Issue Resolution Report

Title:	Rev:
Washington State Legislature, Joint Transportation Committee Independent Review Team Feasibility of Placing LRT on the Homer M. Hadley Floating Bridge	1

Prepared for:

Washington State Legislature
Joint Transportation Committee

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Table of Contents

Executive Summary

The purpose of this independent review is to evaluate the original bridge analysis, subsequent studies, tests, and preliminary concept studies to confirm the feasibility to install and operate LRT on the Homer M. Hadley Floating Bridge. While there are similar developments of light rail across suspension bridges, there is no precedent for implementing light rail across a floating bridge.

This report identifies tracks and provides resolution to the issues that have an effect on the feasibility of placement of the LRT on the Homer M. Hadley Floating Bridge. The Independent Review Team concludes that all issues identified as potentially affecting feasibility can be addressed; however, several of the issues will impact the cost estimates and schedules and therefore should be resolved at the earliest stages of the project design.

The classification of each issue is based on the importance of that issue with respect to feasibility, cost and schedule impacts for construction and operation of the light rail on the Homer M. Hadley Floating Bridge. The East Link project is currently in the environmental review and conceptual design phase with final design anticipated to start in 2010 and revenue operation in 2020, assuming approval of an ST2 plan with East Link funding.

Below is a summary of each issue with the Independent Review Teams resolution and recommendations. The body of this report contains additional information regarding the definition of the issues, references provided by Sound Transit and Washington State DOT and details of the Independent Review Team's findings.

General

1. In order for the Independent Review Team to assess the impact of placing the LRT on the bridge, Washington State DOT and Sound Transit should state their goal for life expectancy of bridge (Issue T - High Importance).
    - Washington State DOT and Sound Transit agreed to a 100 year design life for the bridge.
    - When light rail is installed, the remaining life for the bridge will be about 70 years.
2. Criteria should be established for Independent Review Team to evaluate numerous issues (Issue K - High Importance).
    - Sound Transit is preparing an East Link design criteria document consistent with the criteria applied to the North Link and Airport Link.
    - The Independent Review Team recommends that Sound Transit provide policy level documentation whenever they chose to adopt design criteria that are less stringent than their own criteria where using existing facilities owned by other agencies.
3. Based on lessons learned from the sinking of the Lacey V. Murrow Floating Bridge, additional needs and changes may be required for LRT installation to meet "Blue Ribbon Panel" recommendations (Issue W - Low Importance).The Blue Ribbon Panel recommendations will not likely raise any project feasibility issues.

- They contain provisions that should be incorporated into the design, construction and operations.
- This will likely affect Washington State DOT and Sound Transit maintenance and operation procedures and priorities.

Stray Current Mitigation Measures

4. To meet the minimum requirements for stray current mitigation, Sound Transit should adopt the North Link/Airport Link Stray Current Mitigation design criteria for Homer M. Hadley Floating Bridge installation, with appropriate modifications and measures to meet the special requirements of this bridge (Issue F - High Importance). Sound Transit has agreed to utilize more stringent design criteria for stray current analysis and include in the LRT design:
   - Collection mats with ground electrodes to dissipate stray current.
   - A stray current monitoring system.
5. Since the Homer M. Hadley Bridge and Lacey V. Murrow Bridge are in close proximity and their respective anchor cable systems pass very close to the pontoons of the adjacent bridge, stray current and cathodic protection system interference should be considered and compatibility of the two systems assured (Issue H - High Importance).

   The Independent Review Team believes that a cathodic protection system provides another layer of defense against stray currents. Therefore the Independent Review Team recommends the following:
   - The cathodic protection systems on the Homer Hadley and the Lacey V. Murrow bridges should be upgraded.
   - Resources and plans are put in place to operate, monitor and adequately maintain the cathodic protection systems.
6. In order to protect the bridge from stray current effects and provide for rapid identification and repair, methods for identifying stray current failure and a response and repair plan should be in place (Issue U - Medium Importance).

   The plan as a minimum should include:
   - Remote monitoring of stray current at each stray current collector mat zone and at each ground electrode.
   - Voltage measurement of each collector mat.
   - Track-to-earth resistance measurements.
7. For Washington State DOT to insure safe operation of LRT on the Homer Hadley Bridge, modification of current bridge inspection procedures is recommended (Issue Q - Low importance).
   - More stringent inspection procedures will be implemented to ensure safe operation of the system.

- The Independent Review Team recommends that inspection team include agency staff members with expertise in the following engineering disciplines:
  a. Structural (Engineer with bridge preservation background)
  b. Electrical (Engineer with cathodic protection background)
  c. Material Science (Engineer with corrosion background)

8. To provide rational engineering inputs for performing stray current damage estimates, the strength and resistance of existing concrete should be determined (Issue P - Medium Importance).

   Sampling and testing is expected to be completed within a month. This will confirm some of the design assumptions.

Impact of LRT Track System Installation on the Bridge

9. To avoid damage to the Homer Hadley Bridge reinforcing and post tension steel, attachment of OCS supports to edge of the bridge deck cantilevers should be carefully considered (Issue N - High Importance)

   Sound Transit has provided conceptual attachment design and details that accommodate LRT loads and minimize roadway deck penetrations.

10. To avoid damage to the Homer Hadley Bridge, reliable method(s) should be utilized for locating rebar and post tensioning in the bridge deck (Issue O - High Importance)
    - Ground Penetrating Radar and X-Ray were successfully demonstrated for use on this project.
    - Sound Transit is researching methods for attaching track supports to the deck which will minimize or eliminate penetrations.
    - The Independent Review Team encourages the development of such alternative attachment methods. Such methods are as critical on the approach spans due to higher concentration of deck reinforcement.

11. Since the LRT OCS may attract more lightning than currently strikes the bridge, the need for lightning arrestors on floating bridge and approach spans should be considered (Issue E - Medium importance).
    - A lightning protection system will be designed for the floating bridge.
    - The Independent Review Team recommends:
      a. Lightning protection system should be separate from the stray current system.
      b. OCS support plate and bolts be electrically isolated from the pontoons.

12. Small amounts of stray current will be discharged into the water and therefore the impact of stray current dispersion in Lake Washington on the environment and fish should be addressed (Issue G - Low Importance).

    Sound Transit has provided documentation that indicates the amount of stray current associated with LRT will not have a significant effect on fish.

Weight Mitigation Measures Effects of the LRT Loads on Bridge Elements

13. Previous studies have indicated that the operational level bridge global torsional moment demand was very close to the allowable torsional moment capacity. Analysis should be performed to confirm torsional capacity of the existing bridge (Issue I - High Importance)

    Calculations provided by Washington State DOT and Sound Transit have addressed this issue. The Independent Review Team's assessment is ongoing and we expect that our assessment will soon provide a resolution to this issue.

14. Measure R-8A requires that the median barrier be relocated two feet to the south, which may require attachment of the new barrier, and may present maintenance and drainage issues (Issue S - High Importance).

    - Sound Transit provided preliminary design concepts that suggest three alternative approaches.
    - Sound Transit and Washington State DOT will study all three alternatives to determine the optimum one.
    - The Independent Review Team recommends that every effort be made to avoid relocation of the existing median barrier.

15. The bridge will become a shared asset of Sound Transit and Washington State DOT following placement of LRT and therefore, operation and maintenance coordination agreement between Sound Transit and Washington State DOT is necessary (Issue L - Medium Importance).

    Washington State DOT and Sound Transit provided documentation that outlines development, review, and approval of a Sound Transit/Washington State DOT Operation and Maintenance Agreement for the Homer M. Hadley Bridge.

16. Operational restrictions for combination of train loading and one-year storm loading from north should be addressed (Issue B - Medium Importance).

    - Based on the Independent Review Team preliminary investigation, this issue does not present a serious operational limitation.
    - Further Independent Review Team investigation of this issue is ongoing and is expected to be completed soon.

17. Analysis "North Wind" storm effects on Homer M. Hadley Floating Bridge should be considered (Issue J - Medium Importance).

    Independent Review Team calculations indicate that the 1-year northerly storm conditions are less severe than the 1-year southerly storm conditions used in the previous assessment.

18. Currently, Washington State DOT uses barge cranes to facilitate replacement of anchor cables, which will pose an operation and safety issue when LRT is placed on the bridge. Therefore the effect of LRT installation on construction operations associated with anchor cable replacement should be addressed (Issue V - Low Importance).

- Anchor cables can be replaced using small portable barge units latched together inside the channel between bridges, outfitted with all necessary lifting equipment that does not include overhead cranes.
- Anchor cable replacement can be performed without significant impact on personnel safety or cost of replacement.

Rail Expansion Joint Design and Prototype Testing

19. Since the track bridge is unique and has never before been used on a floating bridge, track bridge/expansion joint design should be accelerated and prototyped and performance criteria should be carefully considered (Issue A - High Importance).

    The Independent Review Team recommends an accelerated prototype track bridge design, fabrication, and construction approach that include the following:

    - Early start to the design is critical.
    - Prototype fabrication and testing.
    - Design modification based on prototype testing.
    - Special contracting approaches for the fabrication of production track bridges may be appropriate.

20. Since the track bridge is unique and has never been used on a floating bridge before, rider comfort performance for LRT track bridge at expansion joints should be evaluated (Issue M - High Importance)

    As Sound Transit has assumed, the LRT vehicle will need to traverse the track bridge at reduced speed in order to assure rider comfort and safety.

21. The track bridge will cross the existing expansion joints and storm water drainage system modifications must be addressed (Issue R - Low Importance)

    Sound Transit has provided acceptable conceptual design and construction details for collection of storm water for discharge into existing drainage system.

Seismic Vulnerability of Approach Spans and Transition Span

22. Placing light rail on the approach spans and transition span does not change their seismic vulnerability. However, to protect the large investment the East Link Project represents and to determine the impact on cost and schedule of construction, the Independent Review Team recommends that seismic vulnerability and seismic retrofit strategies be developed for the approach spans and transition spans (Issue C - Medium Importance)

    - The approach structures were designed to meet the seismic requirements at the time of construction. Considering the importance of the structure, current seismic retrofit standards should be met.
    - The Independent Review Team recommends that a full seismic vulnerability study be performed prior to final design.

- This could potentially lead to East Link project cost and schedule impacts and therefore the Independent Review Team recommends that this vulnerability assessment be accelerated. The ultimate decision on whether or not to retrofit will need to take into account seismic vulnerability, cost-effectiveness of retrofit approaches, potential disruption to traffic and state-wide funding priorities.

23. Placing light rail in the west tunnel or other structures in the corridor does not change the seismic vulnerability, however to protect the large investment the East Link Project represents, the Independent Review Team recommends that seismic vulnerability be assessed and a consistent seismic design criteria for the west approach tunnel and all other existing structures in the project should be considered. (Issue D - Medium Importance).

    - Although this issue is does not affect feasibility, the vulnerability of the west tunnel structure could have an impact on the risk of down time for the East Link.
    - The Independent Review Team recommends that Washington State DOT and Sound Transit perform a full seismic vulnerability study of all existing structures that will be used for LRT during preliminary design.
    - The ultimate decision on whether or not to retrofit will need to take into account seismic vulnerability, cost-effectiveness of retrofit approaches, potential disruption to traffic and funding priorities at the state and regional level.

1. Introduction

The central Puget Sound region is home to Fortune 500 corporations such as Microsoft, Boeing and Starbucks, while serving as a primary gateway for the movement of goods to and from East Asian markets through its world class ports and terminal facilities. The region has only two transportation facilities crossing Lake Washington: I-90 and SR 520 Floating Bridges. The Puget Sound area is faced with a growing population and increased congestion on these key regional links. The Central Puget Sound region has a steadily growing population with an estimated 3.5 million people in 2005 and is projected to grow to over 4.6 million by 2030 with notable growth assumed on the east side of Lake Washington.

For the I-90 Corridor, past studies and regional agreements have identified I-90 as the preferred corridor for high capacity transit, light rail. The I-90 roadway and floating bridges link the City of Seattle with the island community of Mercer Island and communities on the east side of Lake Washington such as Bellevue and Issaquah with I-90 serving as the only connection between Mercer Island and the mainland. During an average weekday the I-90 roadway carries approximately 133,000 vehicles per day. It is for these reasons that Sound Transit is proposing the corridor to accommodate high capacity transit in the form of light rail across the I-90 floating bridge.

The Homer M. Hadley Floating Bridge was designed in the early 1980s. The design for the bridge was supported by the 1976 Memorandum Agreement signed by communities and jurisdictions along the I-90 corridor to support the development of high capacity transit in the center roadway of the Homer M. Hadley Floating Bridge. As part of the bridge design process, the design included analysis of the bridge for light rail (LRT) which had design characteristics similar to the current Sound Transit LRT loading standards. This previous analysis assumed that the center roadway HOV (South side) lanes would be converted to LRT.

Beginning in 2001 studies and tests were re-initiated to evaluate the effects of LRT on the floating bridge utilizing current Sound Transit LRT loads. These structural feasibility studies, performed by Washington State DOT consultants, assessed placing LRT in the center roadway and adding an HOV lane to the outer westbound roadway (R-8A scenario). The analysis showed LRT conversion modifications were structurally feasible with weight mitigation measures on the bridge and limitations on track system weight.

In 2005, fully loaded large trucks were run across the Homer M. Hadley Bridge to simulate an LRT system based on current Sound Transit train and track standards. The bridge was fully instrumented to record pontoon deflections and stresses during the test. The data from the load test demonstrated close correlation to the computer model used in earlier studies with minor modifications. LRT loads were combined with original design load combinations like wind, wave, temperature, dead load and pre-stress.

The analysis showed that live loading (obtained by creating the live load envelopes including two-four-car crush loaded LRV and three lanes of HS25 highway loading) combined with the 1-year storm loads, from the south, produced demands that were 97% of the allowable stresses becoming the controlling case for operational limitations of LRT. The allowable stress criteria protect the bridge from fatigue. This calculation also ignored the shielding effect providing by the Lacy V, Murrow Bridge to storms from the south.

In 2006, Governor Christine Gregoire reaffirmed the State's previous commitment to dedicate the center roadway to light rail or light rail convertible bus rapid transit. During this year, the Sound Transit Board also identified light rail as the preferred mode for high capacity transit across the I-90 Bridge.

During summer and fall 2007, Sound Transit prepared preliminary concept studies for:

- Rail Expansion Joints Across The Transition Spans Joints
- LRT-Induced Vibrations
- Overhead Contact System (OCS)
- Stray Current Issues (Structures and Utilities)
- Instrumentation of Transition Spans Joints For Current In-Service Motions

Sound Transit intends to expand structural analysis of light rail and mitigation to the Homer M. Hadley Bridge during the design phase of East Link, following the funding of the project.

Revision 0 of this report presents the issues and many of the supporting references that were evaluated as part of the resolution of the issues. This Revision 1 to this report addresses the resolution to those issues and the Independent Review Team's preliminary findings to the Joint Transportation Committee.

2. Purpose and Scope of Independent Review

The purpose of the independent review is to evaluate the original bridge analysis, subsequent studies, tests, and preliminary concept studies to confirm the feasibility to install and operate LRT on the Homer M. Hadley Floating Bridge. While there are similar developments of light rail across suspension bridges, there is no precedent in the world for implementing light rail across a floating bridge.

The following questions will be addressed as part of the independent review:

1. Review Sound Transit conceptual proposals for stray current mitigation, recommend areas of further investigation, and design milestones through preliminary engineering and final design. Specifically, review of designs for isolating stray current that avoids corrosion of the steel reinforcing and other metal elements of the existing floating bridge and transition spans.
2. Review Sound Transit standard directives drawings for the light rail track and power system. Review and recommend design approaches for attaching the LRT track system (including OCS poles, plinths and track fasteners, and safety rails) to the pontoon, elevated roadway, and transition span decks that maintains the reinforcing steel, post-tensioning cables, other metallic embeds; and limits existing concrete installation damage to an acceptable levels.
3. Review the previous load test data, perform preliminary analysis as required to evaluate structural feasibility, and recommend any additional analysis needed to determine the operational “storm” limitation on the floating bridge in combination with LRT dead and live loads. Assess weight mitigation measures for sufficiency.
4. Assess impact of weight mitigation measures on bridge life, effects of LRT track system on existing maintenance and operations policies, recommend new policies, maintenance criteria and potential work force and cost increases needed to accommodate LRT beyond existing bridge maintenance practices and budget, and recommend any additional analysis.
5. Identify the effects (including eccentricity) of the LRT dead/live loads and rails on the transition spans expansion joints, bridge decks, and other bridge elements and make recommendations for design criteria.
6. Review the proposed rail expansion joint design and provide any additional comment or suggestions to accommodate anticipated joint movements and any associated modifications to the bridge.

Although not part of this independent review, the stakeholders (Joint Transportation Committee, Washington State DOT and Sound Transit) should assess the cost associated with “risk” of earlier loss and reconstruction of the Homer M. Hadley Floating Bridge and approaches than expected remaining life. There are several elements, such as stray current and corrosion, associated with placing LRT on the Homer M. Hadley Floating Bridge that require careful attention during design to avoid reducing the remaining life of the bridge. To adequately assess the risk of the potential loss of bridge and/or reduced remaining life, all stakeholders need to

understand the costs associated with loss of this facility. The risk can be defined in terms of cost as follows:

- Time required to redesign bridge and approaches and associated cost
- Time required to reconstruct a new floating bridge and approaches and associated cost
- The economic impact costs associated with the total time identified in items 1 & 2
- The total cost impacts associated with items 1, 2, & 3.

Having this risk information should put the importance of each issue in proper perspective.

This is considered an important issue when considering the cost of design measures to protect the useful life of the floating bridge, however, from an engineering standpoint, will not affect the feasibility of placing LRT on the bridge.

3. Definition and Classification of Issues

This report identifies, tracks, and provides resolution to the issues that have an effect on the feasibility of placement of the LRT on the Homer M. Hadley Floating Bridge. During the Independent Review Team activities the action plan and list of issues was prepared. Independent Review Team assignments were made (Table 1) and Independent Review Team members have defined the issues. Washington State DOT and Sound Transit provided responses to these issues and resolution is documented in this report.

Table 1: Issue Resolution List by Reviewer

Responsible Independent Review Team Member	Issue Number
Tom Ballard	Issue C
	Issue D
	Issue I
	Issue K
	Issue M
	Issue T
Tom Bringloe	Issue B
	Issue J
	Issue V
	Issue W
Steve Nikolakakos	Issue E
	Issue F
	Issue Q
	Issue U
Chuck Ruth	Issue A
	Issue G
	Issue L
	Issue N
	Issue R
	Issue S
Ali Akbar Sohanghpurwala	Issue H
	Issue O
	Issue P

The classification of each issue is based on the importance of that issue with respect to finding a feasible design solution in order to construct and operate the light rail on the Homer M. Hadley Floating Bridge. The East Link project is currently in the environmental review and conceptual design phase with preliminary design anticipated in 2009 and final design anticipated starting in 2010. Revenue service is projected for 2020 in the current ST2 plans under consideration by

the Sound Transit Board. The definitions in Table 2 have been adopted as part of this independent review assessment

Table 2: Definition of Importance of Each Issue to the Feasibility Study

Importance of Issue	Definition
High	Issue to be resolved before the Independent Review Team can provide an assessment of the feasibility of the East Link project using the Homer M. Hadley floating bridge to facilitate the crossing of Lake Washington. These issues, if not addressed, could prevent the Independent Review Team from reaching a conclusion regarding the feasibility of the design. If feasibility assessment at this stage cannot be made, an action plan should be developed by Sound Transit and/or Washington State DOT to address the issue during concept studies and before preliminary design. This action plan will then be assessed by the Independent Review Team and a determination will be made as to whether the plan meets the goal of demonstrating that a feasible design can be achieved.
Medium	Issue should be resolved before preliminary design is complete and final design can proceed, but will most likely not affect the engineering feasibility of placing the LRT on the Homer M. Hadley floating bridge. This could be an important issue that the Independent Review Team believes can be resolved, but may impact the design considerably. If feasibility assessment at this stage cannot be made, an action plan should be developed by Sound Transit and/or Washington State DOT to address the issue during preliminary design.
Low	Issue is important, but will have no impact on the Independent Review Team determining whether the concepts developed for the design are feasible. This issue may be resolved during the final design**,** but before construction begins. An example of this is the modification of the storm water catchment system.

Issue A	**Track Bridge/Expansion Joint Design and Performance Criteria**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Chuck Ruth	High	Sound Transit

General Description and Background of Issue

The feasibility of connecting the East Link light rail line to the Central Link requires that the track bridge, at each end of the transition spans, be functional at all times during operation.

The Independent Review Team acquired the design/performance criteria used by Washington State DOT for the new expansion joints that they are placing in the Homer M. Hadley Floating Bridge (Issue K). These criteria should be a good basis for outlining the performance specification for the track bridge at the expansion joints. The need for early prototype testing is important because the track bridge is unique. At the time the existing Homer M. Hadley Floating Bridge expansion joints were installed, there was little information about bridge expansion joints of this size. Washington State DOT solicited designs from expansion joint manufacturers and received several proposals. Only one of proposals met the joint expansion/rotation criteria and was listed in the Homer M. Hadley Floating Bridge contract as a "single source". The existing joint is being replaced with a newer and improved version of the original expansion joint.

The Independent Review Team is not aware of any current manufactured track bridge concept that could be adopted for the use on the floating bridge. Sound Transit has developed and provided the Independent Review Team with conceptual details for the proposed track bridge. Since the successful installation and operation of the track bridge is a critical element for East Link and a unique design, the track bridge concept needs to be developed and tested before design begins. The track bridge attachments and effects on the supporting structure require testing as well. Preliminary analysis by the Independent Review Team indicates that some elements of the proposed track bridge and attachments may be overstressed under load combinations that include ultimate environmental load conditions beyond those which will be encountered during normal operation. These ultimate environmental load provisions were based on original expansion joint performance criteria and suggest about 7-feet relative vertical movement and 3-feet relative horizontal movement between fixed piers and floating pontoons happening simultaneously. This unique track bridge concept is very sensitive to internal element properties and boundary properties.

Required Information for Independent Review Team's Review

- Design and performance criteria for new expansion joint from Washington State DOT.
- Prototype development and test plan for track bridge.
- Method for production track bridge testing.
- Proposed approach for incorporation of track bridge into final contract (agency-

furnished contract element or contractor-fabricated element).

Data Sources and Documents Provided by Responsible Agency

1. INCA Engineers, Inc., "Eastside HCT Corridor, I-90 floating Bridge (Homer Hadley), Expansion Joint Final Conceptual Report, January 2008.
2. May 30th, 2008 letter from Sound Transit in response to the Independent Review Team's April 24, 2008 letter.

Resolution of Issue

Prototype testing and vetting of the track bridge concept design needs to be performed as soon as possible. This type of track bridge has never been utilized before and there is no historical data available for Independent Review Team to judge the feasibility of this concept. Therefore, the Independent Review Team recommends the following action plan for track bridge:

- Perform preliminary and final design of the track bridge system based on Washington State DOT-accepted design criteria for the following two load conditions: (1) LRT max load in combination with "normal operating conditions" (to be established based on nominal bridge storm movement and maximum lake level drop or rise, with appropriate load factors), and (2) extreme (maximum operational level storm movement) in combination with max LRT load (up to yield material stress allowed with no load factors). Preliminary and final design of the track bridge system should be completed prior to prototype testing.
- Based on member sizes, connections, bridge rail elements, and fasteners determined from final design, fabricate a "prototype" track bridge and test in accordance with Washington State DOT fatigue testing requirements for major bridge expansion joints. Prototype testing should include provisions for testing maintenance/removal/replacement of a track bridge. Prototype fabrication and testing should be completed prior to the start of final design of the LRT installation.
- Modify track bridge design based on results of prototype testing and perform additional testing until it is determined that the final prototype will function with tolerable maintenance for the anticipated remaining life of the bridge or until scheduled replacement milestones. This stage should be completed at least two years before the anticipated final LTR installation contract on the Homer Hadley Floating Bridge, and before any construction begins on the East/West LRT Link.
- Consider fabricating track bridges prior to final contract for placing LRT on Homer Hadley Floating Bridge. Fabrication would include development of a "track bridge maintenance manual" and at least one extra replacement track bridge.
- Consider installing track bridges in final LRT contract as "agency-furnished materials"

Issue B	**Operational Restrictions for Combination of Train Loading and One-year Storm Loading from North**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Tom Bringloe	Medium	Washington State DOT and Sound Transit

General Description and Background of Issue

Earlier studies by KPFF concluded combined live load from two four-car crush-load trains plus three lanes of HS25 highway loading plus a one-year recurrence storm from the south would load the bridge to 97% of its operational capacity in torsion. The storm demand will be verified (Issue J). The train live load demand will be reviewed, but has been validated by full scale experiments. SC Solutions will review the assumed values of capacity (Issue I).

Required Information for Independent Review Team's Review

All required information is in hand to address this issue.

Data Sources and Documents Provided by Responsible Agency

Resolution of Issue

Based on the Independent Review Team preliminary investigation, this issue does not represent a severe operational limitation on LRT. Investigation of this issue is still in process and is expected to be completed by the end of June, 2008.

Issue C	**Seismic Vulnerability and Seismic Retrofit of Approach Spans and Transition Span**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Tom Ballard	Medium	Washington State DOT and Sound Transit

General Description and Background of Issue

The Homer M. Hadley Floating Bridge approaches and transition span were designed based on ATC-6 detailing requirements and a 475-yr return period earthquake.

The Sound Transit Design Criteria Manual for the North Link and Airport Link states that structures owned and operated by local agencies (Washington State DOT, cities and counties) shall be designed by the codes adopted by the local agency and jurisdiction. Beginning in 2008, Washington State DOT adopted a new seismic retrofit policy for bridges using a 1000-year return period earthquake in combination with a of the no-collapse damage limit.

Since the bridge is the only link between the Central Link and East Link lines, the level of seismic risk and performance goals for the structure should be evaluated in a consistent manner with the rest of the East Link project. The Homer M. Hadley bridge remaining life should first be determined (Issue T).

This issue is not considered to be critical to the feasibility of placing the LRT on the bridge; however, it does represent a potentially a design and construction impact to the project and should be addressed before final design can proceed.

Required Information for Independent Review Team's Review

Two aspects of the seismic vulnerability and retrofit feasibility should be addressed:

- The vulnerability of the approach spans to the acceleration ground motions. This should be assessed with a response spectrum demand analysis and push-over capacity analysis. It should be noted that the Sound Transit design criteria for new aerial structures requires that the inertia effects of a LRV on a single track, without impact, be considered along with the design earthquake loads. These criteria results from the fact that Sound Transit has aerial structures that are several miles long which increases the probability of having the LRV on an aerial structure during a seismic event. Strategies that address this vulnerability should be presented and their feasibility should be discussed.
- The vulnerability of the transition spans, pivot pins and bearings to the acceleration ground motions and the maximum horizontal and vertical ground displacements. For this analysis, response modification factors should not be greater than one. Strategies that address this vulnerability should be presented and their feasibility should be discussed.

Data Sources and Documents Provided by Responsible Agency
1. INCA Engineers, Inc., "Eastside HCT Corridor, I-90 floating Bridge, Seismic Vulnerability Study, Final Conceptual Report, January 2008. 2. May 30th, 2008 letter from Sound Transit in response to the Independent Review Team's April 24, 2008 letter. 3. INCA Engineers, Inc., Sound Transit East Link Phase 2 Project – IRT ISSUE C – Seismic Vulnerability and Seismic Retrofit of Approach Spans and Transition Span, June 13, 2008
Resolution of Issue
It appears that the design of the approach structures met the seismic requirements at the time of construction. Considering the importance of the structure to transit and general purpose traffic, current AASHTO seismic retrofit standards should be assessed, which could potentially lead to retrofit costs and schedule impacts. The Independent Review Team recommends that Washington State DOT and Sound Transit perform a full seismic vulnerability study before preliminary design. Sound Transit has agreed that seismic vulnerability studies will be undertaken as an early-start Preliminary Engineering activity. Retrofit strategies should then be developed during preliminary design to address these vulnerabilities.

Issue D West Approach Tunnel Design Criteria Consistency		
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Tom Ballard	Medium	Sound Transit

General Description and Background of Issue

Although the West Approach Tunnel is not the responsibility and therefore not the focus of the Independent Review Team, the tunnel at the western approach to the Homer M. Hadley Floating Bridge is a critical structural element in the East Link Project. The Sound Transit Design Criteria Manual for the North Link and Airport Link states that structures owned and operated by local agencies (Washington State DOT, cities and counties) shall be designed by the codes adopted by the local agency and jurisdiction. However, Washington State DOT does not currently have seismic retrofit policies for tunnel structures.

This tunnel is also an existing Washington State DOT structure and is therefore similar to the situation with the approach and transition spans. The design criteria for the tunnel should therefore be aligned with the design criteria for the approach and transition spans to the floating bridge. A consistent level of risk should be specified for all structures making up this link.

This issue does not affect the feasibility of placing the LRT on the bridge; however, it is important for developing consistent design criteria for the East Link project and therefore should be resolved before final design begins.

Required Information for Independent Review Team's Review

Verification from Sound Transit and Washington State DOT that this issue will be addressed as part of the design process.

Data Sources and Documents Provided by Responsible Agency

1. Parsons, "East Link Project, Ventilation Analysis of Existing I-90 Tunnels, Mount Baker and First Hill Tunnels, Final Draft Report, August 2007.
2. May 30th, 2008 letter from Sound Transit in response to the Independent Review Team's April 24, 2008 letter.

Resolution of Issue

Although this issue is not a feasibility issue, given that the vulnerability of this structure will have an impact on the risk of down time for East Link as well as the general purpose traffic in the upper tunnel level, the Independent Review Team recommends that Washington State DOT and Sound Transit perform a full seismic vulnerability study of all existing structures that

will be used for LRT before preliminary design. Sound Transit has agreed that seismic vulnerability studies will be undertaken as an early-start Preliminary Engineering activity. Retrofit strategies should then be developed during preliminary design to address these vulnerabilities.

Issue E	**Need for Lightning Arrestors on Floating Bridge and Approaches**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Steve Nikolakakos	Medium	Sound Transit

General Description and Background of Issue

Lightning can cause safety hazards and damage to equipment, structures, electrical systems, etc. Lightning protection systems are designed and installed to provide protection against such threats. The systems normally consist of lightning arrestor/rods, down conductors and ground electrodes. The Sound Transit "North Link and Airport Link Design Criteria Manual provide general guidelines for Lightning Protection and Grounding. The Independent Review Team requests additional details to be able to evaluate the adequacy of the system for the approach structures and the Homer M. Hadley Floating Bridge.

It is assumed that the lightning protection system will be designed during the final design of the project. It is important that the lightning protection system be designed and installed to minimize structural damage to the pontoon walls, approach structures, pier foundations, and provide protection to the traction power system and personnel/public. It should be noted that although lightning storms do not occur very often in the Pacific Northwest, compared to other areas of the United States, they do represent a risk.

Required Information for Independent Review Team's Review

Detailed lightning/grounding protection criteria. The issue on design criteria is also raised in Issue K. The final design criteria should include:

- Structures/equipment to be provided with lightning arrestors/rods.
- Down conductor (description).
- Ground electrode (description and location).

Data Sources and Documents Provided by Responsible Agency

General comments on the lightning protection system for OCS poles were provided to Sue Comis (Sound Transit) from Roger Koester (Parsons) in an e-mail dated April 29, 2008.

1. Sound Transit "North Link and Airport Link Design Criteria Manual" dated November 2005.
2. Lightning Protection Code, NFPA No. 780
3. Master Labeled Lightning Protection System, UL 96A.
4. May 30th, 2008 letter from Sound Transit in response to the Independent Review Team's April 24, 2008 letter.

Resolution of Issue
A lightning protection system will be designed for the floating bridge. Based on the review of the proposed lightening protection system, the Independent Review Team recommends the following: • The conductors and ground electrodes are not to be connected to the stray current conductors and ground electrodes (this will minimize stray current from discharging from the OCS support plates on the pontoon walls). • The OCS support plates and bolts are to be electrically isolated from the concrete walls of the pontoons (this will minimize possible damage to the wall from lightning discharges).

Issue F	**Sound Transit Adoption of North Link/Airport Link Stray Current Mitigation Design Criteria for Homer M. Hadley Floating Bridge Installation**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Steve Nikolakakos	High	Sound Transit

General Description and Background of Issue

The Sound Transit "North Link and Airport Link Design Criteria Manual provide stray current control guidelines under Section 17.3 of the manual. The guidelines, even though do not specifically refer to the Homer M. Hadley floating bridge, they provide criteria for stray current corrosion control for different transit fixed facilities. For facilities with direct fixation rails the criteria for stray current corrosion control include:

- Electrical continuity of the top layer of the reinforcing steel or a wire mesh current collector mat.
- Ground electrode system.
- Test facilities

Such stray current corrosion control systems are designed to collect the stray current and discharged it to earth/water through the ground electrodes. These systems will minimize/prevent stray current corrosion of support reinforced concrete structures.

Sound Transit's primary approach to stray current corrosion control is to minimize the stray current by lowering the return circuit resistance, increasing the track to earth resistance, and frequently monitoring the stray current of the system. The Independent Review Team reviewed the preliminary stray current information provided by Sound Transit and requested additional information.

Required Information for Independent Review Team's Review

The information below was required, by Independent Review Team, to evaluate the overall stray current effects on the structures and determine, based on the calculation/assumptions made, if the proposed design (including the use of stray current collection mats, ground electrodes and monitoring systems) assumes an increased level of risk.

- Stray current calculations.
- Track-to-earth resistance under different weather conditions.
- Stray current variations due to changes in track-to-earth resistance.
- The monitoring of stray current and estimated time to identify and repair/replace failed fasteners.
- Preliminary design details of stray current corrosion control system components (to

collect and discharge the stray current).

- The process for identifying and repairing failed components of the system that would increase the stray current.

Data Sources and Documents Provided by Responsible Agency

1. Sound Transit "North Link and Airport Link Design Criteria Manual" dated November 2005. "
2. Stray Current Analysis Report - Draft" Dated August 31, 2007. Prepared by Sound Transit East Link Project Team
3. Data Sheet for Stray Current Calculations: Sound Transit I-90 Bridge Feasibility dated May 20, 2008.
4. May 30th, 2008 letter from Sound Transit in response to the Independent Review Team's April 24, 2008 letter.
5. Sound Transit East Link Project – Issue Resolution Report – Support Data; June 13, 2008

Resolution of Issue

Sound Transit has agreed to utilize more stringent design criteria for stray current analysis. They have also agreed to provide collection mats with ground electrodes to dissipate stray current and provide stray current monitoring system. These measures (if properly implemented, monitored and maintained) should protect the useful life of the floating bridge.

The Independent Review Team recommends, based on the review of various stray current documents, that the following be included in the final design calculations:

- The resistance of the rails applied in calculations should be greater than the actual resistance of the final configuration for the negative return .
- Field testing on other transit systems shows that a wide range of resistance values for in-service rail fasteners can occur depending on the mode of deterioration. The track-to-earth resistance calculations, for the life of the project, should reflect degradation of the insulating characteristics of the rail fasteners with time. The results of these calculations should be included in the overall stray current analysis including metal loss calculations.
- The failure mode calculations should consider worst case and intermediate case scenarios. The metal loss calculations should also consider potential failures of the stray current collector mat. The worst case scenarios should include failures of the fastener insulation and collector mat. The results of such an evaluation should define the risks and the requirements for timely repairs. All assumptions made and formulas used in the calculations should be supported by references.

The Independent Review Team also makes the following design recommendation:

- The top steel reinforcement layer of the deck and possibly the transverse post tension cables in the deck under the rails may not be electrically continuous. These steel components could be affected by the stray current and therefore the stray current mitigation system that Sound Transit proposes to design and install must be capable to collect most of the stray current. In addition the monitoring system must initiate an alarm when increased levels of stray current are detected or a stray current collector mat has failed. The cause of such alarms must be investigated and corrected in a short period of time.
- The cathodic protection system, if upgraded, could provide stray current protection to the underwater steel reinforcing of the pontoons and anchor cables; it would not however, provide any stray current protection to the top steel reinforcement layer of the deck and the post tension cables in the deck that are assumed not to be electrically continuous. It is therefore important that any failures in fastener insulation and/or collector mats be detected and repaired in a short period of time.

Issue G	**Impact of Stray Current Dispersion in Lake Washington on Environment and Fish**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Chuck Ruth	Low	Sound Transit

General Description and Background of Issue

There is currently some electrical current dispersion in Lake Washington originating from the existing cathodic protection system. While there is no known impact on fish from this system, the Independent Review Team recommends assessing how stray current levels from the light rail system compare to the existing cathodic protection system and determining whether impacts to fish are possible.

The Independent Review Team does not consider this as a critical issue relative to the feasibility of placing the LRT on the bridge. However, it does need to be resolved as part of the environmental approval process and therefore should be addressed before the final design begins.

Required Information for Independent Review Team's Review

An assessment by Sound Transit/ Washington State DOT environmental specialists.

Data Sources and Documents Provided by Responsible Agency

1. Herrera Environmental Consultants, Inc., Interstate 90/Homer Hadley Bridge, Light Rail Transit (LRT) Stray Current – Assessment of Potential Effects on Fish, June 13, 2008.

Resolution of Issue

Information provided by Sound Transit indicates that stray current will not have an impact on marine life.

Issue H	**Stray Current and Cathodic Protection System Interference and Compatibility**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Ali Akbar Sohanghpurwala	High	Washington State DOT and Sound Transit

General Description and Background of Issue

Cathodic protection systems are presently installed on the Homer M. Hadley and the Lacey V. Murrow Bridges. The original goal of the system was to protect the anchor cables of both bridges, minimize corrosion and reduce the frequency of replacement. The cables of both bridges cross under each other and each system can be expected to interfere with the other systems.

The present cathodic protection systems are deficient; many anodes are missing and they are not fully operational. Considering the recent findings by Sound Transit that much of the reinforcement and many of the anchor cables are continuous, it can be expected that some of the cathodic protection current is distributed to the reinforcement in the concrete pontoons. The original system was not designed to provide such protection and therefore, cannot be expected to provide the level of protection originally intended for the anchor cables. Even if Light Rail is not installed on the bridge, the present condition of the system may inadvertently cause corrosion of the anchor cables or reinforcement.

If and when stray currents are generated by light rail, they can impact the integrity of the anchor cables and the exterior reinforced concrete elements of the pontoons exposed under water. The cathodic protection systems will then be essential in mitigating corrosion on the cables and the reinforcement in the pontoons. The present system is not capable of performing this function and needs to be upgraded.

The stray current from the light rail can also impact the integrity of the anchor cables of the Lacey V. Murrow Bridge as they pass right under the Homer M. Hadley Bridge and therefore, it is necessary the cathodic protection systems on both bridges, the Homer M. Hadley and the Lacey V. Murrow be upgraded and effective monitoring and maintenance procedures be put in place.

For the cathodic protection systems to be effective, sufficient resources will have to be devoted to regular monitoring and maintenance. An effective plan for monitoring and maintenance will be needed to ensure that stray current impact is kept to a level that will achieve the desired 100-year bridge life expectancy.

Required Information for Independent Review Team's Review

- Information already exists to address this issue, however, a commitment from Washington State DOT to upgrade, monitor and maintain the cathodic protection

systems is required.

- The impact to Washington State DOT of running this system needs to be factored into near term and long term costs associated with this issue.

Data Sources and Documents Provided by Responsible Agency

1. Cathodic Protection Systems Third Lake Washington Bridge, Norton Corrosion Engineers, July 1993.
2. Cathodic Protection Assessment, I-90 Bridges, R. W. Beck & Associates, October 1993
3. In-Depth Cathodic Protection System Inspection and Recommendations, May 2004
4. In-Depth Cathodic Protection System Inspection and Recommendations, May 2006

Resolution of Issue

The Independent Review Team believes that a cathodic protection system provides another layer of defense against environmental and stray currents. Therefore the Independent Review Team recommends the following:

- The cathodic protection systems on the Homer Hadley and the Lacey V. Murrow bridges should be upgraded,.
- Resources and plans must be in place to operate, monitor and adequately maintain the cathodic protection systems.

Issue I **Analysis to Confirm Torsional Capacity of the Existing Bridge**		
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Tom Ballard	High	Washington State DOT and Sound Transit

General Description and Background of Issue

The capacity of the floating bridge has been previously computed using classical analysis methods, which could be in error as compared to more rigorous methods, such as finite element analysis methods. Specifically, torsional stiffness and stress distribution is very difficult to determine using simple hand calculations. In addition, the web shear distribution can be in error. The Independent Review Team will assess the existing calculations and perform or recommend supplemental analysis to provide a more exact determination of the need for the LRT operational restrictions during storms (Issue B and Issue J)

Required Information for Independent Review Team's Review

Study that addresses the stresses in the bridge overhang, side wall and side wall/overhang joint that demonstrate that the calculations performed to date are accurate and do not represent an overstress condition.

Data Sources and Documents Provided by Responsible Agency

Resolution of Issue

Calculations provided by Washington State DOT and Sound Transit have addressed this issue. The Independent Review Team's assessment is ongoing and a satisfactorily resolution is expected soon.

Issue J	**Analysis "North Wind" Storm Effects on Homer M. Hadley Floating Bridge**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Tom Bringloe	Medium	Washington State DOT

General Description and Background of Issue

Earlier studies by KPFF concluded combined live load from two crush-loaded passing trains plus three lanes of HS25 highway loading plus a one-year recurrence storm would load the bridge to 97% of its capacity in torsion. The one-year wave loading was based on a south storm and ignored the sheltering provided by the LVM Bridge. This approach was taken because, at the time the original Homer M. Hadley wave load analysis was performed, the old LVM Bridge was a very old structure that was expected to be removed and replaced, leaving the Homer M. Hadley Bridge unprotected for some time period. And that situation in fact happened for two years.

The question is whether a north storm would produce larger seas than the storms from the south because of the longer fetch and lack of protection. This question should be answered to resolve Issue B.

Required Information for Independent Review Team's Review

All required information is in hand to address this issue.

Data Sources and Documents Provided by Responsible Agency

1. The Glosten Associates, Inc., Wave Loading Analysis of Lake Washington Bridges Volume 1, June 1983.
2. Unpublished work in progress on Lake Washington climatology re SR-520 bridge design, in the files of The Glosten Associates.

Resolution of Issue

The Independent Review Team has performed preliminary analysis for the 1-year north storm event and estimates that a storm from the north would produce lower seas than the storm from the south used in previous assessment:

- The sea condition characterized in the 1983 work as 1-year southerly storm was described as:

  Significant wave height = 2.2 feet
  Peak period = 2.7 seconds

- Based on recent (unpublished) work done for the SR-520 site, we computed a hindcast

1-year recurrence northerly sea condition of

Significant wave height = 1.2 feet
Peak period = 2.3 seconds

- Both height and period have a strong effect on bridge responses. We estimate that the torsional response to waves will be reduced to about 1600 kip-feet, compared to the 10,000 kip feet used in the earlier KPFF study.

Issue K	**Criteria Established for Independent Review Team to Evaluate Numerous Issues**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Tom Ballard	High	Washington State DOT and Sound Transit

General Description and Background of Issue

Design criteria for the East Link Project will be established by updating the North Link and Airport Link design criteria to address the unique requirements established in conceptual engineering. To evaluate issues relative to use of existing facilities, such as, the Homer M. Hadley bridge, approach spans, transition spans and west approach tunnel, the Independent Review Team needs confirmation of design criteria for several design details, such as:

1. Stray current collector system (Issue F)
2. Lightening arrestors for entire bridge (Issue E)
3. Seismic return period and performance criteria (Issue C, Issue D,)
4. Passenger safety and comfort criteria requirements (Issue M)
5. Expansion joint and track bridge performance criteria (Issue A)

If Sound Transit is not going to apply the North Link and Airport Link design criteria to the East Link Homer M. Hadley floating bridge, approach and transition spans and western approach tunnel, then alternate criteria needs to be developed, reviewed and formally adopted.

This issue is considered critical in order for the Independent Review Team to make the assessment as to the feasibility of placing the LRT on the bridge.

Required Information for Independent Review Team's Review

Criteria for stray current collection, lightening protection, seismic return period and performance criteria for approach spans, passenger safety and comfort criteria and expansion joint and track bridge performance criteria.

Data Sources and Documents Provided by Responsible Agency

1. May 30th, 2008 letter from Sound Transit in response to the Independent Review Team's April 24, 2008 letter.

Resolution of Issue

The Independent Review Team recommends that Sound Transit prepare a design criteria document consistent with the criteria applied to the North Link and Airport Link and addresses the unique features of the East Link. The Independent Review Team recommends that Sound

Transit should provide policy level documentation whenever they chose to adopt design criteria that are less stringent than their own criteria when using existing facilities owned by other agencies.

Issue L	**Operation and Maintenance Coordination Agreement between Sound Transit and Washington State DOT**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Chuck Ruth	Medium	Washington State DOT and Sound Transit

General Description and Background of Issue

If appropriate staff and maintenance funds are not consistently dedicated to the operation and maintenance of the LRT and Homer M. Hadley Floating Bridge and approaches, it is unlikely that the adopted 100 year bridge life can be achieved.

At the "executive" meeting the responsible Independent Review Team member attended on April 29, 2008, between Washington State DOT and Sound Transit, this issue was discussed. Sound Transit and Washington State DOT indicated that initial maintenance coordination discussions have been held. For instance, the conceptual plans include a protected maintenance lane for access to the pontoon hatches without the current requirement for traffic control. Resolving the stray current issues will likely result in some kind of "mitigation concept" that will be installed on the Homer M. Hadley Floating Bridge and approaches as part of the LRT construction. Whatever the mitigation systems is, it will require constant monitoring and dedicated maintenance staff and maintenance funds to achieve the desired bridge life (100 years total). This is only one element of many associated with maintenance of the bridge and the LRT facilities the bridge will have to support. With two agencies having maintenance functions on the same bridge at the same time, coordination, communication and commitment are essential.

A plan for developing a coordinated operations and maintenance agreement to ensure the desirable life of the bridge should be developed, approved and implemented as part of the design/construction process.

Required Information for Independent Review Team's Review

Letter from Sound Transit and Washington State DOT establishing a plan to develop a coordinated operations and maintenance agreement for the bridge.

If this issue cannot be resolved in the time frame of our study, the Independent Review Team will outline general recommendations for Washington State DOT and Sound Transit maintenance function coordination (including maintenance function priorities), as part of our findings.

Data Sources and Documents Provided by Responsible Agency

1. May 30th, 2008 letter from Washington State DOT and Sound Transit in response to the Independent Review Team's April 24, 2008 letter.

Resolution of Issue
Washington State DOT and Sound Transit have provided documentation acceptable to the Independent Review Team that outlines development, review, and approval of a Sound Transit/Washington State DOT Operation and Maintenance Agreement for the Homer Hadley Bridge.

Issue M	**Rider Comfort Performance for LRT Track Bridge at Expansion Joints**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Tom Ballard	High	Sound Transit

General Description and Background of Issue

The LRT vehicles will cross the transition spans and two track bridges at each end of the Homer M. Hadley Floating Bridge.

The North Link and Airport Link design criteria, Section 12.7.6 Ride Quality, requires that: "The rms acceleration values shall not exceed the 4-hour, reduced comfort level (vertical) and 2.5 hr, reduced comfort level (horizontal) boundaries derived from Figure 2a (vertical) and Figure 3a (horizontal) of ISO 2631 over the range of 1 Hz to 80 Hz, for all load conditions AW0 to AW3."

The track bridge should be designed to meet these standards. There are two ways to demonstrate that this standard has been met. The design should be first based on an analytical model comprised of a vehicle dynamic based on Reference 1 and a track-structure model, based on the preliminary design for the track bridge. This model should be used to determine the shock and vibration levels that the vehicles are subjected to traveling at the proposed 30 and 40 mph operating speeds under load conditions AW0 and AW3. The final designed track bridge should then be prototyped before production.

The maximum acceptable single amplitude horizontal acceleration is 0.05 g to 0.08 g.

Also, refer to Issue 1 for further discussion of prototype testing.

Since the track bridge is such a unique structure, prior to prototype testing, it is important to get a feel for whether the bridge is going to work from the standpoint of passenger safety and comfort, as a minimum prior to the start of any construction on the proposed East/West LRT link.

Required Information for Independent Review Team's Review

- Study reports on track bridge analysis for passenger ride quality and comfort.
- Test plan for conducting tests of the track bridge.

Data Sources and Documents Provided by Responsible Agency

1. ER2013, Car Body Roll Control Method, Kinkisharyo International, L.L.C., Rev 0, March 31, 2005
2. INCA Engineers, Inc., "Eastside HCT Corridor, I-90 floating Bridge (Homer Hadley), Expansion Joint Final Conceptual Report, January 2008.

3. CH2M Hill, INCA Engineers and Parsons Transportation Group Working Draft Technical Memorandum "Sound Transit East Link Project – Rider Comfort Performance for LRT Track Bridge at Expansion Joints", May 21, 2008
4. May 30th, 2008 letter from Sound Transit in response to the Independent Review Team's April 24, 2008 letter.

Resolution of Issue

The Independent Review Team has performed independent analysis for this issue and we have concluded that the LRT vehicle will most likely be able to traverse the track bridge during normal conditions without undue discomfort to the riders but with reduced speed. This conclusion should be revisited following final design and prototype testing of the track bridge elements, including 3-link beam, track fasteners, and centering mechanism. Sound Transit has anticipated the need to traverse the track bridges at reduced speeds, already taking this into account in its systems operations planning and evaluation studies to date.

Issue N	**Attachment of OCS Supports to Edge of Homer M. Hadley Floating Bridge Deck Cantilevers**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Chuck Ruth	High	Washington State DOT and Sound Transit

General Description and Background of Issue

The proposed Overhead Contact System (OCS) pole support attachments rely on retaining a 4 to 8 foot piece of the existing traffic barrier at the edge of the cantilever and new attachments/connections into the existing concrete at the edge of the cantilever at every OCS pole location. The ends of the cantilevers are in good condition in their current configuration. Located at the ends of the cantilever are the transverse deck post tensioning tendon anchorages (and surrounding bursting stress reinforcing) that support the entire cantilever. There is mild reinforcing steel as well for load distribution. Damage to any of these elements is not acceptable structurally. Therefore, the OCS support pole attachment and support base load distribution needs to be carefully studied, analyzed, and detailed to prevent any potential damage to the end of the cantilever. The goal should be to design an OCS support pole attachment that minimizes barrier removal and does not rely on any direct connection into the end of the cantilever.

Constructing the OCS pole attachments could damage the deck in a manner that may not be repairable. Therefore an acceptable OCS pole attachment concept should be developed prior to the start of preliminary design. The OCS poles and attachments should not impact the structural integrity of the bridge and should not cause cracking on the deck.

Required Information for Independent Review Team's Review

Calculations supporting the design for the attachment of the OCS poles to the deck overhang.

Data Sources and Documents Provided by Responsible Agency

1. Parsons, "East Link Project, Overhead Catenary System Concept Study, Final Draft Report, December 2007
2. CH2M Hill and INCA Engineers Working Draft Technical Memorandum "Sound Transit East Link Project – OCS Pole/Deck Attachment Analysis", May 16, 2008
3. INCA Engineers, Inc., Sound Transit East Link Phase 2 Project – IRT ISSUE N – Attachment of OCS Supports to Edge of Homer M. Hadley Floating Bridge Deck Cantilevers, June 13, 2008.

Resolution of Issue

Sound Transit has provided the Independent Review Team with acceptable conceptual OCS and fall protection rail post attachment details that minimize penetrations into the existing pontoon concrete deck South cantilever. Further analysis will be performed by Sound Transit to prove concept during preliminary design.

Issue O	**Methods to be Utilized for Locating Rebar and Post Tensioning in Bridge Deck**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Ali Akbar Sohanghpurwala	High	Washington State DOT and Sound Transit

General Description and Background of Issue

Plinths will need to be installed for the attachment of the rail tracks and they will be fastened onto the deck slab. However, the higher density of conventional reinforcement and the presence of transverse post tensioning in the floating bridge pose a construction challenge.

Sound Transit has proposed to install plinths at 2' 6" on center, longitudinally. Two plinths will be required per track, i.e. a total of 4 plinths will be required at each longitudinal marker. They propose to fasten each plinth to the deck with two epoxy coated anchors. Each anchor will sit in a hole drilled partially into the bridge deck approximately 5/8" in diameter and 4 1/8" deep. Therefore, at each longitudinal marker, a total of eight holes will have to be drilled. Washington State DOT would like to see no damage to the post tensioning and would like to minimize damage to the conventional reinforcements as any damage would impact the overall integrity of the deck slab and reduce its service life. Also, the number of penetrations in the deck slab could reduce its overall structural integrity. Therefore, the plinth installation should be conducted with the highest level of efficiency in locating the reinforcement and making only necessary penetrations that are absolutely necessary. To do so, a high accuracy mechanism to locate reinforcement will be required.

Although several techniques such as ground penetrating radar survey and X-ray of the concrete slab can be used for this purpose, Washington State DOT has had limited success with them on this structure. Sound Transit should evaluate the applicability of these technologies to this particular situation and perform some preliminary field studies to demonstrate feasibility of such technology on this structure and determine the absolute minimum number of penetrations (if any) required for acceptable performance of the plinths.

Required Information for Independent Review Team's Review

- Sound Transit should demonstrate a mechanism or protocol for locating reinforcing steel on the deck surface without any more excavations then necessary to install the plinths. The number of plinths and tolerance on the spacing of the plinths needs to be considered.
- Sound Transit need to demonstrate that the method selected can locate the reinforcing and post tensioning within a high level of accuracy necessary to assure that no transverse post-tensioning tendons are damaged and that damage to existing mild reinforcing steel is minimized.

Data Sources and Documents Provided by Responsible Agency
1. Pontoon Bars, which contains slides and drawings identifying reinforcement in the deck slab. 2. CH2M Hill and INCA Engineers Working Draft Technical Memorandum "Sound Transit East Link Project – Plinth Block Analysis", May 20, 2008 3. Mayes Testing Engineers, Sound Transit East Link Non-Destructive Testing Demonstration/Evaluation – Mayes Testing Engineers Project Number S08040, June 10, 2008.
Resolution of Issue
Sound Transit has conducted an evaluation of several technologies to ascertain their effectiveness in locating reinforcing steel in the deck slab and the report has been submitted. The report concludes that Ground Penetrating Radar can be an effective tool to locate reinforcement including post-tensioned bars in the deck slab for placement of the plinths. Sound Transit has indicated that they are researching plinth attachment methods that minimize and/or eliminate penetrations into the deck. The Independent Review Team encourages the development of these alternate plinth attachment methods. Such alternative attachment methods may be more critical for the segmental concrete approach spans due to longitudinal post tensioning congestion at the piers.

Issue P **Determining Strength and Electrical Resistance of Existing Concrete**		
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Ali Akbar Sohanghpurwala	Medium	Washington State DOT
General Description and Background of Issue		
To ascertain the impact of plinth block installation on the deck slab, information on the strength of in place concrete will be required. The strength of concrete is also required to ascertain the time to cracking due to stray current discharge from reinforcement in the pontoon. In addition, the resistivity of concrete is required for determining the impact of stray current on the structure. The information on the resistivity of concrete is helpful in understanding the resistance offered by the pontoon deck slab to the flow of stray current down the pontoon walls to the below the water level where it is likely to cause corrosion.		
Required Information for Independent Review Team's Review		
Washington State DOT to provide any information available which would be used to make a reasonable guess at the in place concrete strength. The resistivity of the deck concrete will have to be obtained by literature review or by in-place testing of the existing concrete.		
Data Sources and Documents Provided by Responsible Agency		
Resolution of Issue		
Sampling and testing is expected to be completed by the end of June. This will confirm some of the design assumptions.		

Issue Q	**Modification of Current Bridge Inspection Procedures if LRT Approved**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Steve Nikolakakos	Low	Washington State DOT and Sound Transit

General Description and Background of Issue

The current Bridge Inspection Procedures would need to be modified, if a Light Rail Transit (LRT) system is approved for the bridge, to allow for more thorough and more frequent inspections in order to monitor for stray current damage, if any, to the bridge structures.

The current inspection program of the Washington State DOT for the bridge structures include:

- Interim Inspection of the bridge roadway decks (approximate inspection frequency – 24 months).
- Interim inspection of the Assembly Joint (approximate inspection frequency – 6 months).
- Routine, fracture critical, and special inspections with a under the bridge inspection truck (approximate inspection frequency – 24 months).
- Walk-thru inspection of the Post-Tensioned Box Girders Spans 1-6 and 10-16 approximate inspection frequency – 72 months).
- Watertight inspection of the pontoons (inspection frequency – 12 months).
- Underwater inspection of the pontoons (inspection frequency – 72 months).
- Inspection of the anchor cables (approximate inspection frequency – 24 months).

In addition Washington State DOT/Sound Transit would need to address the issue of updating the existing cathodic protection system to provide corrosion protection to the pontoon walls and the anchor cable system. A modified cathodic protection system would also minimize the stray current corrosion on the reinforcement steel of the pontoon walls. An annual inspection and test program should be considered for the modified cathodic protection system.

Stray current corrosion on reinforced concrete structures could first be detected visually during periodic inspections. Visual observations of an increased number of concrete cracks, concrete spalling, rust stains, and water leakage in the pontoon cells could be assumed that is the result of stray current corrosion; this assumption however, should be verified by stray current testing. An early detection of stray current problems can minimize the corrosion impact on the integrity of the structure and result in additional corrosion stray current mitigation to prevent similar problems.

Required Information for Independent Review Team's Review

Information on proposed modifications to inspection procedures should be provided to Independent Review Team by Washington State DOT and Sound Transit for review and evaluation. Information provided should include:

- Type of modifications proposed for each inspection, and change, if any, to frequency of inspection.
- Modifications, if any, proposed for the cathodic protection systems, including inspection requirements.

The above information is required to determine if modified inspection procedures would be adequate to detect stray current corrosion in the early stages, mitigate the stray current condition and prevent/minimize corrosion.

Data Sources and Documents Provided by Responsible Agency

1. Bridge Inspection Report dated 1/22/2008; Homer M. Hadley Bridge - (Washington State DOT)
2. Underwater Inspection Report for the Homer Hadley Floating Bridge dated September, 2006 – (Washington State DOT)

Resolution of Issue

The Independent Review Team recommends that the current inspection procedures and frequency be modified to timely detect and mitigate/repair any problems that may have resulted from the operation of the LRT. To properly monitor, maintain and operate the Homer Hadley Bridge with LRT on it will require in-house expertise in the following engineering disciplines.

- Structural engineering with bridge preservation background.
- Electrical engineering with cathodic protection and stray current background.
- Material science with corrosion background.

These skill sets are more suitable for incorporation into Washington State DOT staff as they will be useful in preservation of other structures. This recommendation can be met through identifying existing Washington State DOT staff with the required expertise and/or providing training or certification to existing staff.

Issue R	**Storm water Drainage System Modifications under New LRT Track Bridge at Expansion Joints**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Chuck Ruth	Low	Washington State DOT and Sound Transit

General Description and Background of Issue

Developing workable details to direct storm water into the existing collection system should not present a major problem.

Sound Transit is proposing that the Transition Span expansion joints be removed in the area of the LRT. This will require that the deck surface storm water be collected and directed into the existing collection system. There are a number of ways this could be done and should not present a major problem for design or construction.

Required Information for Independent Review Team's Review

Preliminary design details and calculations for storm water drainage system modifications under track bridge at expansion joints.

Data Sources and Documents Provided by Responsible Agency

1. Parsons, Sound Transit East Link Project – Drainage Details at Expansion Joints, June 12, 2008

Resolution of Issue

Sound Transit has provided the Independent Review Team with acceptable conceptual details of the anticipated expansion joint (under the track bridges and adjacent maintenance access lane) and the conceptual method for collecting storm water and transporting it into the existing storm water drainage system.

Issue S	**Median Barrier Relocation Design, Attachment, Maintenance and Drainage**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Chuck Ruth	High	Washington State DOT and Sound Transit

General Description and Background of Issue

Relocation of the median barrier proposed by the I-90 Two-Way HOV/Transit Project (R-8A) is not desirable from a structural standpoint as new barrier attachments to the existing deck represent potential damage to existing post tensioning and reinforcing steel.

The goal of any median barrier relocation concept should be to maintain the existing pontoon access, storm water drainage, and assure that the structural integrity of the bridge and bridge deck. Consideration should be given to not attaching the relocated barrier to the bridge deck, except adjacent to the maintenance access.

Moving the median barrier may damage the deck and therefore a preliminary approach should be developed and approved prior to the start of final design.

Required Information for Independent Review Team's Review

Proposed details and calculations associated with the new barrier placement, showing attachments, avoidance of post tensioning and rebar, and maintenance access.

Data Sources and Documents Provided by Responsible Agency

1. INCA Engineers, Inc., Sound Transit East Link Phase 2 Project – IRT ISSUE S – Median Barrier Relocation, Design, Attachment, Maintenance and Drainage, June 13, 2008.

Resolution of Issue

Sound Transit provided preliminary design concepts that suggest three alternative approaches. Sound Transit and Washington State DOT will study all three alternatives to determine optimum alternative. The Independent Review Team recommends that every effort be made to avoid relocation of the existing median.

Issue T	**Washington State DOT's and Sound Transit's Goal for Life Expectancy of Bridge**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Tom Ballard	High	Washington State DOT and Sound Transit

General Description and Background of Issue

In order to determine the extent of corrosion protection required, the extent of expected corrosion damage due to stray current and other aspects of the design, such as, level of risk associated with a storm or earthquake return period, the life expectance of the bridge needs to be stated.

Required Information for Independent Review Team's Review

Letter from Washington State DOT and Sound Transit regarding the agreement made on April 29, 2008.

Data Sources and Documents Provided by Responsible Agency

1. Washington State DOT and Sound Transit Letter to IRT Establishing Bridge Life Expectancy, May 13, 2008.

Resolution of Issue

This issue is resolved; however, the Joint Transportation Committee should be aware that by defining the total life of the bridge as 100 years, the remaining life, following the construction of the LRT is 70 years. The useful life of structures in the LRT system will be variable. The Downtown Seattle Transit Tunnel which all LRT lines in the Sound Transit system operate through is approaching 20 years old and Airport Link will be 11 years old by the time East Link opens. East Link will ultimately include an Operations and Maintenance facility on the Eastside and be capable of intra-Eastside operations with a bus 'bridge' to Seattle when it comes time to replace the Homer M. Hadley floating bridge.

Issue U	**Method for Identifying Stray Current Failure and Response/Repair Plan**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Steve Nikolakakos	Medium	Washington State DOT and Sound Transit

General Description and Background of Issue

Stray current control measures for a new light rail system mostly consist of insulated rail fasteners, low resistance negative return circuit, and high resistivity concrete ties/plinths. Under normal operating conditions, where the track-to-earth resistance is within design limits, the stray current effects on structures and utilities are in most cases minimal. Under abnormal operating conditions however, where the track-to-earth resistance is lower than the design limits due to insulation damage/failure of the rail fasteners, a significant increase in stray current can result that may have an adverse affect on the structures and utilities. Methods to monitor increased levels of stray current should be implemented in a system in order to timely identify and repair the failed system component and minimize the stray current effects on the structures/utilities. Additional measures, that can be used, to minimize these effects include design and installation of a stray current collection/mitigation system (discussed in Issue F).

Sound Transit proposes continuous monitoring for stray current. Sound Transit should provide the Independent Review Team a plan for developing procedures to be used in identifying system failures, failed components, and repair/replacement of failed components.

Required Information for Independent Review Team's Review

Information on the proposed stray current monitoring system should be provided to Independent Review Team for review and evaluation. Information provided should include:

- The type of monitoring system, such as stray current measurements, track-to-earth resistance, etc.
- Frequency of monitoring.
- Method for analysis of the monitoring system results.
- Method for identifying failed system components such as rail fastener insulation.
- Proposed maintenance and repair/replacement schedule.

The above information will allow the Independent Review Team to ensure that the monitoring system put in place will provide reliable data that could be analyzed, and used to detect system failures that can be repaired in a timely manner and thus prevent/minimize the damaging effect of the stray current on structures, reinforcing steel and/or utilities.

Data Sources and Documents Provided by Responsible Agency

1. May 30th, 2008 letter from Sound Transit in response to the Independent Review

Team's April 24, 2008 letter.

2. Sound Transit East Link Project – Issue Resolution Report – Support Data; June 13, 2008.

Resolution of Issue

Sound Transit has agreed to the following preliminary details of the monitoring system.

The stray current remote monitoring system, as a minimum, should include:

- Track-to-earth resistance measurements (two times a year).
- Continuous stray current measurements at each ground electrode.
- Continuous voltage measurements of stray current collector mats

The design of the monitoring system, as a minimum, should include:

- Current shunts for measuring the stray current.
- Diodes at ground electrodes.
- Continuity monitoring of the collector mat
- Initiation of alarms if the stray current or the track-to-earth resistance exceeds a pre-set value.
- A monitoring system that is capable to collect and store data at programmed intervals.

The repair/maintenance procedure should include a method of inspection/evaluation if an alarm is initiated from the monitoring system.

Washington State DOT should have approval authority over the selected system and Washington State DOT should have access to expertise to evaluate the selected system.

Issue V	**Effect of LRT Installation on Construction Operations Associated With Anchor Cable Replacement**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Tom Bringloe	Low	Washington State DOT and Sound Transit

General Description and Background of Issue

South anchors cables on the Homer M. Hadley bridge (as well as North cables on the LVM Bridge) extend down through the channel between the two bridges. Large construction or crane barges do not fit between the bridges, so it is necessary to reach over the roadway with a large barge mounted crane, or have a truck crane parked on the shoulder to handle the weights involved. Crane operations will not be permitted close to or reaching over the live overhead catenary wires. Anchor cable maintenance/replacement may have to be limited to night shifts when the wires can be de-energized. It is thought that this is a Washington State DOT maintenance issue, not a feasibility issue.

Required Information for Independent Review Team's Review

No additional information required.

Data Sources and Documents Provided by Responsible Agency

None

Resolution of Issue

The Independent Review Team believes that anchor cable replacement can be performed without impact on the LRT operations, safety or cost of replacement.

Following discussions with previous contractors, we believe that anchor cable replacement can be achieved without cranes reaching over the bridge. Small portable barges can be floated into the channel and latched together to form a work platform. This work platform can be fitted with winches and low profile fixed davits that can perform all of the required functions. A larger derrick barge moored on the outside can support the majority of the cable weight.

Issue W	**Additional Needs and Changes Required for LRT Installation to meet "Blue Ribbon Panel" Recommendations**	
Independent Review Team Member Responsible for Resolution of Issue	**Importance of Issue**	**Agency Responsible for Providing Resolution**
Tom Bringloe	Low	Washington State DOT and Sound Transit

General Description and Background of Issue

The report of the Governor's Blue Ribbon Panel, convened following the sinking of the LVM Bridge, is the established standard for Washington State DOT construction and maintenance work on floating structures. It will not likely raise any project feasibility issues. However it contains provisions that the designers should incorporate into any special provisions for work on the bridge and will likely affect Washington State DOT and Sound Transit maintenance operation procedures and priorities.

Required Information for Independent Review Team's Review

No additional information required.

Data Sources and Documents Provided by Responsible Agency

1. Report of the Governor's Blue Ribbon Panel, Investigation into the Sinking of the I-90 Lacey V. Murrow Bridge, May 2, 1991.

Resolution of Issue

The Blue Ribbon Panel recommendations will not likely raise any project feasibility issues. However they contain provisions that the designers should incorporate into any special provisions for work on the bridge and will likely affect Washington State DOT and Sound Transit maintenance operation procedures and priorities.

The specific recommendations, and the appropriate times to implement them are:

Recommendations that have been implemented by Washington State DOT

- *Electronic surveillance:* implement an electronic system to monitor water level in all cells.
- *Automated bridge barricades:* Study the most effective mechanical means to close the bridge when needed.

Recommendations for contract provisions and other detailed design phase activities. Language has been developed by Washington State DOT.

- *Reconstruction or renovation:* Washington State DOT to prepare a set of contractual

provisions that establish minimum standards for surveillance, inspection, reporting, and immediate rectification of discrepancies during construction.

- *Interagency cooperation:* Fully implement the agreement between the Washington State DOT and the Department of Ecology; fully involve Washington State DOT environmental staff.
- *Environmental requirements:* Require contractor to demonstrate knowledge of environmental regulations when bidding.
- *Construction practices:* Incorporate procedures for assuring watertightness, and for surveillance and response activities.
- *Prequalification of contractors:* Assure that the successful contractor acquires specific marine expertise.

Recommendations that will apply during construction

- *Contract enforcement:* Assure that bridge safety requirements are fully implemented.
- *Outside counsel:* Since rapid decisions are sometimes critically necessary, consider the assignment of outside contract counsel on major projects.

Recommendations that will apply to ongoing operations. Note that Washington State DOT and Sound Transit have committed to a joint operating agreement.

- *Independent random inspections:* To be conducted, emphasizing the watertightness of the bridge and the reliability of systems.
- *Staff continuity:* Review the training procedures for personnel who make decisions in inclement weather, and assure implementation and back-up in all key positions.

4. References

Calculations:

1. Washington State DOT, Log of Test Boring, 3rd Lake Washington Floating Bridge, February through April, 1983.
2. INCA Engineers Inc., OCS Pole Attachment Calculations, ST HCT Post-Conceptual, Job Number 06-035A, May 2008
3. Parsons, OCS Pole Attachment Calculations, Computation of Axial, Shear and Moment Loads at Pole Bases for Two-Track Portal, Seattle Sound Transit, April 2008.
4. Parsons, OCS Pole Attachment Calculations, Computation of Axial, Shear and Moment Loads at Pole Bases for Two-Track Cantilever, Seattle Sound Transit, April 2008.
5. Washington State DOT, Homer M. Hadley Bridge, Ultimate Section Capacities for Flooding Analysis and subdivision Recommendations, August 1994.
6. Washington State DOT, 3rd Lake Washington Floating Bridge Stage II, Roadway Pontoon Design Calculation and STRUDL Output Typical Section and Final Condition, March 1983.
7. INCA Engineers, Inc., ST HCT Post-Conceptual, Plinth Block Attachment Calculations, May 2008.

Design Criteria:

8. Sound Transit, Link Light Rail – North Link and Airport Link Design Criteria Manual, Revision 0, Reprint November 2005.

Reports:

9. Kinkisharyo International, L.L.C., Sound Transit - Car Body Roll Control Method ER2013, March 2005.
10. E-Mail Communication from Parsons to Sound Transit, Lightening Protection, April 29, 2008.
11. Shannon & Wilson, Inc., Summary Geotechnical Report, Interstate 90, Mt. Baker Ridge Tunnel Bore, Seattle, Washington, November 1981.
12. The Glosten Associates, Inc., Wave Loading Analysis of Lake Washington Bridges Volume 1, June 1983.
13. The Glosten Associates, Inc., Wave Loading Analysis of Lake Washington Bridges Volume 2, Analysis and Results, New 9-90 Floating Bridge, May 1983.
14. Municipality of Metropolitan Seattle, I-90 Light Rail Conversion Feasibility Study, May 1984.
15. Report of the Governor's Blue Ribbon Panel, Investigation into the Sinking of the I-90 Lacey V. Murrow Bridge, May 2, 1991.
16. Parsons Brinckerhoff / Kaiser Engineers Team Technical Memo, Use of I-90 Floating Bridge for Rail Transit, November 11, 1991.
17. Intermountain Corrosion Service, Inc., Cathodic Protection Assessment, I-90 Bridges, Lacey V. Murrow & 3rd LW Bridge, October 1993.

18. KPFF Consulting Engineers, Evergreen Point Floating Bridge Seismic Evaluation, June 1993.
19. Norton Corrosion Engineers, Cathodic Protection Systems, Third Lake Washington Bridge, July 1993.
20. The Glosten Associates, Inc., Homer M Hadley Floating Bridge, Flooding Analysis and Subdivision Recommendations, December 1994.
21. KPFF Consulting Engineers, Homer Hadley (Interstate 90) Floating Bridge, Draft Structural Feasibility Study, Light Rail Conversion, September 13, 2001.
22. KPFF Consulting Engineers, Homer Hadley (Interstate 90) Floating Bridge, Approach Structure and Transition Span, Draft Structural Analysis Study, Light Rail Conversion, August 31, 2001.
23. Hardesty & Hanover, LLP and CONCORR, Inc., In-Depth Cathodic Protection System Inspection and Recommendations, Lacey V. Murrow Bridge, Homer Hadley Bridge, May 2004.
24. KPFF Consulting Engineers, Homer Hadley (Interstate 90) Floating Bridge, Draft Structural Feasibility Study, Monorail Conversion, February 2005.
25. KPFF Consulting Engineers, Third Lake Washington Bridge, Design Criteria – Floating Structure – Stage II Pontoons, October 2005.
26. Collins Engineers, Inc., Underwater Inspection Report for the Homer Hadley Floating Bridge, Volume 1 and 2, September 2006.
27. Conference Call Documentation, Expert Review Panel Members, Regarding Use of the I-90 Bridge for Light Rail Operations, June 7, 2006.
28. Geophysical Survey Systems, Inc., GSSI Handbook for RADAR Inspection of Concrete, August 2006.
29. Geophysical Survey Systems, Inc., StructureScan Standard, November 2007.
30. Hardesty & Hanover, LLP and CONCORR, Inc., In-Depth Cathodic Protection System Inspection and Recommendations, Lacey V. Murrow Bridge, Homer Hadley Bridge, May 2006.
31. KPFF Consulting Engineers, Homer Hadley (Interstate 90) Floating Bridge, Test Program for Light Rail Transit, January 20, 2006.
32. Parsons Brinckerhoff Quade & Douglas, Inc., East Corridor HCT – Summary of I-90 Floating Bridge (Homer Hadley) Studies, March 2006.
33. Daniel G. Stromberg, Underwater Inspection Report Floating Bridges, 2006.
34. Washington State DOT, Homer Hadley Bridge Operations, Inspection and Preventative Maintenance Guidelines and Procedures, July 2006.
35. Expert Review Panel Meeting Summary, June 28 and 29, 2007.
36. The Glosten Associates, Dynamic Analysis of SR520 Replacement Floating Bridge Response to Wind and Wave Loads, Interim Report, Volume 1, May 30 2007.
37. INCA Engineers, Inc., Eastside HCT Corridor, SR90 Floating Bridge (Homer Hadley), Expansion Joint Study, Final Report, March 2007.
38. Jacobs Associates, Final Draft Summary Geotechnical Report for Preliminary Route Selection, September 6, 2007.
39. LTK Engineering Services, Sound Transit East Link Rail Transit Project Traction Power Simulation, Draft Report, November 2007.
40. Parsons, Sound Transit East Link Project, Overhead Catenary System Concept Study, Draft Report, September 2007.

41. Parsons, Sound Transit East Link Project, Phase 2, Overhead Catenary System Concept Study, Final Draft Report, December 2007.
42. Parsons, Sound Transit East Link Project, Stray Current Analysis Report, Draft Report, August 2007.
43. Parsons, Sound Transit East Link Project, Phase 2, Stray Current Analysis Report, Draft Report, December 2007.
44. Parsons, Sound Transit East Link Project, Phase 2, Ventilation Analysis of Existing I-90 Tunnels, Mount Baker and First Hill Tunnels, Final Draft Report, August, 2007.
45. Sound Transit, East Link Project, Eastside HCT Corridor, I-90 Floating Bridge Expansion Joint Final Draft Report, September 2007.
46. Washington State DOT, Homer Hadley Floating Bridge, 2007 Random Watertight Inspection, January 10, 2008.
47. INCA Engineers, Inc., Sound Transit East Link Project, Phase 2, I-90 Floating Bridge (Homer Hadley), Expansion Joint Final Conceptual Report, January 2008.
48. INCA Engineers, Inc., Sound Transit East Link Project – OCS Pole./Deck Attachment Analysis, Working Draft Technical Memorandum, May 16, 2008.
49. INCA Engineers, Inc., Sound Transit East Link Project – Plinth Block Analysis, Working Draft Technical Memorandum, May 20, 2008.
50. INCA Engineers, Inc., Sound Transit East Link Project – Rider Comfort Performance for LRT Track Bridge at Expansion Joint, Working Draft Technical Memorandum, May 21, 2008.
51. INCA Engineers, Inc., Sound Transit East Link Project, Phase 2, Existing I-90 Bridges, Seismic Vulnerability Study, Final Conceptual Report, January 2008.
52. INCA Engineers, Inc., Sound Transit East Link Project, Phase 2, Existing I-90 Bridges, Vibration Study, Final Conceptual Report, January 2008.
53. LTK Engineering Services, Rail Voltage Mercer Island TPSS, April 2008.
54. LTK Engineering Services, Rail Voltage Rainier Station, April 2008.
55. Professional Corrosion Services, LLC, Work Plan for Electrical Continuity Testing of the I-90 Pontoon Components and Between Pontoons, April 11, 2008.
56. Professional Corrosion Services, LLC, Work Plan for Rail Fastener Resistance Testing using Standard and Supplemental Isolation Technologies, April 11, 2008.
57. PROCEQ, Profometer 5 Rebar Detection System, 2007.
58. Universal Technical Resource Services, Inc., Data Sheet for Stray Current Calculations, Sound Transit I-90 Bridge Feasibility, May 20, 2008.
59. Washington State DOT, Bridge Inspection Report, Homer M. Hadley, January 22, 2008.
60. UTRS, sound Transit East Link Project – Stray Current Analysis, June 11, 2008
61. Parsons, Sound Transit East Link Project – Drainage Details at Expansion Joints, June 12, 2008
62. Letter from Sound Transit in response to the Independent Review Team's April 24, 2008 letter, May 30th, 2008
63. Mayes Testing Engineers, Sound Transit East Link Non-Destructive Testing Demonstration/Evaluation – Mayes Testing Engineers Project Number S08040, June 10, 2008.
64. Parsons, Sound Transit East Link Project – Issue Resolution Report – Support Data, June 13, 2008.

65. Herrera Environmental Consultants, Inc., Interstate 90/Homer Hadley Bridge, Light Rail Transit (LRT) Stray Current – Assessment of Potential Effects on Fish, June 13, 2008.
66. INCA Engineers, Inc., Sound Transit East Link Phase 2 Project – IRT ISSUE C – Seismic Vulnerability and Seismic Retrofit of Approach Spans and Transition Span, June 13, 2008.
67. INCA Engineers, Inc., Sound Transit East Link Phase 2 Project – IRT ISSUE N – Attachment of OCS Supports to Edge of Homer M. Hadley Floating Bridge Deck Cantilevers, June 13, 2008.
68. INCA Engineers, Inc., Sound Transit East Link Phase 2 Project – IRT ISSUE S – Median Barrier Relocation, Design, Attachment, Maintenance and Drainage, June 13, 2008.
69. Washington State DOT and Sound Transit Letter to IRT Establishing Bridge Life Expectancy, May 13, 2008.

Construction Specifications and Contractor Instructions:

70. Washington State DOT, SR90 3rd Lake Washington Floating Bridge – Pontoons, Phase II, Construction Specifications.
71. Washington State DOT, SR90 Homer M. Hadley Bridge – Anchor Cable Replacement, Instructions.

Drawings:

72. Washington State DOT, SR90 3rd Lake Washington Floating Bridge, As-Built Drawings, 1981
73. CH2M Hill, Link Light Rail Project, East Corridor, Segment A Conceptual Drawings, July 2007.
74. Hatch Mott MacDonald, Link Light Rail Project, South Corridor, MLK Transition Structure, March 2005.
75. CH2M Hill, East Link Project, Segment A Typical Sections, January 2008.

Meeting Minutes:

76. Minutes of Meeting, Independent Review of LRT Feasibility on the I-90 Homer Hadley Floating Bridge, Site Visit and Independent Review Team Meeting, April 21-23, 2008
77. Minutes of Meeting, Independent Review of LRT Feasibility on the I-90 Homer Hadley Floating Bridge, Independent Review Team Meeting and JTC Briefing, May 7, 2008
78. Minutes of Meeting, Independent Review of LRT Feasibility on the I-90 Homer Hadley Floating Bridge, Independent Review Team Meeting and JTC Briefing, June 16-18, 2008