steps to convert the PSRC traffic modeling outputs into inputs to the GHG emission calculations.

Functional Roadway Classes

The PSRC model is capable of categorizing each roadway segment into up to 25 functional roadway classes. However, that level of detail is not warranted for the GHG emission calculations. Instead, we recommend that each roadway segment in the SR 520 roadway system be categorized into the same six functional classes that WSDOT used for its recent congestion pricing and bridge tolling studies.

Diurnal Time Periods

The PSRC model will divide an average day into the following time periods, for purposes of calculating annual GHG emissions:

- AM Peak (6:00–9:00)
- Mid-day (9:00–15:00)
- PM Peak (15:00–18:00)
- Evening (18:00–22:00)
- Night (22:00–06:00)

Traffic Values along Each Roadway Segment

The PSRC regional model will present the following traffic parameters along each roadway link and each diurnal time period. These parameters will then be used to calculate GHG emissions along each link.

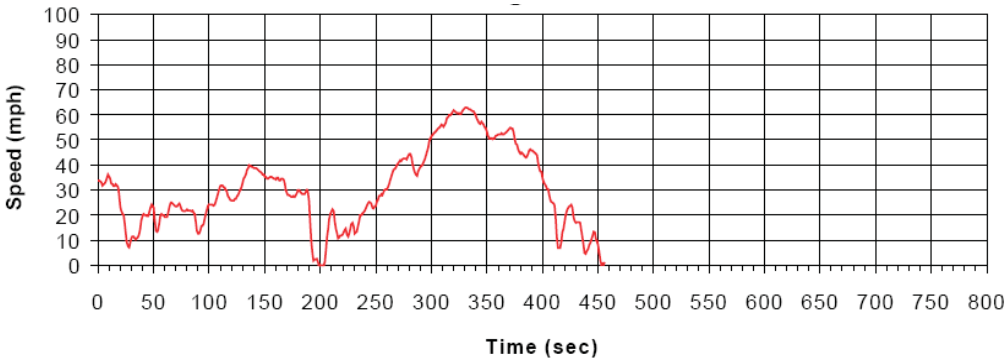
- hourly traffic volume
- average travel speed
- length of roadway segment
- capacity of roadway segment

Driving Cycle by Vehicle Type and by Roadway Segment

A driving cycle is the instantaneous speed and acceleration pattern on a second-by-second basis. Figure 2 illustrates an example of a representative driving cycle for a heavily congested freeway segment. Vehicles driving under a severe start-stop cycle in congested traffic use more fuel than vehicles traveling at a slow, steady-state speed. The PSRC model will output the steady-state average travel speed along each roadway segment, rather than a second-by-second driving cycle. We will adjust the input steady-state link speed to develop driving cycles from other variables that characterize congestion levels at each roadway segment. Amongst those variables are average speed by 15-minute intervals, traffic demand (in vehicles per hour), and traffic density (in vehicles per mile). From these variables, we will determine volume-to-capacity ratio and level of service. Based on level of service, we will develop driving cycles for each type of roadway segment (e.g., freeway, arterial, local road).

Driving cycles will be developed based on a previous study led by Sierra Research, which included a set of driving cycles under a variety of congestion levels and average speeds for different road types. For example, there are specific driving cycles for freeways under high-speed conditions and levels of service A through G. We will customize these driving cycles by considering the data obtained (e.g., average speed by roadway segment) by the PSRC model.

Figure 2. Example Freeway Driving Cycle—Level of Service F



Source: U.S. Environmental Protection Agency 1997.

Vehicle Mix and Fleet Age

The vehicle mix includes not only the vehicle type (e.g., light-duty gasoline vehicle, heavy-duty diesel truck), but also the vehicle age. The PSRC model provides traffic demand broken down by the following vehicle types: single-occupancy vehicle (SOV), high-occupancy vehicle with 2 passengers (HOV2), high-occupancy vehicle with 3 or more passengers (HOV3+), light trucks, medium trucks, and heavy trucks. We will use the same fleet age distribution for 2030 that has been used by PSRC for its periodic regional Transportation Conformity air quality modeling analyses.

Vehicle Occupancy by Vehicle Type

Fuel consumption increases with vehicle weight, and as higher vehicle occupancy increases vehicle weight, vehicle fuel consumption will increase if all other factors remain constant. Because fuel consumption does not increase proportionally with vehicle weight, and because passenger weight is only a small fraction of total vehicle weight, the marginal fuel consumption due to additional passengers might be negligible. We will evaluate this effect and determine whether the model should consider passenger occupancy and vehicle weight as one of the input variables.

Task 1d. Recommended Method to Calculate Greenhouse Gas Emissions

ICF Jones & Stokes recommends the following series of steps to calculate regional GHG emissions generated by the three emission reduction scenarios.

Step 1. Use PSRC regional traffic model to forecast traffic volume, vehicle fleet mix, and average vehicle speed along each roadway segment. Output the PSRC model's output file to a spreadsheet format for use in subsequent GHG emission calculations.

Step 2. Use EPA's MOVES/PERE modeling package to develop speed–versus–miles per gallon fuel economy lookup tables corresponding to the set of output parameters (e.g., vehicle type) from the PSRC regional traffic model.

Step 3. Use the Sierra Research driving cycles, described in Task 1c, to define representative start-stop driving cycles for each functional roadway classification and level of service for the SR 520 roadway system.

Step 4. Evaluate impact of vehicle operational history effects on GHG emissions on a sample of links. We will compare the results from the CMEM model with the results from the lookup tables developed with the MOVES/PERE model. If vehicle operational history effects are significant, we will use the CMEM model, otherwise we will use MOVES/PERE's lookup tables.

Step 5. Use the MOVES/PERE package to calculate the relative emission factors for the three major GHG constituents: CO_2, methane, and nitrous oxide. If the CO_2-equivalent emission factors for methane and nitrous oxide are a small fraction of the CO_2 emission factor, then the remainder of the analysis will focus solely on CO_2 emissions.

Step 6. Consult with EPA staff to adjust the 2030 fuel economy predicted by the current version of MOVES/PERE to account for the California fuel economy standard that has been adopted for Washington State.

Step 7. Based on the driving cycles developed in Step 3, use the modal fuel economy model (MOVES/PERE lookup tables or CMEM) to calculate annual gasoline and diesel fuel usage at each roadway segment in the SR 520 roadway system. This will be done separately for each functional roadway class, level of service, and vehicle type, and the analysis will consider the PSRC traffic model's vehicle traffic volume at each roadway segment.

Step 8. Based on the above steps, sum the fuel usage along each roadway segment in the SR 520 roadway system to compile regional gasoline and diesel fuel usage under the three scenarios.

Step 9. Calculate regional GHG emissions for each scenario by applying the following GHG emission factors to the regional fuel usage (Energy Information Agency, Fuel and Energy Source Codes and Emission Coefficients, www.eia.doe.gov/oiaf/1605/coefficients.html):

- Gasoline: 19.56 pounds CO_2 per gallon of fuel
- Diesel: 22.38 pounds CO_2 per gallon of fuel

Task 2 Report—Selection of Key Modeling Variables

State Route 520 Bridge Replacement and High Occupancy Vehicle Project ■ Puget Sound Clean Air Agency ■ August 2008

ICF Jones & Stokes
an ICF International Company

Task 2 Report: Selection of Key Modeling Variables

Analyzing Greenhouse Gas Emissions for the State Route 520 Bridge Replacement and High Occupancy Vehicle Project

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Acronyms

Agency	Puget Sound Clean Air Agency
CAFE	Corporate Automobile Fuel Economy standard
CBD	central business district
DEIS	draft environmental impact statement
GP lane	general purpose lane
HIA	Health Impact Assessment
HOV	high occupancy vehicle
HOV2	high-occupancy vehicle with 2 passengers
HOV3+	high-occupancy vehicle with 3 or more passengers
mpg	miles per gallon
Project	State Route 520 Bridge Replacement and High Occupancy Vehicle Project
PSRC	Puget Sound Regional Council
SR	state route
VMT	vehicle miles traveled
WSDOT	Washington State Department of Transportation

Introduction

The team of ICF Jones & Stokes and Fehr & Peers has been retained by the Puget Sound Clean Air Agency (Agency) to conduct the greenhouse gas (GHG) emission inventory for comparison of alternatives and operating scenarios for the State Route (SR) 520 Bridge Replacement and High Occupancy Vehicle (HOV) Project (Project). Washington State and King County have both enacted GHG-reduction targets; tailpipe emissions from commuters along the SR 520 corridor are a significant contributor to countywide GHG emissions.

Several significant pieces of legislation passed during the 2008 Legislative Session, including ESSHB 2815—creating a framework to reduce greenhouse gas emissions in Washington State. Several of the policy actions call for reducing emissions by implementing trip-reduction strategies including transit and tolling options. The mode-choice options being evaluated for the Project correspond with these policy actions.

The Washington State Legislature has directed the Agency to prepare a Health Impact Assessment (HIA) for the Project, specifically the six-lane alternative. The HIA must include an evaluation of GHG emissions from the project.

The 2006 Draft Environmental Impact Statement (DEIS) for the Project included an Energy Discipline Report that made a rough estimate of fuel usage for project construction and for vehicles driving along the corridor under each alternative. The discipline report indicated that annual fuel usage would be nearly identical under all alternatives. However, that calculation was based on highly simplified assumptions, so it was unable to accurately distinguish the amount of fuel usage between the project alternatives.

ICF Jones & Stokes and Fehr & Peers are conducting the following tasks as part of the SR 520 GHG analysis.

- Task 1. Identify the most appropriate model and variables for estimating GHG emissions. For this task, we will recommend the specific regional transportation modeling methods and tools to estimate future fuel economy and GHG emissions.
- Task 2. Advise the Agency on the selection of the model and on key project variables and their respective values. For this task, we will work with the interagency team to develop the regional traffic parameters and mode-choice parameters that will make up the three GHG-reduction scenarios:
  - Scenario 1. High GHG Reduction Scenario
  - Scenario 2. Low GHG Reduction Scenario

- Scenario 3. Most-Likely GHG Reduction Scenario

- Task 3. Calculate the GHG emissions. For this task, we will model regional traffic patterns and regional GHG emissions associated with each of the GHG-reduction scenarios.

This report presents our Task 2 recommendations to specify the key modeling variables that will be input to the regional transportation models to forecast traffic volumes, speed, and congestion levels along each regional roadway link under each of the scenarios. The actual modeling will be done under Task 3.

Task 2 Objectives

The objectives of Task 2 are as follows:

1. For each of the key transportation modeling variables identified in the Task 1 Report, recommend three values: "High GHG Reduction," "Low GHG Reduction," and "Most Likely GHG Reduction."
2. Combine the individual modeling variables into three broad scenarios: High GHG-Reduction Scenario, Low GHG-Reduction Scenario, and Most Likely GHG-Reduction Scenario. In addition, recommend which of the "West-End Design Options" described in the DEIS should be evaluated for GHG emissions.

Recommend Values for Key Transportation Modeling Variables

Geographical Study Area

Figure 1 displays the recommended geographical area for the GHG analysis (study area). The study area (shaded) represents the region including roadway segments where 97% of the vehicles using either Interstate (I) 90 or the SR 520 Bridge originate or are destined in the PM peak period for 2006. The "97% capture" roadway network was derived by Fehr & Peers / Mirai, based on the Puget Sound Regional Council Model Version 1.0B for 2006. The study area consists of central and northern Seattle and Shoreline in west King County. In the east King County region, the cities of Bellevue, Kirkland, and Redmond are the key contributors to SR 520 demand. In Snohomish County, areas along SR 522 and SR 2 contribute to SR 520 demand. The study area was expanded slightly based on recommendations from the Agency and its partners to include the area near Tukwila (I-5 and I-405) and the

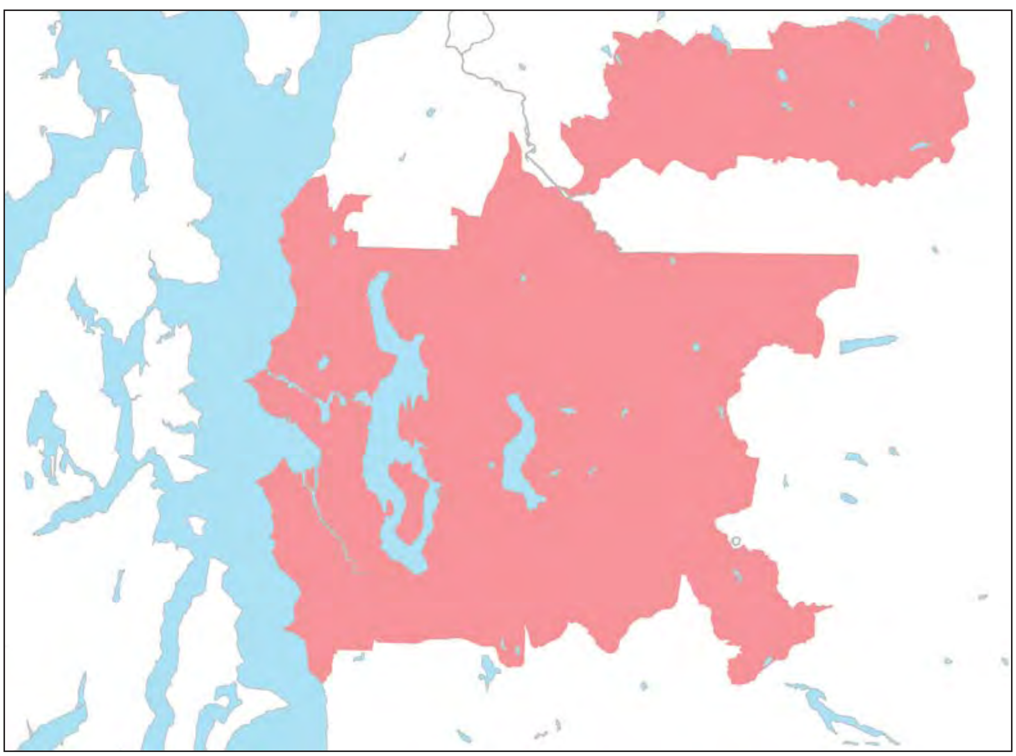
Kenmore area (SR 522). The expanded area will capture the potential shifts in trip making under the different scenarios being analyzed.

Traffic along the I-90 corridor between I-5 and I-405 will also be included in the study area to account for possible shifting of traffic away from the SR 520 Bridge as a result of tolling options.

Project-Influenced Roadway Segments Used for GHG Modeling

Not all roadway segments within the geographical study area will be included in the GHG emission calculations. Instead, the calculations will be limited to "Project-Influenced Segments" within the study area. These are defined as roadway segments for which the ADT traffic volume varies by at least 5% between the High-Reduction scenario and the Low-Reduction scenario. The 5% criterion used to define "Project Influenced Segments" is the same value that has been used by the Federal Highway Administration to evaluate regional Mobile Source Air Toxics emissions for large regional freeway projects.

Figure 1. Study Area



Recommended West-End Design Options to Be Considered for GHG Analysis

As stated in the Task 1Report, the Washington State Legislature directed the Agency to conduct an HIA, including GHG emission calculations, for the six-lane ("4 plus 2") configuration described in the DEIS. The Agency directed ICF Jones & Stokes to evaluate 2030 GHG emissions for three design options for the west-end SR 520 configuration.   Common elements of these three alternatives include:

- A six-lane corridor including two general-purpose and one HOV lane in each direction.
- Lids at I-5, 10th Avenue and Delmar Drive East, and at Montlake Boulevard.
- Bicycle and pedestrian connectivity (across the Evergreen Point Bridge and to adjacent communities).
- Exclusion of a median freeway transit stop.
- Reversible direct access to and from the I-5 express lanes.

Additional baseline design information provided by WSDOT for each of the alternatives is outlined below.

Option A.

- Includes an interchange at Montlake Boulevard, similar to the configuration of the existing interchange.
- Does not include Lake Washington Boulevard ramps.
- Adds a second Montlake bridge parallel to the existing Montlake Bridge.
- Includes a westbound transit-only off-ramp to Montlake Boulevard.

Option K

- A low roadway profile.
- Includes quieter pavement.
- Includes a berm over the roadway at Foster Island.
- Includes a single-point urban interchange under the mainline SR 520 located in the east Montlake area near the existing Museum of History and Industry.
- Includes a tunnel under the Montlake Cut.
- Separates freeway and local traffic across the Montlake Cut, allowing Montlake Boulevard to be a local traffic access roadway.
- Includes access to and from SR 520 and the Arboretum with a roundabout at the terminus of a new roadway parallel to the existing Lake Washington Boulevard.

Option L.

- Includes a single-point urban interchange over the SR 520 mainline at the east Montlake area near the existing Museum of History and Industry.
- Includes a second draw bridge over the Montlake Cut.
- Includes Lake Washington Boulevard ramps.

Inspection of the roadway configurations,(e.g. lanes, grades, interchanges, distances) for Option K and Option L indicates that the trip generation and regional vehicle miles traveled (VMT) should be nearly identical for those options. Consultation with the Agency and its partners during the review of the Task 1 Report provided a consensus on this assessment. Therefore, this study will assume that Option K and Option L are likely to produce similar GHG emissions given the precision of the models used.

Option A and the combined Option K/L will be analyzed for GHG emissions.

Transportation Network Assumptions

Table 1 provides an overview of the assumed transportation networks and variables that will be modified in the modeling runs. For each GHG-reduction scenario, the assumed transportation network is divided into highway system and transit system. Detailed descriptions of the components of each scenario are provided below.

Table 1. Assumed Highway and Transit System Networks under Each Scenario

	Transportation Network	
Scenario	Highway System[1]	Transit System
1 – Low GHG Reduction Scenario	2030 Infrastructure	2020 (Infrastructure + Frequency)
2 – Most Likely GHG Reduction Scenario	2020 Infrastructure	2030 (Infrastructure + Frequency)
3 – High GHG Reduction Scenario	2020 Infrastructure	2030 Transit Infrastructure "2030 +" Frequency of Service

[1]The assumed highway system describes the configuration of future roadways in the study area, including the number of freeway lanes, HOV lanes, and arterial lanes.

Table 2 provides details on the regional highway and transit improvements assumed by PSRC for 2010, 2020, and 2030. The top section shows the assumed highway system infrastructure. Although details are not listed in Table 2, the regional arterial system is also assumed to be enhanced based on local transportation plans. The bottom section summarizes the assumed transit system infrastructure—future fixed transit facilities—including fixed light rail lines and commuter rail lines as well as the assumed frequency of service for bus networks.

Table 2. Regional Highway and Transit Infrastructure Assumptions

2010	2020	2030
	Highway System Infrastructure	
SR 16: 1 new HOV lane per direction (I-5 to Olympic View Dr.)	SR 520: 1 new HOV lane per direction (I-5 to I-405)	I-90 Bridge: 1 new HOV lane per direction (I-5 to I-405)
Tacoma Narrows Bridge: Widen GP lanes from 2 to 3 lanes per direction.	I-405: widen GP from 3 to 4 lanes per direction (SR 520 to 85th, 132nd to SR 522); 2 to 3 (195th to SR 527); 2 to 4 (SR 169 to SR 167)	I-405: widen GP from 4 to 5 lanes per direction (I-90 to 132nd); 2 to 4 (SR 169 to Coal Creek Pkwy)
SR 16: 1 new HOV lane per direction (I-5 to Olympic View Dr)	SR 9: widen GP from 1 to 2 per direction	SR 18: widen GP from 1 to 2 lanes per direction (Hobart to I-90)
SR 167: 1 new HOV lane per direction (15th St NW to SR 410)	SR 522: widen GP from 1 to 2 per direction (Paradise Lake Rd. to SR 2)	SR 167: widen GP from 2 to 3 lanes per direction (S 43rd to SR 410)
I-405: widen GP from 2 to 3 lanes (SR 167 to I-5); 3 to 4 (Coal Creek to SE 8th); 3 to 4 (85th to 132nd)	SR 509: new extension to I-5 (2 GP and 1 HOV per direction)	SR 3: widen GP from 1 to 2 lanes per direction (SR106 to SR 304 in Bremerton)
I-90: new westbound HOV land (Bellevue Way to Mercer Island)	I-5: widen GP from 4 to 5/6 per direction (S 218th St to 320th St in Federal Way)	SR 104: widen GP from 1 to 2 lanes per direction (Kingston terminal to SR307)
SR 18: widen GP 1 to 2 (SR 169 to Hobart Road)		
	Transit System Infrastructure	
Light Rail: SeaTac to Seattle CBD	Light Rail: Seattle CBD to Bel-Red Road	Light Rail: Northgate to Lynnwood
Commuter Rail: extend to Lakewood	Light Rail: Seattle CBD to Northgate	Light Rail: Bel-Red Road to Overlake
		Light Rail: SeaTac to Tacoma
		Commuter Rail: extend to Dupont

GP = general purpose; CBD = central business district.

As shown in Tables 1 and 3, Scenario 3 (High GHG Reduction) assumes an enhanced frequency of transit service along the SR 520 Bridge corridor.

Table 3 provides the assumed transit frequency (buses per hour) for the AM peak period for 2020 and 2030, and 2030+, an enhanced level of service beyond 2030 levels. The 2030+ increase would not depend on agency funding, but on private transit options similar to the existing Microsoft fleet or other funding sources. Note, the values listed in Table 3 are subject to final confirmation by multiple transit agencies.

The 2020 transit service is reflective of Sound Transit's current level of funding as specified in its 2008 Transportation Conformity modeling analysis. Service for the other transit entities is assumed to escalate by an annual 1% growth rate.

Table 3. Frequency of Transit Service on SR 520 (1-Way Buses/Hour AM Peak-Hour)

		Assumed AM Peak-Hour Buses/Hour		
Direction	**2006**	**2020**	**2030**	**2030+**
Westbound	38	55	82	102
Eastbound	19	24	33	45

Each scenario has a unique combination of assumed future highway infrastructure improvements and level of transit service.

Scenario 1 (Low GHG Reduction)—2030 highway system and 2020 transit system. This combination of network assumptions is expected to result in the highest use of passenger vehicles, and therefore, the highest regional GHG emissions.

Scenario 2 (Most Likely GHG Reduction)—2020 highway system and 2030 transit system. This is the transportation network described by the six-lane option of the DEIS. The 2030 transit assumptions for both bus and rail, depicted in Tables 2 and 3, are aggressive considering the current state of the system and the assumed funding for future expansion. As described in Chapter 5 of the DEIS, Sound Transit has not committed to funding the level of transit service included under the 2030 transit system assumptions.

Scenario 3 (High GHG Reduction) combines the—2020 highway system and 2030+ transit system. The 2030+ transit system signifies an enhanced level of transit service surpassing the optimistic 2030 levels described in the DEIS.

Cost Options

PSRC recommended parking costs and bridge tolls as the key variables for modeling the scenarios. These costs are expected to have a substantial influence on modal shifts, and as such are deemed the most likely factors to reduce VMT.

Table 4 shows the cost factors applied to each scenario, and Table 5 quantifies the assumed SR 520 bridge tolls. The bridge toll definitions are derived from work previously done during the SR 520 Toll Feasibility and SR 520 DEIS. The PM peak period has the highest toll for all time periods and scenarios. The rationale for each bridge tolling concept is as follows:

- Minimum toll. This toll is based on a traffic management approach whereby tolls are set by time of day and direction of travel to levels sufficient to minimize congestion and maintain good traffic flow without the unnecessary diversion of traffic to other roadways. The minimum toll is not designed to induce a substantial mode-choice shift to public transit. PSRC recommended the use of the minimum toll for Scenario 1.
- Medium toll. This toll is a Washington State Department of Transportation (WSDOT) estimate, based on a medium range of tolls that have been investigated for the 2007 SR 520 Finance Plan. The medium toll matches the assumptions used in the DEIS.
- Maximum toll. This toll is set by time of day and direction of travel following a more precise time schedule and tailored to maximize toll revenue collections. The maximum toll is expected to induce mode-choice shifts from passenger vehicles to mass transit, thereby inducing the greatest reduction in VMT along the SR 520 corridor.

Table 4. Cost Factors by Scenario

	Cost Factors	
Scenario	**SR 520 Bridge Tolls**	**Parking Cost**
1 - Low GHG Reduction	Minimum Toll	PSRC
2 – Most Likely GHG Reduction	Medium Toll	PSRC +
3 – High GHG Reduction	Maximum Toll	PSRC + Tax

Table 5. SR 520 Bridge Tolls By Time of Day (Year 2000 Dollars)

Time Period	Minimum Toll	Medium Toll	Maximum Toll
Morning Peak	$1.20	$2.57	$4.00
Mid Day	$0.83	$1.77	$2.76
Afternoon Peak	$2.10	$3.21	$5.00
Evening	$0.75	$0.75	$0.75
Night	$0.35	$0.77	$0.75

All values expressed as Year 2000 dollars.

Bridge Toll Adjustments: medium trucks pay two times the toll rate; heavy trucks pay four times the toll rate; HOV 3+ and transit pay no toll.

The parking costs used in this analysis—Bellevue and Seattle central business districts and the University of Washington—will vary by scenario based on the following methodologies:

- Scenario 1—Low GHG Reduction. This scenario uses current PSRC methodology increased by 1.5% annually.
- Scenario 2—Most-Likely GHG Reduction. This scenario uses a revised methodology incorporating employment density, and escalates parking costs by 2% annually. This approach will provide realistic parking costs in faster growing areas like South Lake Union and the Bellevue-Overlake corridor. The rate of increase will also be consistent with recent observed rates of growth in parking costs.
- Scenario 3—High GHG Reduction. This scenario uses a higher rate of cost increase and a parking surcharge on the parking costs. The initial parking tax would be 15%. For this scenario all parking costs and the parking tax would be escalated by a conservatively high annual growth factor of 2.5%, compared to the annual escalation rate of 2% used for the Most-Likely GHG Reduction scenario.

Gasoline Price Assumptions

Two values of gasoline prices will be evaluated for the Year 2030 traffic volume forecasts, as follows:

- For the Low-Reduction and Most-Likely Reduction scenarios, the fuel price will be fixed at $1.57/gallon (Year 2000 dollars), based on the current default value used for the PSRC model.
- For the High-Reduction scenario, two fuel prices will be used: 1) the $1.57/gallon (Year 2000 dollars) value used for the Low- and Most-Likely Reduction scenarios; and 2) a fuel price of $7.30 (Year 2000 dollars), which was derived from the value evaluated by PSRC for their Vision 2040 project.

Other Transportation Variables Not Modified

The following transportation variables were not modified for this analysis because they represent factors that are beyond the control of state and regional transportation agencies.

Non-gasoline vehicle operating costs. As described above a range of fuel prices will be evaluated. However, other vehicle operating costs will be fixed at the values in the current PSRC model.

Local transit-oriented land use regulations. It is acknowledged that future GHG-emission reduction regulations might encourage (or require) local governments to adopt more stringent transit-oriented land use regulations to reduce VMT and GHG emissions. The agreed upon future land use vision developed by PSRC, which incorporates jurisdictional response to the state's Growth Management Act, supports a denser urban form. Therefore, this factor is beyond the scope of this analysis.

Value of time. PSRC recently updated the value of time for auto travel based on observed estimates collected as part of the Traffic Choices Study. These observed values were 50% higher than previous estimates and will have an impact on modeling traffic diversion due to tolls. Value of time for freight travel was updated based on a literature search of national research and by working with the Washington State Freight Data. In discussion with PSRC it was felt that the value of time should not be changed for any of the scenarios. The value of time for work trip ranges from $6 to $21 per hour depending on income (all values in constant Year 2000 dollars). The value of time for non-work trips is almost $10 per hour.

Recommended Method to Calculate 2030 Fuel Economy Based on New California Fuel Economy Standards

This study will evaluate GHG-emission reductions for 2030. However, the current version of MOVES does not include the new California fuel economy standards, which have been adopted by Washington state. To more accurately predict GHG emissions for 2030, this California/Washington regulation needs to be considered. Since CO_2 emissions are directly related to fuel consumption, actual GHG emissions will be lower than predicted by MOVES for modeling years after the California standards are phased in.

Table 6 lists the fuel economies mandated by the California standards. The currently-applicable federal CAFE standards in MOVES include 27.5 miles per gallon (mpg) for passenger cars and 23.5 mpg for light-duty trucks. The new California standard for light-duty automobiles and light-duty trucks is shown in Table 6 along with the gallon per mile ratio of the proposed new standard to the current CAFE standards. Gallons per mile is used to determine the actual fuel use for fixed VMT.

The fuel economy factors listed by MOVES will be scaled according to the new California regulation, and will also be scaled by using EPA's Physical Emission Rate Estimator (PERE) model.

Table 6. California Standards for Light-Duty Automobiles and Trucks

	Light-Duty Automobiles		Light-Duty Trucks	
Model Year	Fuel Economy (mpg)	Gallons-per-Mile Ratio to Current Standard	Fuel Economy (mpg)	Gallons-per-Mile Ratio to Current Standard
2004	26.3	1.000	19.5	1.000
2005	26.6	0.989	20.1	0.970
2006	26.6	0.989	20.7	0.942
2007	26.6	0.989	21.3	0.915
2008	26.6	0.989	21.6	0.903
2009	27.2	0.966	21.4	0.911
2010	29.2	0.901	22.5	0.868
2011	32.9	0.800	24.4	0.800
2012	37.6	0.699	26.6	0.734
2013	38.1	0.690	26.8	0.727
2014	39.0	0.675	27.2	0.716
2015	40.6	0.648	28.0	0.696
2016	42.1	0.625	28.8	0.677
2017	44.2	0.595	30.7	0.635
2018	46.5	0.566	33.2	0.588
2019	47.8	0.551	34.8	0.560
2020+	49.1	0.536	35.5	0.549

Task 3 Summary Tables

Analyzing Greenhouse Gas Emissions for the State Route 520 Bridge Replacement and High Occupancy Vehicle Project

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Introduction

The following tables show GHG summary results for the Low-Reduction, Mid-Reduction, High-Reduction, and High2-Reduction Scenarios (the High2-Reduction scenario is the same as the High-Reduction scenario, except with higher gas prices as defined by PSRC Vision 2040). Summary results are presented for two different roadway networks used to calculate GHG emissions:

- The entire geographical study region as originally defined in our original Task2 Report. This geographical area constitutes the vicinity from which 97% of SR 520 traffic originates.
- "Project-influenced roadways", defined as the smaller subset of segments within the geographical study area for which the VMT changed by at least 5% between the High2-Reduction scenario and the Low-Reduction scenario. This is the method that FHWA uses to define roadway networks for purposes of calculating regional MSAT emissions for NEPA analyses.

The modeled GHG results include the proposed California fuel standards.

Table 1. GHG Results Comparison – Entire Study Region

Alternative	Scenario	Daily VMT				Daily GHG Emissions (tons CO2)			
		LDV	Buses	HDT	Total	LDV	Buses	HDT	Total
Montlake	Low-Reduction	46,307,171	150,124	9,417,088	55,874,383	9,494	162	20,232	29,887
	Mid-Reduction	45,926,104	159,488	9,368,569	55,454,161	9,325	171	19,908	29,403
	High- Reduction	45,863,526	162,354	9,357,106	55,382,986	9,284	173	19,797	29,255
	High2-Reduction	43,919,400	162,354	9,368,920	53,450,674	8,882	174	19,562	28,618
	Mid vs Low	-0.8%	6.2%	-0.5%	-0.8%	-1.8%	5.7%	-1.6%	-1.6%
	High vs Low	-1.0%	8.1%	-0.6%	-0.9%	-2.2%	7.3%	-2.1%	-2.1%
	High2 vs Low	-5.2%	8.1%	-0.5%	-4.3%	-6.4%	7.4%	-3.3%	-4.2%
Bridge/ Tunnel	Low	47,228,657	141,264	9,478,646	56,848,567	9,620	152	20,108	29,879
	Mid	45,900,532	159,359	9,376,740	55,436,631	9,317	170	19,965	29,453
	High	45,920,611	162,210	9,366,618	55,449,438	9,304	173	19,882	29,359
	High2	43,985,646	162,210	9,376,159	53,524,015	8,902	173	19,658	28,734
	Mid vs Low	-2.8%	12.8%	-1.1%	-2.5%	-3.1%	12.4%	-0.7%	-1.4%
	High vs Low	-2.8%	14.8%	-1.2%	-2.5%	-3.3%	14.4%	-1.1%	-1.7%
	High2 vs Low	-6.9%	14.8%	-1.1%	-5.8%	-7.5%	14.4%	-2.2%	-3.8%

LDV=Light-duty Vehicles; MHDT=Medium Heavy-Duty Trucks; HHDT=Heavy heavy-duty Trucks

Table 2. GHG Results Comparison – "Project-Influenced" Links where VMT changed by at least 5%

Alternative	Scenario	Daily VMT				Daily GHG Emissions (tons CO2)			
		LDV	Buses	HDT	Total	LDV	Buses	HDT	Total
Montlake	Low-Reduction	20,691,991	59,598	4,194,006	24,945,596	4,209	63	8,143	12,414
	Mid-Reduction	20,413,815	64,352	3,839,734	24,317,901	4,037	67	7,106	11,210
	High-Reduction	20,346,957	65,574	3,833,066	24,245,597	4,002	68	7,018	11,088
	High2-Reduction	18,926,454	65,574	3,829,435	22,821,462	3,710	68	6,722	10,500
	Mid vs Low	-1.3%	8.0%	-8.4%	-2.5%	-4.1%	6.7%	-12.7%	-9.7%
	High vs Low	-1.7%	10.0%	-8.6%	-2.8%	-4.9%	8.2%	-13.8%	-10.7%
	High2 vs Low	-8.5%	10.0%	-8.7%	-8.5%	-11.8%	8.3%	-17.4%	-15.4%
Bridge/ Tunnel	Low-Reduction	25,813,885	74,255	5,817,310	31,705,450	5,320	79	12,049	17,449
	Mid-Reduction	24,865,762	87,287	4,986,696	29,939,745	5,073	93	9,874	15,040
	High-Reduction	24,854,702	89,041	4,986,654	29,930,397	5,051	95	9,800	14,946
	High2-Reduction	23,518,373	89,041	4,993,689	28,601,103	4,779	95	9,677	14,550
	Mid vs Low	-3.7%	17.6%	-14.3%	-5.6%	-4.6%	17.0%	-18.0%	-13.8%
	High vs Low	-3.7%	19.9%	-14.3%	-5.6%	-5.1%	19.1%	-18.7%	-14.3%
	High2 vs Low	-8.9%	19.9%	-14.2%	-9.8%	-10.2%	19.3%	-19.7%	-16.6%

LDV=Light-duty Vehicles; MHDT=Medium Heavy-Duty Trucks; HHDT=Heavy heavy-duty Trucks

Table 3. GHG Results for Low-Reduction Scenario – Montlake Alternative (Entire Study Region)

Time Period	Daily VMT				Daily GHG Emissions (tons CO2)			
	LDV	Buses	HDT	Total	LDV	Buses	HDT	Total
AM Peak	7,279,017	45,325	2,114,877	9,439,219	1,559	49	5,222	6,830
Midday	14,901,041	44,373	3,242,359	18,187,773	3,124	47	7,158	10,329
PM Peak	9,606,424	41,620	2,319,433	11,967,476	2,043	46	5,438	7,527
Evening	8,504,979	18,807	979,888	9,503,674	1,676	20	1,455	3,151
Night	6,015,710	-	760,532	6,776,242	1,091	-	959	2,050
Total	46,307,171	150,124	9,417,088	55,874,383	9,494	162	20,232	29,887

LDV=Light-duty Vehicles; MHDT=Medium Heavy-Duty Trucks; HHDT=Heavy heavy-duty Trucks

Table 4. GHG Results for Mid-Reduction Scenario – Montlake Alternative (Entire Study Region)

Time Period	Daily VMT				Daily GHG Emissions (tons CO2)			
	LDV	Buses	HDT	Total	LDV	Buses	HDT	Total
AM Peak	7,241,898	47,336	2,113,382	9,402,617	1,552	51	5,207	6,811
Midday	14,549,719	48,818	3,212,739	17,811,277	2,967	51	6,853	9,871
PM Peak	9,624,107	43,678	2,320,423	11,988,207	2,049	48	5,444	7,541
Evening	8,531,559	19,655	968,675	9,519,888	1,659	20	1,437	3,116
Night	5,978,822	-	753,350	6,732,172	1,097	-	968	2,065
Total	45,926,104	159,488	9,368,569	55,454,161	9,325	171	19,908	29,403

LDV=Light-duty Vehicles; MHDT=Medium Heavy-Duty Trucks; HHDT=Heavy heavy-duty Trucks

Table 5. GHG Results for High-Reduction Scenario – Montlake Alternative (Entire Study Region)

Time Period	Daily VMT				Daily GHG Emissions (tons CO2)			
	LDV	Buses	HDT	Total	LDV	Buses	HDT	Total
AM Peak	7,271,551	48,402	2,110,209	9,430,162	1,559	53	5,198	6,809
Midday	14,566,280	49,178	3,208,129	17,823,588	2,956	52	6,795	9,803
PM Peak	9,582,592	44,671	2,318,630	11,945,894	2,040	49	5,440	7,529
Evening	8,501,681	20,102	967,082	9,488,865	1,640	20	1,400	3,060
Night	5,941,422	-	753,056	6,694,478	1,090	-	964	2,054
Total	45,863,526	162,354	9,357,106	55,382,986	9,284	173	19,797	29,255

LDV=Light-duty Vehicles; MHDT=Medium Heavy-Duty Trucks; HHDT=Heavy heavy-duty Trucks

Table 6. GHG Results for High2-Reduction Scenario – Montlake Alternative (Entire Study Region)

Time Period	Daily VMT				Daily GHG Emissions (tons CO2)			
	LDV	Buses	HDT	Total	LDV	Buses	HDT	Total
AM Peak	6,752,349	48,402	2,117,700	8,918,451	1,441	53	5,158	6,652
Midday	14,041,439	49,178	3,211,953	17,302,570	2,837	51	6,602	9,490
PM Peak	9,519,192	44,671	2,317,277	11,881,141	2,023	49	5,433	7,506
Evening	8,171,979	20,102	967,424	9,159,506	1,576	20	1,400	2,997
Night	5,434,441	-	754,566	6,189,007	1,005	-	969	1,974
Total	43,919,400	162,354	9,368,920	53,450,674	8,882	174	19,562	28,618

LDV=Light-duty Vehicles; MHDT=Medium Heavy-Duty Trucks; HHDT=Heavy heavy-duty Trucks

Table 7. GHG Results for Low-Reduction Scenario – Bridge/Tunnel (Entire Study Region)

Time Period	Daily VMT				Daily GHG Emissions (tons CO2)			
	LDV	Buses	HDT	Total	LDV	Buses	HDT	Total
AM Peak	7,801,288	41,989	2,132,530	9,975,807	1,691	46	5,249	6,986
Midday	15,075,681	44,351	3,253,875	18,373,907	3,069	47	6,883	9,998
PM Peak	10,037,677	37,879	2,351,543	12,427,098	2,165	42	5,625	7,832
Evening	8,499,453	17,045	980,447	9,496,946	1,628	17	1,384	3,029
Night	5,814,557	-	760,251	6,574,808	1,068	-	967	2,035
Total	47,228,657	141,264	9,478,646	56,848,567	9,620	152	20,108	29,879

LDV=Light-duty Vehicles; MHDT=Medium Heavy-Duty Trucks; HHDT=Heavy heavy-duty Trucks

Table 8. GHG Results for Mid-Reduction Scenario – Bridge/Tunnel (Entire Study Region)

Time Period	Daily VMT				Daily GHG Emissions (tons CO2)			
	LDV	Buses	HDT	Total	LDV	Buses	HDT	Total
AM Peak	7,279,017	47,297	2,114,877	9,441,190	1,559	51	5,222	6,833
Midday	14,588,074	48,787	3,217,602	17,854,463	2,982	51	6,916	9,950
PM Peak	9,619,130	43,638	2,320,803	11,983,571	2,046	48	5,440	7,534
Evening	8,524,738	19,637	969,737	9,514,112	1,647	20	1,417	3,084
Night	5,889,573	-	753,721	6,643,294	1,083	-	969	2,052
Total	45,900,532	159,359	9,376,740	55,436,631	9,317	170	19,965	29,453

LDV=Light-duty Vehicles; MHDT=Medium Heavy-Duty Trucks; HHDT=Heavy heavy-duty Trucks

Table 9. GHG Results for High-Reduction Scenario – Bridge/Tunnel (Entire Study Region)

Time Period	Daily VMT				Daily GHG Emissions (tons CO2)			
	LDV	Buses	HDT	Total	LDV	Buses	HDT	Total
AM Peak	7,292,455	48,357	2,112,582	9,453,394	1,561	52	5,187	6,801
Midday	14,652,421	49,145	3,209,232	17,910,798	2,984	52	6,867	9,903
PM Peak	9,563,203	44,626	2,322,155	11,929,984	2,035	49	5,453	7,537
Evening	8,487,385	20,082	969,040	9,476,506	1,637	20	1,409	3,066
Night	5,925,147	-	753,609	6,678,756	1,087	-	965	2,052
Total	45,920,611	162,210	9,366,618	55,449,438	9,304	173	19,882	29,359

LDV=Light-duty Vehicles; MHDT=Medium Heavy-Duty Trucks; HHDT=Heavy heavy-duty Trucks

Table 10. GHG Results for High2-Reduction Scenario – Bridge/Tunnel (Entire Study Region)

Time Period	Daily VMT				Daily GHG Emissions (tons CO2)			
	LDV	Buses	HDT	Total	LDV	Buses	HDT	Total
AM Peak	6,758,154	48,357	2,119,134	8,925,645	1,443	53	5,170	6,665
Midday	14,149,867	49,145	3,214,111	17,413,123	2,861	51	6,657	9,570
PM Peak	9,477,456	44,626	2,319,879	11,841,962	2,016	49	5,458	7,524
Evening	8,191,028	20,082	968,268	9,179,377	1,583	20	1,404	3,007
Night	5,409,141	-	754,767	6,163,908	999	-	969	1,968
Total	43,985,646	162,210	9,376,159	53,524,015	8,902	173	19,658	28,734

LDV=Light-duty Vehicles; MHDT=Medium Heavy-Duty Trucks; HHDT=Heavy heavy-duty Trucks

Note that you get slightly different results if you use the “Entire Geographical Study Area” roadway network vs. the “Project-Influenced Segments” network, because the “Project-Influenced Segments” exclude a considerable number of outlying roadways, each of which individually contributes a very small fraction of the total regional VMT . Table 11 compares the results using the two different roadway networks.

Table 11. Variation Between “Entire Study Region” and “Project-Influenced Segments” (Comparison based on Montlake Option)

Study Area	Reduction Scenario	Total Daily VMT	Daily Tons CO_2
Entire Study Area	Low-Reduction	55,874,000	29,877
	High2-Reduction	53,451,000	28,618
	Overall VMT Reduction	**2,423,000**	**1,269**
Project-Influenced Segments	Low-Reduction	24,946,000	12,414
	High2-Reduction	22,821,000	10,500
	Overall VMT Reduction	**2,125,000**	**1,914**
Variation Between “Overall VMT Reduction” Assuming “Entire Study Region” vs. “Project-Influenced Segments”		298,000 VMT (12% difference)	645 Daily tons (34% difference)

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