Seattle Waterfront Streetcar Reactivation Study

Technical Memorandum

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Prepared for:

The Washington State Major League Baseball Stadium Public Facilities District (PFD)
The Washington State Public Stadium Authority (PSA)
The Seattle Mariners
First and Goal, Inc. (The Seattle Seahawks and The Seattle Sounders FC)

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1. Executive Summary

The Washington State Major League Baseball Stadium Public Facilities District (PFD), in association with its study partners, asked URS to examine the existing conditions of the Waterfront Streetcar line and vehicles and assess what would be needed to reactivate the line. This report describes the technical and political issues that would need to be resolved in order to reactivate the Waterfront Streetcar.

Background

Service on the existing Waterfront Streetcar line was initiated in 1982. The existing tracks run two miles from Broad Street down Alaskan Way and turn east on South Main Street to a terminus station on 5th Avenue South and South Jackson Street in the International District. Service was suspended in 2005 when the maintenance facility was removed to make room for the Seattle Art Museum’s Olympic Sculpture Park at Alaskan Way and Broad Street. Waterfront Streetcar vehicles are currently in storage in a Metro Transit warehouse south of downtown.

The Waterfront Streetcar line consisted of a single track located between Alaskan Way and the pillars of the Alaskan Way Viaduct and along South Main Street, with two short passing track sections and nine stations. The Broad Street station was removed as part of the construction of the Olympic Sculpture Park. The line served key destinations along the waterfront, including the Seattle Ferry Terminal, Pike Place Market, Bell Harbor International Conference Center, the Seattle Cruise Ship Terminal (Pier 66), the Seattle Aquarium, Pioneer Square, the International District, Link light rail, Metro and Sound Transit bus routes at the International District/Chinatown Station, and Sounder Commuter Rail and Amtrak at King Street Station. The line is also a short walk from Qwest Field and Event Center and Safeco Field.

Current Plans

The City of Seattle is completing design work on the First Hill Streetcar project, a modern streetcar that will connect Capitol Hill and First Hill to the International District and Pioneer Square, in particular connecting to the International District/Chinatown Station for convenient transfers to and from Link light rail, buses, commuter rail, and Amtrak. The First Hill Streetcar presents an opportunity to support reactivating service on the Waterfront Streetcar by utilizing the same maintenance facility as the First Hill Streetcar, which is planned to initiate service in late 2013.

The Seattle Waterfront area is scheduled to undergo a tremendous amount of construction activity between 2011 and 2018. The planned improvement projects include the following discrete, yet interrelated projects:

Seawall Replacement Project – This is a City of Seattle project to replace or reinforce significant portions of the seawall between Washington Street and Broad Street. The project is scheduled to run from 2012 to 2015 and would require a temporary easement on up to 60 feet of right-of-way along Alaskan Way for construction staging.

Planning to date has not made accommodations for the Waterfront Streetcar and, in fact, has assumed that the Waterfront Streetcar tracks would be removed.
Alaskan Way Viaduct Replacement – This is a WSDOT project that includes constructing a bored tunnel between approximately Denney Way and King Street, a rebuilt Highway 99/Alaskan Way surface street and demolition of the Alaskan Way Viaduct. The viaduct demolition work is tentatively scheduled for 2016 and would follow completion of the seawall project. Plans to date for this work have also assumed that the Waterfront Streetcar tracks would be removed.

Central Waterfront Project – This is a City project charged with defining the vision for the post-viaduct waterfront. This visioning process will likely consider whether the revitalized waterfront is best served with a streetcar in or adjacent to Alaskan Way, on 1st Avenue or on both alignments.

Issues with Reactivation

Four alternatives were identified for reactivation of the Waterfront Streetcar. These include slight differences in the southern and northern terminus points. All alternatives would serve the ferry terminal, Pike Place Market, Bell Harbor International Conference Center, the cruise ship terminal, the aquarium, Pioneer Square, the International District, the International District/Chinatown Station, and King Street Station. The following lists the key issues that would need to be resolved to reactivate the Waterfront Streetcar.

Maintenance Facility - The key need to reactivate service on the Waterfront Streetcar is a maintenance facility. A maintenance facility for the First Hill Streetcar is planned at a Seattle Department of Transportation (SDOT) maintenance yard in the International District and would be available for use in 2013. While the planned building is just large enough to meet the needs of the First Hill Streetcar, there is adequate space on the SDOT property to expand this building or build a second building to include space for the Waterfront Streetcar vehicles. It is critical that the Waterfront Streetcar vehicles have indoor storage space, preferably heated, to accommodate the five vintage vehicles. This study estimates the cost to expand the planned First Hill Streetcar maintenance facility to accommodate the Waterfront Streetcar at approximately $1.25 million. There may be some efficiency to be gained by programming the First Hill Streetcar maintenance facility site so that it can accommodate the expansion needed to facilitate the vintage streetcars or other additional vehicles.

Compatibility with First Hill Streetcar - The Waterfront Streetcar and the First Hill Streetcar run on the same gauge tracks and have similar vehicle dimensions. Therefore, Waterfront Streetcar vehicles would be able to run on sections of the First Hill Streetcar line as needed to access the maintenance facility. The Waterfront Streetcar vehicles are high-floor vehicles that utilize high-level boarding platforms, and as such they would not be able to utilize the same stations as the First Hill Streetcar, which will have low-floor boarding. The most important compatibility issue is that the two systems use different voltage systems. The Waterfront Streetcar vehicles would need to be upgraded to operate on the same system as the First Hill Streetcar vehicles. In addition, the Waterfront Streetcar would need to construct additional connecting track and overhead contact system (OCS) wires and poles to connect to the First Hill Streetcar. Additional communications and train signal systems will also be needed for the two systems to operate together.

Traffic - New or modified traffic signals would be needed at certain intersections, depending on which alternative is chosen for Waterfront Streetcar reactivation. There is a wide range of existing traffic control treatments along Alaskan Way that treat the streetcar crossings informally and, when the Waterfront Streetcar was in service, relied on low speed operation of the streetcar at these crossings to
ensure safety. Discussions with the City traffic department will be needed to determine what the City’s comfort level is with these rail crossings. An allowance for costs to install new signals or gates is included in the capital cost estimate for Waterfront Streetcar reactivation.

**Americans with Disabilities Act (ADA)** - Though they were designed to be wheelchair accessible, the high-level station platforms were built prior to the adoption of the ADA. Therefore, there are some deficiencies with compliance with ADA that could pose risks if not addressed as part of system reactivation. For instance, some platform edges are not properly protected by guardrails and there may be some deficiencies with regard to the width of the accessible routes through the platform areas. The capital cost estimate included in this report does not include costs for ADA compliance. Further analysis would be needed to prepare a reasonable estimate.

**South Terminus** - Two south terminus options were considered. One would restore service as it was previously, utilizing South Main Street and terminating on 5th Avenue South. Another offers the possibility of utilizing part of the First Hill Streetcar track along South Jackson Street and operating as a couplet in this area. This option may add some operational flexibility, but would add complications with sharing this section of the First Hill Streetcar. For instance, the First Hill Streetcar is planned to operate without OCS wires in this section of South Jackson Street (battery powered) because of the number of crossings of existing overhead wires (mostly trolley bus wires) in this area. The cost estimate indicates that the couplet option would add approximately $1.2 million to the reactivation cost.

**North Terminus** - A north terminus could be located at either Bell Street or Broad Street. If there is a desire for the northern terminus to extend to Broad Street, the Broad Street station platform, which was removed during construction of the Sculpture Park, would need to be reconstructed. Further investigation would be needed to determine with certainty that it could be located on the north side of Broad Street, as it was before or if it would need to be located on the south side of Broad Street. A north side location would be preferred if the Port of Seattle’s reported interest in extending the Waterfront Streetcar to Piers 90 and 91 could be implemented in the long-term. Such a station could be located just north of the Sculpture Park’s structure over the BNRR tracks, allowing easy access to the Sculpture Park, Myrtle Edwards Park and Pier 70.

**Vehicles** - The five 1924-vintage Melbourne W-2 vehicles have been in storage since 2005. They have been inspected and found to be in excellent condition. They would need to be thoroughly inspected, cleaned and lubricated, and could be put back into service immediately.

**Recommended Reactivation Strategy** - Depending on the terminus alternative chosen, the Waterfront Streetcar could be reactivated for a cost in the range of $10.3 million to $12.7 million. This includes replacement of missing track sections, cleaning and rehabilitation of station platforms, cleaning and rehabilitating the vehicles, new track and OCS wires to connect to the First Hill Streetcar alignment, upgrades to the power supply, and traffic signal and crossing upgrades.

The following summarizes the physical work that would be needed to reactivate the Waterfront Streetcar:

- Open track sections need general clean up including removing debris on top of ballast surface
- Paved track sections need general clean up including removing debris on the track flangeway
- All station platforms need power washing, painting, tactile strip replacement and other minor upgrades
- Stone grind running rails to remove rust to restore effective vehicle wheels and rail interaction
• Repair portion of Yesler Way Asphalt Crossing - Paved Track. The track has settled and needs to reset rail, concrete ties and ballast
• Repair of drainage ponding at the end of curve paved track at Alaskan Way South and South Main Street
• Re-install the paved track at intersection of 1st Avenue South
• Cleaning, lubricating and testing switch points
• Re-commissioning electrical equipment tests for the existing Waterfront Substation and equipment replacement if needed
• New track, OCS and signal system to connect with First Hill Streetcar track
• Inspect, clean, test and lubricate all vehicle components
• Electrical component conversion to 750 Vdc
• Maintenance and storage facility improvements (assuming the First Hill Streetcar facility)

In the short-term, these physical improvements could take up to one year to complete. These could be timed to coincide with the completion of the First Hill Streetcar, planned for October 2013.

This is also the timeframe for the beginning of construction of the seawall and the Alaskan Way Viaduct replacement tunnel. The reactivated Waterfront Streetcar could be considered as a mitigation measure for traffic and pedestrian circulation impacts of these other construction projects.

The Public Facilities District should immediately engage the City, Metro, and WSDOT in discussions to determine whether it is feasible to accommodate the Waterfront Streetcar while the seawall and tunnel construction is underway and whether the Waterfront Streetcar could play a role in traffic mitigation.

Short-term reactivation of the Waterfront Streetcar should be considered as the first phase of a longer-term strategy to provide transit service linking waterfront tourist destinations, ferry services, and other regional transit services.

For the second phase, the Public Facilities District and its study partners should engage the City’s Central Waterfront planning process as soon as possible to ensure that their interests and objectives related to activation of long-term operation of the Waterfront Streetcar are represented. The Central Waterfront plan should explicitly consider the value a Waterfront Streetcar could provide in the revitalized Central Waterfront as a “people-friendly” mode of transportation along its 2-mile length.
2. Background

The Waterfront Streetcar line was a 1.6-mile streetcar line operated in downtown Seattle along the Elliott Bay waterfront from May 29, 1982, until November 18, 2005. Service began after George Benson, a Seattle City Council member from 1973 to 1993, helped the city secure the initial two “W2-class” streetcars from Melbourne, Australia. Three additional W2-class Melbourne streetcars would be added to the fleet between 1990 and 1993; all five vehicles had been constructed in the late 1930s. Eight years of effort and $3.6 million were needed to complete construction and start up service of one of the country’s first “vintage” streetcar operations. It was also the first fully-accessible surface rail system in the U.S.

The streetcar service was intended to link the multiple tourist venues along Seattle’s waterfront after major port activities, and freight rail traffic, shifted south from the central waterfront piers to the Port of Seattle’s modern port facilities. George Benson, credited as the project’s founder and advocate, noted that the genesis of the idea for a streetcar operation along Alaskan Way came from a local butcher, Robert Hively, who possessed two Brill streetcars.

Benson and other supporters found mixed support and numerous challenges to implementing the streetcar. Seattle Mayor Wes Uhlman and others were advocating a trolley line to run down 1st Avenue to link the Pike Place Market on the north with Pioneer Square to the south. When this route proved too costly (due in part to utility relocation costs), focus shifted to the waterfront route.

The challenges to commencing operation along the waterfront utilizing the existing freight rail tracks included the following issues:

- Hively’s two Brill streetcars did not meet Federal Railroad Administration (FRA) safety standards which were applicable because tracks were part of the transcontinental rail system.
- The rail line itself had a tangled ownership dating back many years and multiple ownership stakes included the Burlington Northern, the Union Pacific and the Milwaukee Road. Each entity needed to approve its use for the streetcar operation.
- The Burlington Northern, the actual operator of the existing rail line at the time, raised numerous technical objections to the proposal.
- Individual waterfront pier owners had to waive their (long unused) rights to service from the rail line.
- The railroad workers union had to approve an exemption to standard labor rules that required three-person crews operating engines (even streetcars) on an interstate railroad.

It wasn’t until Benson enlisted the help of U.S. Senators Warren Magnuson and Henry Jackson that support for the idea gathered momentum from railroad officials, Seattle politicians and city planning staff. A large stumbling block was overcome when the Burlington Northern suggested disconnecting the western-most rail tracks along Alaskan Way from the transcontinental rail system. This freed the project from FRA regulation and railroad union rules and allowed it to be covered by the more flexible transit union. It still took more than two years to get the necessary permissions amid a tangled mix of railroad owners and access-rights holders.
The service was extended 0.4 miles along South Main Street to 5th Avenue South in 1990 in order to maximize its utility by connecting with the southern end of the Downtown Seattle Transit Tunnel (DSTT) at the International District station. The development cost of the full 2.0-mile line was approximately $10 million. The service was suspended in 2005 when the streetcar maintenance facility was removed to allow for the construction of the Seattle Art Museum’s Olympic Sculpture Park. Figure 1 shows the alignment of the existing Waterfront Streetcar tracks from Broad Street to the International District.

**Characteristics**

The original line included a single trackway sandwiched between Alaskan Way to the west and the pillars of the Alaskan Way Viaduct to the east. A single short passing track was constructed south of Pike Street. The most recent Waterfront Streetcar operation in 2005 served nine stations. The stations consisted of a concrete raised platform with a ramp for wheelchair access, a shelter and rider information.

These station locations are listed below from north to south.

- Broad Street (platform and maintenance facility both demolished)
- Vine Street
- Bell Street
- Pike Street
- University Street
- Madison Street (served Pier 52/Washington State Ferry Terminal)
- Main Street (original southern terminus)
- Occidental Park (extension station)
- International District (extension station/southern terminus)

The system operated year round for 12 hours per day with a minimum of two vehicles providing 30-minute headways. An additional streetcar was operated during peak periods and during summer months and reduced headways to 20 minutes. Each streetcar was operated with a “motorman” and a “conductor.” The streetcar service was not part of the downtown “Ride Free” zone and Metro Transit charged its standard one-zone fare for the service. The fare in 1992 was 75 cents and provided a transfer that allowed rides on other Metro Transit routes for one hour.
Figure 1: Seattle Waterfront Streetcar – Existing Track Alignment
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When streetcar operations ended in 2005, Metro Transit replaced the streetcar service with interim bus service, Route 99, that follows the streetcar route, operates at the same 20-30 minute frequencies and uses buses that are painted to look like the streetcars. Unlike the streetcar service, there is no fare for the interim bus service. In 2011 Metro plans to transition to using standard buses rather than the specially painted vehicles to service this route.

**Items of Note**

- A local improvement district that provided $1.2 million for the original line was approved by 72 percent of nearby businesses and property owners.
- The streetcar line’s highest ridership in its first decade of service was during its first full year of operation in 1983 when over 277,000 fares were paid. A Seattle Times article in March 2005 noted annual ridership of 400,000 with activity peaking during the summer tourist season.
- In 1991, the line garnered fare box revenues of $129,600 versus an annual operating cost of $862,000. Besides advertising sales, federal grants and other sources, the operating deficit was partially offset by the elimination of conventional bus service along the central waterfront.
- The Waterfront streetcars are currently stored in a Metro Transit warehouse south of downtown.
3. **Streetcar Plans and Policies**

The City of Seattle initiated service on its first modern streetcar line, the South Lake Union Line, in 2007. The development of this line helped to spark interest in the potential of streetcars to enhance and support improved transportation options and development in Seattle’s dynamic inner city neighborhoods. In 2008 the Seattle City Council adopted Resolution 31042 which authorized City’s Department of Transportation to prepare an evaluation of a range of potential streetcar corridors and routes. The purpose of this evaluation was to identify the most promising corridors for early implementation. The corridors evaluated included:

- First Hill/Capitol Hill/International District
- Central District/International District
- Rainier Avenue/First Hill
- UW/Ballard/Lake Union/Downtown
- Ballard/Interbay/Seattle Center
- First Avenue/Waterfront
- Seattle Center/SLU/Capitol Hill
- West Seattle/Downtown

The study considered criteria such as technical feasibility, cost, travel time, ridership and funding potential. Based on this initial evaluation, four potential streetcar lines emerged as the most viable candidates for initial implementation. The four lines include the Central Streetcar (via First Avenue), the Fremont/Ballard Streetcar (extending the South Lake Union Line via the Fremont Bridge), the U-Line (extending the South Lake Union Line via Eastlake and University Way) and the First Hill/Capitol Hill Line (via Broadway and Jackson). See Figure 2.
The First Hill/Capitol Hill Line was identified as the top priority and is currently moving through planning and final design toward implementation, with service planned to initiate in late 2013 or early 2014. The First Hill Line is being developed in conjunction with Sound Transit and it is funded as part of the ST2 Plan. The First Hill line will link First Hill employment centers to the light rail system via connections on Capitol Hill and in the International District.
4. Waterfront Projects and Plans

The Waterfront Streetcar ceased operations in 2005. King County Metro currently operates Route 99 as a free bus service between Alaskan Way and Clay to South King Street and 8th Avenue South. Metro is currently using the streetcar track area on the west side of 5th Avenue South between South Main Street and South Jackson Street for bus layover.

The Seattle Waterfront area is scheduled to undergo a tremendous amount of construction activity between 2011 and 2018. The construction is related to a series of improvements largely tied to the planned removal of the Alaskan Way Viaduct in 2016. The scheduling of the various projects and elements is complicated and is likely to evolve as construction and demolition activity progresses. Figure 3 provides a map of the various construction elements and Figure 4 provides a graph that shows a rough estimate of the project timelines. Note that the estimated timelines are draft and as the projects develop, the schedule will continue to evolve.

The planned improvement projects include several discrete projects as well as various inter-related project elements. The following is a description of the major projects and project elements that would have the most potential to influence consideration of Waterfront Streetcar reactivation.

**Seawall Replacement Project** - The Seawall Replacement Project is a City of Seattle project that will replace and/or reinforce significant portions of the seawall between Washington Street and Broad Street. Seawall construction is scheduled to begin in 2012 and be completed by 2015. The project will replace or rehabilitate the existing wooden piles that currently support the seawall and Alaskan Way.

Two construction methods are being considered, one would replace more piles and would require up to 60 feet for construction staging and the other would involve less pile replacement and could potentially be completed within a 45 foot construction zone. With either method, construction plans include providing a temporary 2-lane or 4-lane roadway and maintaining pedestrian access to shops and restaurants on the west side of Alaskan Way. In addition to the 2-lane or 4-lane temporary roadway, construction planning includes accommodating a temporary bicycle and pedestrian pathway.

Planning to date has not made accommodations for the Waterfront Streetcar, but instead, has assumed that the Waterfront Streetcar is gone and that the existing streetcar tracks and right-of-way (ROW) are available to be used as needed to provide maximum flexibility during construction.
Figure 3: Central Waterfront Projects Map

Figure 4: Central Waterfront Projects Timeline

* Simplified project schedules for internal discussions only. Preliminary April 2010 estimates.
Alaskan Way Viaduct Replacement - The Alaskan Way Viaduct Replacement is a Washington State Department of Transportation project that includes a new bored tunnel between approximately Denny Way and King Street, a rebuilt Highway 99/Alaskan Way surface street and the Alaskan Way Viaduct demolition.

The bored tunnel will range in depth between 60 feet and 200 feet and will avoid numerous subterranean obstacles such as sewer pipes, vaults, building supports, etc. The tunnel is planned to provide a Highway 99 bypass through downtown with two lanes in each direction and no access points directly in downtown. Access to downtown would be available on surface streets including the surface Highway 99/Alaskan Way replacement. With the bored tunnel technology, WSDOT does not anticipate significant disruption on the surface along the tunnel alignment. However, there may be some activity on the surface related to the tunnel construction.

The viaduct demolition work in the central waterfront area is expected to last for approximately three months and is tentatively scheduled to occur in 2016. It is anticipated that this work will follow completion of the seawall project. Demolition will require staging areas and similar to the seawall project, will require a temporary Alaskan Way surface roadway. Plans have assumed that the existing Waterfront Streetcar tracks would be removed and the right-of-way would be available to accommodate various project needs. In December 2010, WSDOT submitted a letter to King County requesting “…concurrence with the removal of Waterfront Streetcar facilities along Alaskan Way, between Yesler Street and Spring Street.”

Central Waterfront Project - The Central Waterfront Project is a city project that is charged with defining the vision for the post-demolition waterfront and then designing and implementing the planned improvements. The project will likely include a four lane roadway with turn pockets, bicycle and pedestrian pathway or other improvements, public open spaces, gardens, street furniture and public art. In early 2011 the city is initiating a community-based visioning process that is expected to take 18 months. This visioning process will likely consider whether the revitalized waterfront is best served with a streetcar in or adjacent to Alaskan Way, on 1st Avenue or on both alignments.
5. Waterfront Streetcar - Existing Conditions

The existing streetcar facilities along the Seattle Waterfront have been out of use for nearly six years and in many respects are showing signs of the lack of use or active maintenance. This section discusses the general findings of a physical inventory of the Waterfront Streetcar facilities. A detailed engineering summary is included as Appendix A.

There are two distinct sections of the streetcar trackway, the original open tie-and-ballast section along the eastern side of Alaskan Way between Broad Street and South Main Street and the paved-track section along South Main Street and 5th Avenue South that was added in 1990. The tracks are single-track with passing tracks located on the Alaskan Way section between Union Street and Pike Street and on South Main Street between 2nd Avenue South and the 2nd Avenue Extension South.

The open tie and ballast track sections along Alaskan Way are largely on straight, tangent tracks with an almost level track profile. The tracks in this segment are rusty and dirty and would require power washing and stone grinding to be put back into use.

The paved track sections are located in South Main Street between Alaskan Way South and 5th Avenue South and on 5th Avenue South between South Main Street and South Jackson Street. The paved track treatments include sections of asphalt paving, cast-in-place concrete, red paver bricks and concrete panels. Paved track sections on South Main Street at 1st Avenue South and at 4th Avenue South have been removed and paved over. These tracks would need to be replaced in order to continue to operate as far east as 5th Avenue South. Many of the paved track sections have accumulated debris in the flangeway and these would also require rehabilitation.

The Waterfront Streetcar stations were developed as minimalist concrete block platforms that provided a high platform for wheelchair and disabled access. The station platforms have accumulated dirt and moss and would require a thorough cleaning and upgrading to be reactivated. Upgrades could include painting, replacing the tactile warning strip, electrical and signage upgrades. The original station at Broad Street was removed along with the construction of the sculpture garden.
6. Alternative Alignments and Termini

When it ceased operations in 2005, the Waterfront Streetcar operated between Broad Street and South Jackson Street via an alignment east of Alaskan Way and via South Main Street and 5th Avenue South. This reactivation study is evaluating how to best interface with the planned First Hill Streetcar line (planned to initiate service in 2013) at the south end of the Waterfront line and what would be the best terminus location at the north end of the line. The interface with the First Hill Streetcar is essential to the reactivation because it would provide access to a potential shared maintenance facility. Maintenance needs and facility options are discussed in Chapter 7.

South End Alignments and First Hill Streetcar Interface

Existing Waterfront Alignment - The southern portion of existing Waterfront Streetcar track alignment runs along South Main Street between Alaskan Way South and 5th Avenue South. This segment is primarily single track with a short section of passing track between 2nd Avenue South and 2nd Avenue Extension South. The alignment turns south on 5th Avenue South for one block and terminates at South Jackson Street.

The existing terminus station on 5th Avenue South is across the South Jackson Street from the Downtown Seattle Transit Tunnel (DSTT), International District/Chinatown Station, which accesses the Central Link light rail line as well as a range of regional bus services. One block west is King Street Station, which is the downtown Seattle stop for both the Sounder commuter rail and Amtrak. Providing a connection to these transit facilities was a key reason for the extension of the Waterfront Streetcar into the International District in 1990 and an important connection for a reactivated Waterfront Streetcar.

The western segment of the planned First Hill Streetcar would run along South Jackson Street, adjacent to the current terminus of the Waterfront streetcar at 5th Avenue South and South Jackson Street. It would continue west to its terminus station on South Jackson Street immediately west of Occidental Avenue South. Figure 5 shows the planned First Hill Streetcar and the existing Waterfront Streetcar alignments.
Waterfront Streetcar South End Alternatives - This existing Waterfront alignment and the planned First Hill alignment present several potential connection points between the Waterfront streetcar and the First Hill Streetcar. The most direct connection would be at 5th Avenue South and South Jackson Street. Here, the Waterfront streetcar could be reactivated as it operated previously and require only a short section of connecting track.

This evaluation considered a range of potential alignments and connections between the streetcar lines. These alignments and connections are described below and a summary of the initial evaluation follows.

The following lists the alternatives for the southern terminus of the Waterfront Streetcar each with a unique interface with the planned First Hill Streetcar line:

- **Alternative 1 – Connect at 5th**: This alternative would serve the existing Waterfront Streetcar terminus and connect to the First Hill Streetcar at 5th Avenue South and South Jackson Street.
- **Alternative 2 – Connect at 2nd**: This alternative would terminate Waterfront Streetcar service at the Occidental Station and construct a connection to the First Hill Streetcar on 2nd Avenue South between South Main Street and South Jackson Street.
- **Alternative 3 – Connect at Occidental**: This alternative would terminate Waterfront Streetcar service at the Occidental station and construct a connection to the First Hill Streetcar on Occidental Avenue South between South Main Street and South Jackson Street.
- **Alternative 4 – Couplet 2nd to 5th**: This alternative would operate the Waterfront Streetcar as a one-way couplet connecting to the First Hill line at both 5th Avenue South and 2nd Avenue South.
• **Alternative 5 – Couplet Occidental to 5th:** This alternative would operate as a one-way couplet connecting to the First Hill line at both 5th Avenue South and Occidental Avenue South.

• **Alternative 6 – Full Couplet:** This alternative would operate as a one-way couplet and extend the First Hill line connecting at both 5th Avenue South and Alaskan Way South.

• **Alternative 7 – Stadium Extension:** This alternative would provide an extension of the Waterfront Streetcar to the stadiums via Occidental Avenue South to Royal Brougham Way. This would include a non-revenue connection on South Main Street between Occidental Avenue South and 2nd Avenue South.

The following describes the advantages and disadvantages of each of these alternatives.

**Alternative 1 – Connect at 5th** - Alternative 1 (shown in Figure 6) would restore the service on the Waterfront Streetcar to its original southern terminus at 5th Avenue South and South Jackson Street. From here, a short section of non-revenue track would be constructed to connect from southbound 5th Avenue South to the First Hill Streetcar eastbound on South Jackson Street. The Waterfront Streetcar would operate in non-revenue service to 8th Avenue South to provide access to the planned streetcar operations and maintenance facility.

**Figure 6: Alternative 1 – Connect at 5th**

Alternative 1 would require restoration of all existing Waterfront streetcar track on South Main Street between Alaskan Way South and 5th Avenue South. New connecting tracks to the First Hill Streetcar on South Jackson Street could be constructed without requiring the relocation of the existing terminus station at 5th Avenue South and South Jackson Street. This alternative would provide a direct, convenient connection to the International District and to the DSTT International District/Chinatown.
Station (Link light rail, Metro and Sound Transit buses) and Sounder commuter rail and Amtrak at King Street Station.

There is currently an agreement between the city and Metro for buses to layover on 5th Avenue South immediately south of the existing Waterfront Streetcar terminus station. If Waterfront Streetcar service were restored on this alignment, a new location for bus layovers would be needed. This alternative would also require a change in the directional flow on South Main Street. When the Waterfront streetcar was in service, South Main Street operated as a two-way street with the streetcar running bi-directionally in the travel lanes. It has since been converted to a one-way street running eastbound. This alternative would run parallel with the First Hill Streetcar for several blocks, providing duplicative service.

Alternative 1 would be the easiest way to restore service on the Waterfront Streetcar. It would utilize the entirety of the existing Waterfront Streetcar alignment and require only a small amount of additional track to connect to the First Hill Streetcar. This alternative would provide a convenient passenger connection to the First Hill Streetcar, as well as to a wide range of transit routes at the International District/Chinatown Station and King Street Station. Recommendation: Carry forward for further study.
Alternative 2 – Connect at 2nd - Alternative 2 (shown in Figure 7) would terminate Waterfront streetcar service at the Occidental station and connect to the First Hill Streetcar on a new track on 2nd Avenue South between South Main Street and South Jackson Street. 2nd Avenue South is a relatively low volume street with a wide cross-section. It may be necessary to remove a travel lane or parking.

Figure 7: Alternative 2 – Connect at 2nd

This alternative would reduce duplication of service and avoid the existing bus layover area on 5th Avenue South. It would also minimize the segment of South Main Street that would need to be converted back into two-way traffic operation. Since the only passing track in the south terminus area is on South Main Street east of 2nd Avenue South, a new passing track section would be required.

Alternative 2 would terminate revenue service for the Waterfront Streetcar at the Occidental Station. It would not provide a station with direct access to the DSTT International District/Chinatown Station (Link light rail, Metro and Sound Transit buses) or Sounder commuter rail and Amtrak at King Street Station. Transfer access to the First Hill Streetcar would be a block south at South Jackson Street and a new passing track be needed. **Recommendation: No further study.**
Alternative 3 – Connect at Occidental - Alternative 3 (shown in Figure 8) would also terminate Waterfront Streetcar service in the vicinity of Occidental Avenue South. The Waterfront streetcar would turn south on Occidental Avenue South and terminate at a new station on Occidental Avenue South just north of South Jackson Street. This station would replace the current Occidental Station on South Main Street, which would need to be relocated to allow for an adequate turning radius from South Main Street to Occidental Avenue South. This would provide a convenient connection for passengers transferring between the Waterfront streetcar and the First Hill Streetcar. A non-revenue connection to the First Hill Streetcar would be constructed at Occidental Avenue South and South Jackson Street.

Figure 8: Alternative 3 – Connect at Occidental

The block of Occidental Avenue South between South Main Street and South Jackson Street is a pedestrian-only street. Adding streetcar service to this block would require special accommodations to ensure pedestrian safety, but it could also enliven the street and enhance the historic character of the street.

Alternative 3 is similar to Alternative 2 in that it does not maximize use of existing track, and does not provide a connection to the DSTT International District/Chinatown Station (Link light rail, Metro and Sound Transit buses) or Sounder commuter rail and Amtrak at King Street Station. While it would create a more direct passenger connection to the First Hill Streetcar by moving the Occidental Station one block south, implementing streetcar service on the pedestrian only section of Occidental Avenue South would present challenges. **Recommendation: No further study.**
**Alternative 4 – Couplet 2nd to 5th** - Alternative 4 (shown in Figure 9) would provide a connection between the Waterfront Streetcar and the First Hill Streetcar at both 2nd Avenue South and 5th Avenue South. The Waterfront Streetcar would run eastbound on South Main between 2nd Avenue South and 5th Avenue South and then run westbound on South Jackson Street on tracks shared with the First Hill Streetcar back to 2nd Avenue South, where a new connection would be constructed along 2nd Avenue South between South Jackson Street and South Main Street.

**Figure 9: Alternative 4 – Couplet 2nd to 5th**

Utilizing a couplet system would negate duplication of service between the Waterfront Streetcar and the First Hill Streetcar. It would also allow South Main Street to continue to operate as a one-way street eastbound. However, it would not avoid the current bus layover area on 5th Avenue South.

This alternative would require relocation of the Waterfront Streetcar terminus station on 5th Avenue South in order for the streetcar to make the turn onto South Jackson Street. This would also reduce capacity for a layover at this station. In addition, the tracks would likely need to swing into the oncoming lane in order to make the turn from 5th Avenue South southbound to South Jackson Street westbound. This may require reconfiguring the traffic lanes on 5th Avenue South or implementing a separate signal phase for the Waterfront streetcar.

Alternative 4 maximizes the use of the existing Waterfront Streetcar track and connects passengers directly to the First Hill Streetcar and the DSTT International District/Chinatown Station (Link light rail, Metro and Sound Transit buses) and Sounder commuter rail and Amtrak at King Street Station. Since this alternative would operate as a couplet, it would maximize capacity of the system, which would otherwise be limited by the number and location of passing tracks. With this alternative, the existing
section of passing track between 2nd Avenue South and 2nd Avenue Extension South could be utilized for extra layover capacity. **Recommendation: Carry forward for further study.**

**Alternative 5 – Couplet Occidental to 5th** - Alternative 5 (shown in Figure 10) would be similar to Alternative 4, but would create the western connection of the couplet on Occidental Avenue South rather than 2nd Avenue South. This would have the same issues as Alternative 3 in the vicinity of Occidental Avenue South (relocation of the existing Occidental station and potential concerns about operating on a pedestrian-only street) and the same issues as Alternative 4 in the vicinity of 5th Avenue South (relocation of the 5th Avenue South station and traffic reconfiguration required to make the turn).

*Figure 10: Alternative 5 – Couplet Occidental to 5th*

In addition, the station location on Occidental Avenue South proposed for Alternative 3 would not be practical for this alternative, because there would be no eastbound station in the vicinity of Occidental Avenue South. It may be more practical to relocate the Occidental station further west on South Main Street.

Alternative 5 would be similar to Alternative 4, but would introduce streetcar service on the pedestrian-only section of Occidental Avenue South. Alternative 5 would also require that either one new Occidental Station be constructed west of the existing one, or that two new stations be constructed, one for the eastbound direction on South Main Street and one for the westbound direction on South Jackson Street. This alternative offers no advantages over Alternative 4. **Recommendation: No further study.**
**Alternative 6 – Full Couplet** - Alternative 6 (shown in Figure 11) would be similar to Alternatives 4 and 5, but the westbound Waterfront streetcar would continue west on South Jackson Street to Alaskan Way South and then turn north to rejoin the existing line at South Main Street. An advantage to this alternative is that South Main Street could remain one-way eastbound for the entire length between Alaskan Way South and 5th Avenue South.

**Figure 11: Alternative 6 – Full Couplet**

With the Full Couplet alternative, the Occidental Station would remain in its current location. However, it would only be an eastbound station. An additional westbound station would be needed on South Jackson Street in the vicinity of Occidental Avenue South or 1st Avenue South. Since the First Hill Streetcar is planned to terminate on South Jackson Street just west of Occidental Avenue South in a single tail track, track would need to be added for the westbound Waterfront streetcar to continue passed the First Hill Streetcar.

Alternative 6 would add a significant amount of new track in order to extend the westbound Waterfront Streetcar west on South Jackson Street from the First Hill Streetcar terminus to Alaskan Way South. This would require approximately three blocks of new track. The benefits of this new track would be limited, since the westbound Waterfront Streetcar could return to South Main Street further east and utilize existing track. Alternative 6 could require an additional traffic signal at the intersection of Alaskan Way South and South Jackson Street. **Recommendation: No further study.**
**Alternative 7 – Stadium Extension** - Alternative 7 (shown in Figure 12) would best serve the stadiums. It would leave the existing Waterfront streetcar tracks at Occidental Avenue South and relocate the Occidental station to Occidental Avenue South just north of South Jackson Street. The trolley would continue south on new tracks on Occidental Avenue South, traveling immediately adjacent to Qwest Field, and terminating at South Royal Brougham Way, adjacent to Qwest Field Event Center and across the street from Safeco Field. A connection to the First Hill Streetcar would be provided at Occidental Avenue South and South Jackson Street. Alternative 7 would not provide a connection to the DSTT International District/Chinatown Station (Link light rail, Metro and Sound Transit buses) or Sounder commuter rail and Amtrak at King Street Station.

This alignment would require approximately a half-mile of new track. This could be single or double-track. If it is single-track, a short section of passing track may be required at some point between South Main Street and South Royal Brougham Way, depending on desired frequency.

*Figure 12: Alternative 7 – Stadium Extension*

Occidental Avenue South is a low traffic volume street that is frequently used for event staging at Qwest Field and Event Center. Regular weekday activity along this segment of Occidental Avenue South
includes a number of truck loading docks where the trucks extend well into the traffic way. During events at the stadiums, the character of Occidental Avenue South becomes an informal festival marketplace with street vendors and pedicabs and the street becomes an informal pedestrian zone.

Alternative 7 would require a significant amount of new track. While it would serve the stadium area more directly, it introduces significant issues associated with operating adjacent to the stadiums in a crowded pedestrianized area on game days. In addition, the current land uses along Occidental Avenue South near the stadiums include warehouses with truck loading areas. Trucks often partially block Occidental Avenue South in this area. Truck loading as well as event staging for Qwest Field and Event Center would conflict with streetcar operations. Alternative 7 also would not provide a convenient connection for passengers to the International District/Chinatown and King Street stations.

**Recommendation: No further study.**

**North Terminus Options**

The construction of the Seattle Art Museum Olympic Sculpture Garden in 2005 eliminated the Waterfront Streetcar maintenance building and also the Broad Street station platform that served as the streetcar line’s northern terminus. This reactivation study considered the most appropriate locations to consider for a northern terminus for a reactivated Waterfront Streetcar line.

There are many activity nodes and tourist destinations along the central waterfront including the Seattle Ferry Terminal (Colman Dock) at Marion Street, the Seattle Aquarium at Pike Street, Pike Place Market, the Seattle Cruise Ship Terminal (Pier 66) at Bell Street, the Victoria Clipper terminal at Clay Street and the Olympic Sculpture Garden at Broad Street. In addition to these activity nodes, there are numerous restaurants and shops occupying the waterfront piers. As part of this study of reactivating the Waterfront Streetcar two alternative locations for the northern terminus are being considered, at Bell Street and at Broad Street.

A northern terminus at Broad Street would restore Waterfront Streetcar service to pre-2005 levels. There may be an issue with fitting a northern terminus station in at Broad Street, since construction of the Sculpture Garden removed the Broad Street station. An alternative northern terminus point would be Bell Street. This station location would serve the Seattle Cruise Ship Terminal (Pier 66) and the Bell Harbor International Conference Center.

**Evaluation of Combined Alternatives (including north and south termini)**

In order to understand the issues and impacts associated with streetcar reactivation and to determine the best termini for reactivated service, the two south termini alternatives forwarded for further study are each coupled with the two north termini to form four distinct alternatives to be evaluated. The four alternatives include:

**Alternative 1A** – This includes the south terminus Alternative 1 (existing streetcar alignment to 5th Avenue South) coupled with the Broad Street northern terminus.

**Alternative 1B** - This includes the south terminus Alternative 1 (existing streetcar alignment to 5th Avenue South) coupled with the Bell Street northern terminus.

**Alternative 4A** - This includes the south terminus Alternative 4 (a couplet on South Main and Jackson Streets) coupled with the Broad Street northern terminus.
Alternative 4B - This includes the south terminus Alternative 4 (a couplet on South Main and Jackson Streets) coupled with the Bell Street northern terminus.

These four alternatives have been evaluated and compared using criteria that address operations, accessibility, traffic and costs.

Criteria

Criteria were developed to provide for a comparison among the alternatives. Key criteria that help to clarify which routing and termini would be preferred include:

- Operations
- Access
- Traffic
- Costs

The following describe how the alternatives were evaluated based on these four criteria.

Operations

Operations refer to how the streetcar would operate and the comparison of alternatives relates to the ability of each to provide desired frequency and capacity. When suspended in 2005, the Waterfront Streetcar service operated at 20-minute headways during the peak hours and 30-minute headways during the remainder of the day. Alternative 1A, which is the same alignment as the previous service, would be able to accommodate a 20-minute headway. It may be possible to run the service at a 15-minute frequency if the line does not extend as far north as it did previously (e.g., Alternative 1B).

Each of the four combined alternatives is suitable for reactivating streetcar operations. In terms of physical alignment (including track layout, station locations, passing tracks, etc.), both alternatives 1A and 1B would closely resemble the Waterfront Streetcar physical characteristics prior to rail service suspension in 2005. The only difference between alternatives 1A and 1B would be the northern terminus location (either at Broad Street in 1A or Bell Street in 1B).

While alternatives 4A and 4B are workable options for streetcar service reactivation, they do not appear to provide any appreciable operational gains over alternatives 1A and 1B. In fact, while 4A and 4B do not appear to provide any noted advantages (e.g. no stations closer to the International District/Chinatown DSTT Station, King Street Station, or the stadium properties, no additional storage capacity for special event staging of trains, etc.), they would modestly reduce the amount of track available for staging streetcar vehicles at the southern terminus for large spectator events at the stadium sites and would present some operational challenges.

Operational Considerations

All four alternatives were evaluated on the following operational criteria:

- whether they could either replicate or enhance the service characteristics (e.g., service frequency) and connections previously provided by the streetcar service prior to its suspension
- whether they would use the existing rail facilities that would maintain operational flexibility previously provided (i.e., they would or could use the existing two passing tracks)
• the degree to which they had the capability to stage multiple streetcars for spectator events at the stadium sites, and
• whether they had any other operational constraints or issues.

**Replicate or Enhance Service Characteristics; Maintain Operational Flexibility**

All four combined alternatives would be capable of nearly replicating the streetcar service provided prior to suspension in 2005. Alternatives 1A and 4A would extend to a new station at Broad Street near the northern terminus of the previous service. Alternatives 1B and 4B would extend as far north as the existing Bell Street station where they would serve the cruise ship terminal, the Bell Harbor International Conference Center and the Victoria Clipper. By operating north of Union Street, all four options would be able to use the passing track located between Pike and Union streets in order to maintain operational flexibility.

**Capability to Stage Multiple Streetcars for Events**

All four combined alternatives would be capable of providing at least some staging area for multiple streetcars to be positioned for the conclusion of special events at the stadium sites. However, the two alternatives that terminate at Bell Street in the north (1B and 4B) and the two alternatives that terminate at 5th Avenue South (the two non-couplet alternatives 1A and 1B) would likely have greater capacity at their respective route ends for this function. Of the four, Alternative 1B would likely have the greatest capacity at its route ends to position streetcars for this purpose.

Of the four alternatives, Alternative 1B would have the greatest ability to restore the Waterfront Streetcar service to most of its previous service area, maintain and increase operational flexibility by slightly shortening the route to the north and maintain the ability to position streetcars for stadium events. See also Section 10 – Streetcar Operations.

**Access**

Access refers to the ability of the streetcar line to serve major employment destinations, activity nodes and transportation connections. The evaluation of access includes considerations such as the number of major destinations and other transit lines that the line would connect to. Differences in access to the stadium facilities at the south end of the line would be relatively minor. Both alternatives would provide an eastbound station at the existing platform on South Main Street near the Occidental Avenue South pedestrian-only walkway connection south toward Qwest Field.

There are two alternative termini at the northern end of the line, at Broad Street (Alternative 1A or 4A) or at Bell Street (Alternative 1B or 4B). A terminus at Broad Street would require reconstruction of the Broad Street station platform that was removed with the construction of the Olympic Sculpture Garden.

The Broad Street Station would provide good access to the sculpture garden and would connect directly to the Olympic Sculpture Park, which is a major tourist destination. Alternatives 1A and 4A would also get riders to within approximately 0.4 miles from the Seattle Center, also a major tourist destination. Alternatives 1B and 4B, which would terminate at Bell Street, would get riders to approximately 0.4 miles from the Olympic Sculpture Park and almost a mile from the Seattle Center.

All alternatives would serve the Bell Harbor International Conference Center, the Seattle Aquarium, Waterfront Park, the ferry terminal, Pioneer Square, Chinatown, and the International
District/Chinatown and King Street stations, which are major hubs for the Central Link light rail line, multiple bus routes, Sounder commuter rail, and Amtrak.

Traffic

The key differences among the alternatives with regard to traffic impacts would be at the southern terminus. With either southern terminus alternative, traffic signal modifications would be required at 5th Avenue South and South Jackson Street and at 5th Avenue South and South Main Street. With the couplet alternatives (4A and 4B), the intersection of 2nd Avenue South and South Main Street would require a new signal, including train signal equipment to allow an eastbound streetcar on South Main Street to clear the single track section before a northbound streetcar on 2nd Avenue South turns onto South Main Street.

The intersection of South Jackson Street and 2nd Avenue South would get a new signal with the construction of the First Hill Streetcar. This signal would need to be modified for the Waterfront Streetcar.

Several new or modified signals may be required along Alaskan Way. This would be the same regardless of the alternative selected.

Between Bell Street and Broad Street, the crossings are currently gated because the Waterfront Streetcar tracks are parallel to the active freight rail line at this location. No modifications would likely be required to signals in this area, regardless of which alternative is selected.

Cost

Construction costs will vary depending on which alternative is selected. The key differences are at the northern and southern termini. Table 1 lists the elements that would differ among the alternatives.
Table 1: Key Elements that Differ Among the Alternatives

<table>
<thead>
<tr>
<th>Element</th>
<th>Alternative 1A</th>
<th>Alternative 1B</th>
<th>Alternative 4A</th>
<th>Alternative 4B</th>
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<td>Connecting track to First Hill Streetcar</td>
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<td>Relocated 5th Ave station</td>
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<td>Yes</td>
</tr>
<tr>
<td>Construct OCS poles and wires</td>
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<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Modify signal at 2nd and Jackson</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>New signal at 2nd and Main</td>
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<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Construct new station at Broad Street</td>
<td>Yes</td>
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<td>Yes</td>
<td>No</td>
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</tbody>
</table>

Table 2 shows that the couplet alternatives at the southern terminus would cost more to implement. If the couplet option is selected, the Waterfront Streetcar project would need to construct the OCS infrastructure along South Jackson Street because the First Hill Streetcar will not be using OCS infrastructure in this segment.

At the northern terminus, the key difference among the alternatives would be the need to construct a new station platform at Broad Street for Alternatives 1A or 4A.

Table 2 summarizes the capital costs by alternative.

Table 2: Capital Cost Summary

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<thead>
<tr>
<th>Alternative</th>
<th>Total Capital Cost (in millions, 2011 dollars)</th>
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<tr>
<td>Alternative 1A (1.67 route miles)</td>
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</tr>
<tr>
<td>Alternative 1B (1.26 route miles)</td>
<td>$10.3</td>
</tr>
<tr>
<td>Alternative 4A (1.80 route miles)</td>
<td>$12.7</td>
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<tr>
<td>Alternative 4B (1.40 route miles)</td>
<td>$12.0</td>
</tr>
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</table>
Evaluation Summary

Table 3 shows the relative rankings for each alternative under each of these criteria categories. The alternatives are ranked on a scale of 1 to 5, with 5 being best and 1 being worst.

Table 3: Evaluation Summary

<table>
<thead>
<tr>
<th>Criteria Category</th>
<th>Alternative 1A</th>
<th>Alternative 1B</th>
<th>Alternative 4A</th>
<th>Alternative 4B</th>
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<td>Traffic</td>
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<td>2</td>
</tr>
<tr>
<td>Cost</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
7. Waterfront Streetcar/First Hill Streetcar Technical Compatibility

The construction of the First Hill Streetcar presents an opportunity for the Waterfront Streetcar to share the First Hill maintenance facility planned for a site in the International District. In order for the Waterfront Streetcar to access this maintenance facility, it would need to be compatible with the First Hill Streetcar in order to operate on the same tracks between the maintenance facility and the southern terminus of Waterfront Streetcar revenue service. Compatibility issues include track gauge, station clearance, power, and signaling systems.

Track Gauge and Station Clearance

The Waterfront Streetcar and the First Hill Streetcar tracks are the same gauge and are, therefore, compatible. Station clearance (the distance between the rail and the edge of the station platform) would be the same for both systems. This will enable Waterfront Streetcar vehicles to travel on the First Hill Streetcar tracks and clear the First Hill Streetcar station platforms.

Power Supply Systems

If the Waterfront Streetcar is to utilize a portion of the First Hill Streetcar tracks, either in revenue service or only to access the maintenance facility, power supply issues would need to be addressed. A key issue with running the Waterfront Streetcar along a portion of the First Hill Streetcar tracks is that the two systems use different voltages. The Waterfront Streetcar electrical system is based on a 600 Vdc power supply, while the First Hill Streetcar would use a 750 Vdc power supply. While sharing power supply is technically feasible for short periods, for daily use it is recommended that the Waterfront Streetcar power supply system be converted to be compatible with the First Hill Streetcar system. This power supply system conversion is included in the capital cost estimates. Further detail on power supply systems is provided in the Waterfront Streetcar Re-activation Systems Assessment and Feasibility Report in Appendix C.

Overhead Contact System

The overhead Contact System (OCS) is the overhead wire system that delivers power to the streetcar vehicles. There would be differences between the two south terminus alternatives regarding OCS needs. With Alternative 1, which would connect to the First Hill Streetcar at 5th Avenue South and South Jackson Street, additional OCS equipment would be needed to make the connection from the Waterfront Streetcar to the First Hill Streetcar. This would include one crossing of an existing Metro electric trolley bus (ETB) OCS. With Alternative 4, which would operate on First Hill Streetcar tracks westbound on South Jackson Street between 5th Avenue South and 2nd Avenue South, more OCS equipment would be required. Because the First Hill Streetcar would operate wirelessly (without OCS equipment) in this segment of South Jackson Street, OCS equipment would need to be added on South Jackson Street and on 2nd Avenue South. This would require approximately seven crossings of ETB OCS lines.

Signals

In order for the Waterfront Streetcar and the First Hill Streetcar to operate on a joint system, a signal system would be required to control rail traffic between the two systems.
Revenue Service East of 5th

The Waterfront Streetcar would utilize the First Hill Streetcar tracks to access the operations and maintenance facility from the Waterfront Streetcar terminus. This could also present an opportunity to extend Waterfront Streetcar revenue service eastward along the First Hill Streetcar tracks on South Jackson Street. The following discusses issues that would be associated with extending Waterfront Streetcar revenue service on South Jackson Street east of 5th Avenue South.

The Waterfront Streetcar vehicles require a very high platform (2 ft. 1.5 in.) to provide ADA access. The First Hill Streetcar would use modern low-floor, streetcar vehicles and the platforms would be substantially lower (9.5 in.). As such, the station platforms for each would be at different heights and it would not be feasible for the Waterfront Streetcar to use the First Hill station platforms on South Jackson Street between 5th Avenue South and 6th Avenue South or between 7th Avenue South and 8th Avenue South. In addition, the First Hill Streetcar would utilize a combination of median and curbside stations with vehicles with doors on both sides. The Waterfront Streetcar vehicles only have doors on one side. As a result, the existing platforms are only on the west or south side of the tracks. This further reduces flexibility for locating new stations to serve the Waterfront Streetcar.

The only apparently feasible station opportunity for the Waterfront Streetcar east of 5th Avenue South, would be a station located on 8th Avenue South, after the streetcar would turn south of South Jackson Street on its way to the maintenance facility.
8. Maintenance Facility

A new maintenance and storage facility for the Waterfront Streetcar would be necessary in order to reactivate the streetcar service using the vintage 1924 W-2 vehicles originally from Melbourne, Australia. A detailed description of the maintenance facility and storage needs is included in Appendix C.

A maintenance facility for the Waterfront Streetcar vehicles would need to include the following:

- Protection from the weather, preferably a heated building, to protect five vintage vehicles.
- Two interior tracks.
- A service pit under at least one track.
- Room to store parts and equipment.

The planned First Hill Streetcar maintenance facility in the International District is scheduled for construction in 2012 and would be available for use in early 2013. The facility is planned to be constructed on one block of a Seattle Department of Transportation (SDOT) street maintenance facility site. The full site is approximately six square blocks.

The planned First Hill Streetcar maintenance facility is not large enough to accommodate the needs of the Waterfront Streetcar listed above or the five Waterfront Streetcar vehicles. It is sized to accommodate three modern streetcar vehicles inside the building and three more outside. In order to accommodate the maintenance needs of the Waterfront Streetcar, either an addition to the planned First Hill Streetcar car house or an entirely new building would be required.

There is a significant amount of space in the SDOT maintenance yard dedicated to parking and City vehicle storage. It is feasible to locate a maintenance facility for the Waterfront Streetcar within this site. However, it may require the construction of additional parking to accommodate displaced SDOT vehicle storage area.

Whether or not the Waterfront Streetcar is put back into service, the construction of the First Hill Streetcar maintenance facility provides an opportunity to build a permanent covered and powered storage space for the Waterfront Streetcar vehicles. If plans for the First Hill Streetcar maintenance facility were expanded to include space to store the Waterfront Streetcar vehicles, this would preserve both a short-term and long-term opportunity to utilize these vehicles. There may be some efficiency to be gained by programming the First Hill Streetcar maintenance facility site so that it can accommodate the expansion needed to facilitate the vintage streetcars or other additional vehicles.
9. **Capital Cost Estimate**

This section provides a summary of the cost estimate for capital elements that would be required to reactivate Waterfront Streetcar service. This estimate was developed using 2011 dollars to provide order-of-magnitude costs, using unit costs from similar projects in the Northwest.

The capital cost estimating methodology utilized several sources for determining quantities and unit prices. Google maps and field work were used to determine the traffic control equipment used at each intersection. The appropriate intersection treatment that would be required to facilitate adequate traffic control operations was based on this observation and discussions with City of Seattle staff. A field reconnaissance of the trackway was done to determine the type of work needed to be completed as well as the distances of track that would need to be replaced (Appendix A). Utility data was obtained from work being completed on the First Hill Streetcar.

Costs and quantities for various elements were derived from the systems analysis report prepared by LTK Engineering. Quantities for the existing system were obtained using online information for the retired Seattle Waterfront Streetcar. All unit prices listed without notes came from data obtained for similar streetcar projects, namely the First Hill Streetcar as well as the Portland Loop Streetcar project.

The capital costs are broken out by alternative with Alternatives 4A and 4B (which include a couplet on South Jackson and South Main streets) costing approximately $1.2 million more than an alternative that uses the existing streetcar alignment on South Main Street and 5th Avenue South. At the north end, a terminus in the vicinity of Broad Street (1A & 4A) would cost approximately $0.6 million more than a shorter alternative with a terminus at Bell Street (1B & 4B). The total capital costs range for reactivation range from $10.3 million to $12.7 million depending on alternative.

The detailed cost estimate spreadsheets are included as Appendix B.
10. Streetcar Operations

Operational Objectives
When the Waterfront Streetcar originated, the service objective was twofold: to operate a transit service that would connect multiple tourist and neighborhood destinations along the central Seattle waterfront and to operate a vintage streetcar line that would itself serve as a tourist amenity and destination. The transit function of the streetcar service was later enhanced when it was extended east along South Main Street so that it also provided a connection to the Pioneer Square neighborhood and the Downtown Seattle Transit Tunnel. Since 2005, when the streetcar service was suspended, the transit service has been replaced by interim bus service that closely matches the streetcar’s route along the central waterfront and roughly parallels the streetcar’s connection east to the DSTT and its International District/Chinatown station. A key benefit of the Waterfront Streetcar was that it provided a link between the ferry terminal and the bus and rail systems at the International District/Chinatown and King Street stations.

The original objectives of the Waterfront Streetcar service could still be met with reactivation of the streetcar service. Providing a stronger transit connection between the three stadium/exposition facilities south of King Street (Qwest Field, Qwest Field Event Center and Safeco Field) and the Washington State Ferry Terminal at Marion Street for stadium events is an additional goal for reactivation. The ability of a reactivated Waterfront Streetcar to meet this additional objective was discussed in Chapter 5 in the evaluation of the alternatives. Overall, of the four alternatives, Alternative 1B was found to have the greatest ability to restore the Waterfront Streetcar service to most of its previous service area, maintain and increase operational flexibility by slightly shortening the route to the north and maintain the ability to position streetcars for stadium events.

While the City has plans for an additional modern streetcar line along First Avenue, this would not provide the same direct link between the variety of waterfront tourist destinations, the ferry terminal and the larger transit system as a reactivated Waterfront Streetcar.

Operational Costs
King County Metro reported that in the last year of Waterfront Streetcar operations in 2005, total operating costs for the streetcar were $2.07 million. With over 10,110 train hours expended that year, this equates to just under $205 per operated train hour. With all four reactivation concept alternatives closely matching the operating scenario of the suspended service, similar operating costs could be expected for a reactivated service with the following changes or caveats.

Factors Increasing Operating Costs:
- Inflation – the operating costs per hour for the South Lake Union/Seattle Streetcar (modern streetcar) were recently assumed by the City of Seattle and King County Metro to be around $225 in 2009. Even though annual wage and other cost pressures have recently eased due to the lengthy recession, current streetcar operating costs per hour, in the Seattle market, could be reasonably assumed to be greater than $225 per hour.
- Additional operating hours for special/stadium events – providing additional peak-type transit service, whether for rush hour passenger loads or special event loads, can be costly due to work rules covering minimum shifts and other factors.
• Additional maintenance allowance – a small additional allowance may need to be provided in order to cover additional maintenance of signal systems as the service transitions beyond simple stop controls at numerous intersections along the central waterfront.

Factors Mitigating or Decreasing Operating Costs:
• Off-setting/replacing existing interim bus service – the reactivated streetcar could use the operating funds currently expended for the replacement bus service just as the bus service uses the funds previously allocated for the original streetcar service.
• Shorter route – the slightly shorter route outlined in alternatives 1B and 4B, with its terminus at Bell Street, maintains operational flexibility while decreasing any potential pressure on the operating schedule. This could limit the need (and costs) to operate an additional streetcar to maintain a schedule with a particular frequency of service.
11. Other Issues

This section provides detail on three specific areas related to the Waterfront Streetcar reactivation; traffic, vehicles and Americans with Disabilities Act (ADA).

Traffic

Reactivation of the Waterfront Streetcar would require some new or modified traffic signals at specific intersections in order to ensure safe operations. Rail crossing treatments may be required along the Alaskan Way segment and changes in directional flow and lane markings along South Main Street may also be necessary.

South Terminus Vicinity

Modifications to traffic operations that would be required in the vicinity of the southern terminus are discussed below and broken out by alternative.

Alternatives 1A and 1B

Under Alternatives 1A and 1B, which would reactivate the Waterfront Streetcar to the existing terminus and connect to the First Hill Streetcar at 5th Avenue South and South Jackson Street, the following changes would be required.

The existing signals at the 5th Avenue South/South Jackson Street and the 5th Avenue South/South Main Street intersections would require modification to enable the Waterfront Streetcar to turn safely.

South Main Street, which currently operates as one-way eastbound, would likely need to be converted back into a two-way street between Alaskan Way South and 5th Avenue South to enable two-way single-track streetcar operations.

Alternatives 4A and 4B

Under Alternatives 4A and 4B, which would operate eastbound on South Main Street from 2nd Avenue South to 5th Avenue South and westbound on South Jackson Street from 5th Avenue South to 2nd Avenue South, the following changes would be required.

The intersections of 5th Avenue South/South Jackson Street and 5th Avenue South/South Main Street would require signal modifications. In addition, a signal at 2nd Avenue South and South Jackson Street (currently stop-controlled), which is planned to be installed with the First Hill Streetcar project, would need to be modified. At 2nd Avenue South and South Main Street (currently stop-controlled), a new signal would need to be installed, both to give the Waterfront Streetcar an exclusive phase to safely make the turn and to communicate to the streetcar operator that the single-track section is clear of other streetcars.

The section of South Main Street from 2nd Avenue South to 5th Avenue South could continue to be one-way eastbound, however, from a traffic operations and driver expectations standpoint, it may not make sense for part of this street to be one-way and part of it to be two-way.
Alternatives 4A and 4B would require the Waterfront Streetcar alignment to swing toward the middle of 5th Avenue South in order to make the turn onto South Jackson Street westbound. This may require changes to the traffic lanes on 5th Avenue South to allow room for the streetcar to make this movement. Alternatives 1A and 1B would not require this.

**Alaskan Way**

There is a mixture of stop-controlled and signalized intersection treatments along the Alaskan Way portion of the Waterfront Streetcar line between South Main Street and the northern terminus. In addition to traffic signals, there are also several signalized pedestrian crossings. The Waterfront Streetcar tracks run parallel to Alaskan Way on the east side of the street in a right-of-way located between Alaskan Way and the Alaskan Way Viaduct. For much of the alignment there is a local access road underneath the viaduct providing parking access.

Between South Main Street and Wall Street, east-west streets tend to cross the Waterfront Streetcar tracks with minimal traffic control. On streets where there is a westbound approach across the tracks, there is typically a stop bar located east of the tracks (prior to the crossing), but there is no additional traffic control specific to the rail crossing. From Wall Street north, where the streetcar tracks are parallel to the active freight rail line, there are active gate controls at the crossings. The following describes the existing conditions at each crossing of the Waterfront Streetcar along Alaskan Way (shown in Figure 13).

**South Main Street**

At South Main Street, where the Waterfront Streetcar turns onto Alaskan Way South, the current configuration of South Main Street is one-way eastbound from the local access road under the viaduct to the east. It is one-way westbound from the local access road to Alaskan Way South. The Waterfront Streetcar crosses the local access road as it turns north onto Alaskan Way South. A signal may be required at this crossing, particularly if South Main Street is converted back into a two-way street, which would then add a westbound approach at this intersection.

**South Washington Street**

South Washington does not connect across the Waterfront Streetcar tracks. There is a signalized pedestrian crossing across Alaskan Way South at this location.

A pedestrian path, running parallel to the Waterfront Streetcar tracks, crosses the tracks north of South Washington Street.

**Yesler Way**

There is a signalized intersection at Alaskan Way and Yesler Way. This is also the auto entrance to the ferry terminal. At this point, the sidewalk on the east side of Alaskan Way is also on the east side of the Waterfront Streetcar tracks.
Figure 13: Traffic Configurations along Alaskan Way
Columbia Street

There is a signalized intersection at Alaskan Way and Columbia Street. Columbia Street is one-way westbound where it crosses the Waterfront Streetcar tracks. There is a sidewalk along the east side of the Waterfront Trolley tracks, as at Yesler Way, and a pedestrian entrance to the ferry terminal.

Marion Street

There is a signalized intersection at Marion Street and Alaskan Way. Marion Street is one-way eastbound from Alaskan Way, across the Waterfront Streetcar tracks. The western leg of this intersection is a one-way eastbound auto exit from the ferry terminal. The parallel sidewalk along the east side of the Waterfront Streetcar tracks continues at this location.

Madison Street

The intersection of Madison Street and Alaskan Way is signalized. Madison Street is one-way westbound. While the east side sidewalk remains east of the Waterfront Streetcar tracks, the Madison Street station is on the west side of the tracks, accessed via the crosswalk across Alaskan Way and the tracks.

Spring Street

The intersection of Spring Street and Alaskan Way is unsignalized. Spring Street is one-way eastbound, away from Alaskan Way. There are marked pedestrian crosswalks across Alaskan Way and Spring Street. As with the intersections to the south, the east side sidewalk is east of the Waterfront Streetcar tracks.

Just north of Spring Street, there is a temporary bus stop platform for Route 99 that has been constructed over the top of the existing Waterfront Streetcar tracks.

Seneca Street

Seneca Street is one-way westbound. It meets Alaskan Way at an unsignalized, stop-controlled intersection. There is one crosswalk across Alaskan Way on the north side of the intersection, as well as a crosswalk across Seneca Street. Again, the east side sidewalk is east of the Waterfront Streetcar tracks.

University Street

University Street is a two-way street. Its intersection with Alaskan Way is signalized, with pedestrian crossings at all three legs of the intersection. The east side sidewalk remains east of the Waterfront Streetcar tracks. The University Street station is located on the north side of University Street. As with the Madison Street station, it is located on the west side of the tracks and accessed from the crossing across Alaskan Way and the tracks.
Union Street

Union Street is a two way street. It does not go through to the east, so it only accesses the access road beneath the viaduct. Its intersection with Alaskan Way is stop-controlled. There is one crosswalk across Alaskan Way on the south side of the intersection. The east side sidewalk remains east of the Waterfront Streetcar tracks.

Pike Street

The local access road beneath the Alaskan Way Viaduct terminates just south of Pike Street. It crosses the Waterfront Streetcar tracks one-way westbound to a stop controlled intersection with Alaskan Way. This intersection has no pedestrian crossing across Alaskan Way.

Approximately 40 feet north of this intersection is Pike Street, which is a signalized pedestrian-only crossing of Alaskan Way, which connects to the Pike Place Hill Climb Walk. This is a major pedestrian access point between the Pike Place Market and the waterfront.

Just north of the Pike Place Hill Climb Walk signalized pedestrian crossing (approximately 5 feet), is an auto entrance to a parking area. This is one-way eastbound, away from Alaskan Way and is unsignalized. Just north of this is the Pike Street station, accessed as the Madison Street and University Street stations, from between Alaskan Way and the tracks. The east side sidewalk continues on the east side of the tracks. However, from this point north, there is an additional sidewalk on the east side of Alaskan Way and on the west side of the tracks.

Pine Street

At Pine Street, there is a stop-controlled intersection with a two-way street that accesses a parking area. There is no pedestrian crossing across Alaskan Way at this intersection.

Pedestrian Crossing 350 feet north of Pine Street

Approximately 350 feet north of Pine Street, there is an unsignalized pedestrian crossing across both Alaskan Way and the Waterfront Streetcar tracks.

Lenora Street Walk

At the equivalent of Lenora Street is the Lenora Street Walk, which is a pedestrian access between the waterfront and the Pike Place Market/Belltown area. There is a driveway intersection with Alaskan Way here. This stop controlled driveway crosses the Waterfront Streetcar tracks to access the parking area of adjacent residential buildings. There is a marked crosswalk across Alaskan Way on the north side of this intersection. It is unsignalized, but includes a flashing crosswalk sign.

Marriott Waterfront Entrance

At the equivalent of Blanchard Street, there is a stop-controlled driveway entrance to the Seattle Marriott Waterfront Hotel. This intersection includes an unsignalized crosswalk across Alaskan Way.
Bell Street

There is a signalized pedestrian crossing across Alaskan Way at Bell Street. This also crosses the Waterfront Streetcar tracks adjacent to the Bell Street station. The Bell Street station is on the west side of the tracks, adjacent to the sidewalk. The pedestrian path on the east side of the tracks terminates just north of the Bell Street station.

Each of these intersections provides a relatively unique case. Some may need new or modified auto or train signal equipment depending on the volumes of traffic, pedestrians, and the frequency of the Waterfront Streetcar service.

North Terminus Vicinity

North of Bell Street, where the Waterfront Streetcar alignment parallels the railroad, all intersections are gated. Some train signal equipment may need to be installed in this area for the Waterfront Streetcar to communicate with the gates. All of these intersections are north of Bell Street and, therefore, only Alternatives 1A and 4A would utilize them.

Alternatives 1A and 4A, which would terminate at Broad Street, would utilize the gated rail crossing that already exists. The Broad Street station, which was removed when the Olympic Sculpture Park was constructed, would be located on the north side of Broad Street in order to provide good pedestrian access to the waterfront and the Sculpture Park. If it is not feasible to put the station on the north side of Broad Street, and the station would need to be placed on the south side of Broad Street, then a pedestrian crossing would need to be added across Alaskan Way, south of Broad Street. This could be challenging because it could allow traffic queuing to wait for pedestrians to spill back into the active rail crossing on Broad Street. Alternatively, the terminus station could be built one block south at Clay Street, where there is an existing signal.

Alternatives 1B and 4B would avoid these issues by terminating at the Bell Street station.

Vehicles

The five rebuilt 1924-vintage Melbourne W-2 vehicles have been in storage since the decommissioning of the Waterfront Streetcar in 2005. The vehicles were inspected in February 2011 and found to be in excellent shape. None of the cars exhibited any conditions that would prevent them from returning to service immediately.

The vehicles would need to be thoroughly inspected and components would need to be cleaned and lubricated as appropriate. One concern with extended storage is the potential for the wheels and wheel bearings to exhibit flat spots. The wheels may need to be turned on a lathe to remove any such flat spots. See Appendix C for further detail on vehicle conditions.

Americans with Disabilities Act

The Waterfront Streetcar opened in 1982 prior to the adoption of the Americans with Disabilities Act (ADA) in 1990. Even so, the Waterfront Streetcar was designed to be the first fully accessible streetcar operating in the U.S. The station platforms were built as very high platforms and the vehicles were
modified to allow for mobility devices to enter without any special accommodations such as a deployable ramp.

URS reviewed existing ADA Standards for Transportation Facilities (effective November 29, 2006) to determine how compliant the station platforms would be with current standards. This review found some deficiencies that could pose a risk if not addressed as part of system reactivation. For example, some handrails are lower than the minimum allowable height, some platform edges are not properly protected by guardrails and there may be some deficiencies with regard to the width of the accessible routes through the platform areas.

The capital cost estimates in Chapter 8 do not include an allowance for ADA compliance. Further analysis would be needed to prepare a reasonable estimate.
12. **Recommended Reactivation Strategy**

There are no major physical, technical or operational impediments to potentially reactivating the Waterfront Streetcar to provide service between the northern waterfront area (cruise ship terminal and Victoria Clipper) and the Pioneer Square/Qwest Field area. One immediate stumbling block is the need for a viable maintenance and storage facility. However, opportunities exist to collaborate with the City of Seattle’s First Hill Streetcar Project to share the maintenance facility and develop storage facilities at a site near the International District.

The biggest obstacle to short-term reactivation of the Waterfront Streetcar is not the physical or operational elements, but rather the political and institutional ones. As described in Chapter 3, there are a variety of complex, interrelated construction projects planned to occur in the Central Waterfront area over the next seven to ten years. The Seawall Replacement Project, the Alaskan Way Viaduct Replacement Project and the Central Waterfront Project, will cause significant disruption in the waterfront area and will result in dramatic changes in the way the area is used by both residents and tourists.

The Waterfront Streetcar could be reactivated for a cost in the range of $10 - $13 million (depending on terminus and alignment choices). This price would include replacement of missing track sections, cleaning and rehabilitation of the station platforms, cleaning and rehabilitating the vehicles, new track and overhead contact system to connect with the First Hill Streetcar alignment, upgrades to the power supply, and traffic signal and crossing gate upgrades.

**The physical improvements needed for reactivation** are described in detail Appendix A and Appendix C. This presents a summary of the work that would be needed to reactivate service on the Waterfront Streetcar using the current vehicles primarily along the existing trackway.

- Open track sections need general clean up including removing debris on top of ballast surface
- Paved track sections need general clean up including removing debris on the track flangeway
- All station platforms need power washing, painting, tactile strip replacement and other minor upgrades
- Stone grind running rails to remove rust to restore effective vehicle wheels and rail interaction
- Repair portion of Yesler Way Asphalt Crossing - Paved Track. The track has settled and needs to reset rail, concrete ties and ballast
- Repair of drainage ponding at the end of curve paved track at Alaskan Way South and South Main Street
- Re-install the paved track at intersection of 1st Avenue South
- Cleaning, lubricating and testing switch points
- Re-commissioning electrical equipment tests for the existing Waterfront Substation and equipment replacement if needed
- New track, OCS and signal system to connect with First Hill Streetcar track
- Inspect, clean, test and lubricate all vehicle components
- Electrical component conversion to 750 Vdc
- Maintenance and storage facility improvements (assuming the First Hill Streetcar facility)
Short-term Waterfront Streetcar reactivation is dependent on having access to a maintenance and storage facility. This study has assumed that a Waterfront Streetcar maintenance and storage facility would be a shared facility with the First Hill Streetcar. The First Hill Streetcar is planned for completion in October 2013, and as such this report assumes that would be the earliest date at which Waterfront Streetcar service could be reintroduced. The maintenance facility improvements, new rail connections and physical upgrades needed in order to get the Waterfront Streetcar up and running could take up to one year to complete.

The 2013 timeframe is also when the City plans to begin construction on the seawall improvements and WSDOT begins construction of the Alaskan Way Viaduct replacement tunnel. As discussed in Chapter 3, the City and WSDOT have both assumed that the existing streetcar tracks along the east side of Alaskan Way would be removed and that the right-of-way would be available to provide construction flexibility during the five-year construction period. While it may be possible to reanimate Waterfront Streetcar service prior to significant construction activity along the waterfront, the duration of reactivated service could be limited based on current assumptions. The reactivated Waterfront Streetcar could provide an opportunity to help mitigate construction impacts along the waterfront by providing an additional option for travelers to get around the waterfront area during detours and lane closures.

The Public Facilities District should immediately engage the City, King County Metro and WSDOT in discussions to determine whether it would be feasible to accommodate the Waterfront Streetcar while the seawall and tunnel construction is underway and whether the Waterfront Streetcar could play a role in mitigating traffic impacts resulting from construction.

Short-term reactivation of the Waterfront Streetcar should be considered as the first phase of a longer-term strategy to provide transit service linking waterfront tourist destinations, ferry services, and other regional transit services.

Long-term Waterfront Streetcar reactivation should be considered as part of the Central Waterfront planning and visioning process. Even if Waterfront Streetcar service is not reintroduced in the short-term, the Central Waterfront plan should explicitly consider what role a Waterfront Streetcar could play in the revitalized Central Waterfront. This assessment should compare a Waterfront Streetcar alignment with a potential First Avenue Streetcar alignment in terms of cost, ridership, tourism, special events, transit network integration, economic development and visibility. This study could lead to a decision to include no streetcar, either a First Avenue or Waterfront line or both in the planning for the Central Waterfront. With a long-term reactivation strategy, many of the physical and operational attributes described in this technical memorandum would not be applicable. If a new Waterfront Streetcar track alignment was considered, the potential to utilize modern streetcars should also be considered. In addition, future extensions, such as to the cruise ship terminals at Piers 90 and 91, approximately two miles north of Broad Street, could be considered, as the Port of Seattle is reportedly interested in such an extension, which would serve 450,000 cruise ship passengers each year and connect them to the waterfront attractions and the transportation hubs on Jackson Street.

The Public Facilities District and its study partners should engage in the City’s Central Waterfront planning process to ensure that their interests and objectives related to potential Waterfront Streetcar reactivation are represented.
Seattle Waterfront Streetcar Reactivation Study

Appendices A, B, and C

April 21, 2011

Prepared for:
The Washington State Major League Baseball Stadium Public Facilities District (PFD)
The Washington State Public Stadium Authority (PSA)
The Seattle Mariners
First and Goal, Inc. (The Seattle Seahawks and The Seattle Sounders FC)

Prepared by:
URS
Appendix A – Detailed Physical Description
A. Existing Track Structure

a. Open Track. (Section A). Rail, top of tie, and top of ballast are exposed.
b. Paved Track. Paved Track is further classified by its surface finish as per listed below;
   i. Asphalt Paved Track (Section B)
   ii. PCC (Portland Cement Concrete)- Cast-In-Place - Paved Track (Section C)
   iii. PCC - Cast-in-Place, with paver red bricks, Paved Track. (Section D)
   iv. Pre-fabricated Rubber Crossing Panels Paved Track. (Section E)
   v. Pre-fabricated/pre-cast - Concrete Panels Paved Track. (Section F)
   vi. Bridge Deck Paved Track (Section G)

B. General Physical Description of Existing Track Structures for both Open and Paved Tracks;

a) Track gauge: 4’-8.5” except at special trackwork
b) Flangeway; Top Width =1 3/8”, Bottom Width = 1”, Depth = 1”.
c) Track rail section
   i. Open Track has Bolted 115RE rail section.
   ii. Paved Track appears to have continuous welded rail (CWR) 115RE rails
   iii. No 5 turnout running rails = 90LB rail section.
   iv. Main Street Bridge Deck uses low profile cut-off head of the 11RE rail section (CWR). Low Profile Rail Expansion Joints (Miter Cut) are provided across the Bridge Deck Structural Expansion Joints.
d) Track horizontal alignment. The route is mostly on straight tangent tracks except at the curvature turn (R=90’ Ls= 90’ Ea=0”) at Alaskan Way into Main Street and curvature turn (R=60ft, Ls =45’, w/ 2% superelevation ) at Main St into 5th Avenue South. (The existing 60ft radius might be too tight for Modern Street Car Vehicle’s minimum 65.62ft (20M) turning radius operating capability.

e) Track Vertical alignment; Route profile is almost level at Alaskan Way. Uphill in the east direction on Main Street with maximum +8% grade on Main Street and downhill at -6% on 5th Ave. Vertical sags (low points where no track drains are provided) occur at the following road locations:
   i. East of 1st Avenue South intersection.
   ii. At midblock between Occidental and 2nd Avenue South.
   iii. East of 2nd Ave Extension South.
f) Track Supports.
   i. Open Ballasted track uses concrete cross tie on ballast.
   ii. Paved Ballasted track uses timber cross ties on ballast embedded or covered with pavement material. (ie. Asphalt, Concrete or Rubber)
   iii. Bridge Deck Track low profile running rail is welded and supported by ¾” thick x 10 ½” wide longitudinal continuous steel base plate with continuous resilient rubber base pad. The base is anchored on to the bridge using ¾” anchor bolts drilled and epoxy grouted on to the bridge deck.
g) Track bumping post is provided at the end of the line at 5th Ave. and Jackson. It appears there is no surface drainage inlet under the Bumping Post.
h) Track Drainage: Longitudinal running 6 inches diameter perforated slotted underdrain pipes were provided under both open and paved tracks at the bottom of aggregate sub ballast layer. No track drain appurtenances with surface grating opening are provided anywhere in the paved track area.
i) Existing Track Structure Stray Current Control Description;
   i. Existing open ballasted track appears to provide minimal stray current control. If track is clean of debris, some stray current control could be provided by the concrete tie’s rail insulating base pad, by spring clips with rail plastic insulator and by setting ballast 1” below top of rail, but it appears the bolted rails joint connection is not bonded with rail jumpers and the track’s rails are not cross bonded to maintain equal potentials on all rails. It also appears that the asphalt paving on the open track is in contact with the rail, providing a direct stray current path to earth.
   ii. Existing paved track installation does not provide stray current control as embedded rails are not encapsulated with rubber rail boots and/or the paved track slab is not encased with insulating membrane. Paved track infill surface pavement materials (concrete or asphalt) are in direct contact with the rails.
   iii. It appears the non-insulated track installation is intended for train operation that maintains an operating voltage within an acceptable limit in that it minimizes the generation of stray current as the vehicle moves away from the power source.

a. Existing Track Structure Electrical Insulation description;
   iv. Existing Open Ballasted track concrete ties has rail insulating base pad, spring clips rail plastic insulator and ballast can be set at 1” below top of rail after clean up.
   v. Existing open track paved road intersection is not provided with rail isolation rubber boot. The paved track asphalt materials are indirect contact with running rails providing direct stray current path to earth.
   vi. Existing Paved Track rail is not encapsulated with rubber rail boots and/or paved special trackwork metals and slabs are not provided with any insulating membrane material.

b. Passing tracks,
   i. Passing track on Open Track section on Alaskan Way is located in the north side of Union St intersection.
   ii. Passing track on Paved Track section on Main St is located in the midblock area between 2nd Ave S and 2nd Ave Ext. S.
   iii. Use AREMA No. 5 Turnout (modified for Melbourne W-2 wheels) for tie-in into the mainline track. Track gauge is widened to 4'-9" at the frog turnout side.
   iv. The Paved track No 5 turnout special trackwork is embedded in roadway utilizing the same cast-in-place paved track structures construction.
   v. The No 5 turnout switch point uses an embedded switch stand with spring head rod. (Switch points need to be clean up, tune up and/or testing.)
   vi. Special trackwork track infill slab is poured with light aggregate concrete that is in direct contact with the switch points and stock rails, providing little resistance between negative return circuit and earth.

C. Classification of Existing Track on Alaskan Way; (See attached Figure 1 for location.)
   a) Open Ballasted Track Structures on midblock section between Broad St and Main Street. (Section A)
   b) Asphalt Paved Track vehicular crossings at most intersections between Broad St to Columbia St intersections. (Section B)
   c) PCC Cast in Place with red Brick Paver Paved Tracks for pedestrian crossing at intersection of Washington St. (Section D) (*Architectural
Bollard Pole Barriers are installed in the field sides to prevent vehicular crossings.*

D. Classification of Existing Track on Main St and on 5th Ave South. Section C (See attached Figure 1 for location.)

a) PCC Cast in Place Paved Tracks between Alaskan Way and 1st Ave. (Section C)
b) Paved Track is removed across 1st Avenue South.
c) PCC Cast in Place Paved Tracks between 1st Ave and Occidental St (Section C)
   a. PCC Cast in Place with "Red Brick Paver" Paved Tracks on Main Street on Occidental Avenue South intersection. Red Brick Paver in the field sides. (Section D)
   b. PCC Cast in Place Paved Tracks between Occidental Avenue and 2nd Avenue S. (Section C)
c) Pre-fabricated Rubber Crossing Panels Paved Track at 2nd Avenue S intersection. (Section E)
d) PCC Cast in Place Paved Tracks and Passing Tracks between 2nd Ave South and 2nd Ext Avenue. (Section C)
e) Pre-fabricated/Pre-Cast Concrete Crossing Panels Paved Track at 2nd Ave South intersection through 3rd Avenue South intersection. (Section F)
f) Bridge Deck Paved Track on Main Street Bridge. (Section G)
g) PCC Cast in Place Paved Tracks between east Main Street Bridge approach to the end of track at 5th Avenue and Jackson St. (Section C)

Description of Existing Tracks Required Rehabilitation and/or Repair before Re-Activation.
   a) Major (Mandatory) Repair;
      i. Open Track needs general clean up. Removed all debris on top of ballast surface. Clean Station Stop Platform. (Power Wash)
      ii. Removal and to rebuilt the paved track being currently used as Bus Stop platform in the north side Spring St.
      iii. Paved Track general clean up to removed all debris on the track flangeway. Cleaning of Station Stop Platform. (Power Wash)
      iv. Stone grind running rails, except at the turnout switch points and frog area, to removed rust to restore effective vehicle wheels and rail interaction.
      v. Repair portion of Yezler Way Asphalt Crossing - Paved Track. Track has settled and needs to reset rail, concrete ties and ballast. Approximate track length that needs repair = 20ft to 30ft.
      vi. Repair of drainage ponding at the end of curve paved track at Alaskan Way and Main Street.
      vii. Re-install the paved track at intersection of 1st Ave South...
   b) Minor Repair;
      i. Repair broken patches of “red brick pavers” at Occidental Ave intersection ....
      ii. Review of the precast concrete panel integrity at intersection of 2nd Ave Ext S and 3rd Ave S.
      iii. Repair broken infill pavement/grout at the rail expansion joints location at both side of the Main St bridge deck approach.
      iv. Repair or find solution to prevent drainage runoff under the bumping post that flows across the sidewalk surface on Jackson Street.

Reference:
Appendix B – Capital Cost Estimate Worksheets
### Seattle Waterfront Streetcar Reactivation Study
#### Order of Magnitude Cost Estimate

**Route Miles**: 1.67  
**Cost/Mi**: $6,381,976  
**All costs in 2011 dollars**

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**Cost Summary**

<table>
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<th>% of Total Cost</th>
<th>Summary Total</th>
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<td>27.0</td>
<td>Preliminary Engineering</td>
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<td><strong>Total Project Cost</strong></td>
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</table>

**Notes:**
1. Unit Price is Average of Mean and High Prices listed in the estimate in the 'Waterfront Streetcar Re-activation Systems Assessment and Feasibility Report' prepared by LTK Engineering Services
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7. Unit price is listed in the estimate under 'Signature' from the LTK Report
8. Unit price is listed in the estimate under 'Joint Use FHS Facility' from the LTK Report
9. Unit price is listed in the estimate under 'Signal Options' from the LTK Report. It is assumed that these will be placed at all intersections along Alaskan Way with no existing signals.

Waterfront Streetcar Estimate.xls

URS Corporation
3/11/2011
# Seattle Waterfront Streetcar Reactivation Study

## Order of Magnitude Cost Estimate

### Route Miles = 1.26  Cost/Mi = $7,928,674  All costs in 2011 dollars

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost Category</th>
<th>Quantity</th>
<th>Units</th>
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<th>Subtotal</th>
<th>E&amp;A %</th>
<th>E&amp;A Cont %</th>
<th>Unallocated Contingency</th>
<th>Summary Total</th>
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### Cost Summary

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<th>E&amp;A Cont %</th>
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### Total Project Cost

$10,268,048

---

**Notes:**
1. Unit Price is Average of Mean and High Prices listed in the estimate in the ‘Waterfront Streetcar Re-activation Systems Assessment and Feasibility Report’ prepared by LTK Engineering Services
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7. Unit price is listed in the estimate under ‘Signal’ from the LTK Report
8. Unit Price is listed in the estimate under ‘Joint Use FHSC Facility’ from the LTK Report
9. Unit price is listed in the estimate under ‘Signal Options’ from the LTK Report. It is assumed that these will be placed at all intersections along Alaskan Way with no existing signals.

---

*Waterfront Streetcar Estimate.xls*

*URS Corporation 3/11/2011*
### Seattle Waterfront Streetcar Reactivation Study

#### Order of Magnitude Cost Estimate

**Route Miles:** 1.80  
**Cost/Mile:** $6,855,354

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost Category</th>
<th>Quantity</th>
<th>Units</th>
<th>Unit Price</th>
<th>Subtotal</th>
<th>E&amp;A %</th>
<th>E&amp;A Cont %</th>
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<td>$80,000</td>
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**Notes:**

1. Unit Price is Average of Mean and High Prices listed in the estimate in the 'Waterfront Streetcar Re-activation Systems Assessment and Feasibility Report' prepared by LTK Engineering Services
2. Unit Price is listed in the estimate under 'OCS Preventative Maintenance' from the LTK Report
3. Unit Price is listed in the estimate under 'New OCS for FHSC Interface' from the LTK Report
4. Unit Price is the sum of the items listed in the estimate under 'Traction Power Substation' from the LTK Report
5. Unit Price is the average of the sum of the items listed in the estimate under 'Traction Power Options' from the LTK Report
6. Unit price is the sum of the items listed in the estimate under 'Vehicles' from the LTK Report
7. Unit price is listed in the estimate under 'Signal' from the LTK Report
8. Unit Price is listed in the estimate under 'Joint Use FHSC Facility' from the LTK Report
9. Unit price is listed in the estimate under 'Signal Options' from the LTK Report. It is assumed that these will be placed at all intersections along Alaskan Way with no existing signals.

**Total Project Cost:** $12,716,672

**Profession Services Total:** $352,366

**Cost Summary:**

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**Total Profession Services:** $352,366

**Total Project Cost:** $12,716,672
# Seattle Waterfront Streetcar Reactivation Study

## Order of Magnitude Cost Estimate

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### Notes:
1. Unit Price is Average of Mean and High Prices listed in the estimate in the "Waterfront Streetcar Re-activation Systems Assessment and Feasibility Report" prepared by LTK Engineering Services
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4. Unit Price is the sum of the items listed in the estimate under 'Traction Power Substation' from the LTK Report
5. Unit Price is the average of the sum of the items listed in the estimate under 'Traction Power Options' from the LTK Report
6. Unit price is the sum of the items listed in the estimate under 'Vehicles' from the LTK Report
7. Unit price is listed in the estimate under "Signal from the LTK Report"
8. Unit Price is listed in the estimate under 'Joint Use FHSC Facility' from the LTK Report
9. Unit Price is listed in the estimate under 'Signal Options from the LTK Report. It is assumed that these will be placed at all intersections along Alaskan Way with no existing signals.'

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**Total Project Cost:** $12,046,775
Appendix C – LTK Report
Waterfront Streetcar Re-activation
Systems Assessment and Feasibility Report
Traction Power, Stray Current, Overhead Contact System, Vehicles, and Joint-Use of SDOT Maintenance Facility

Prepared By:

LTK
LTK Engineering Services

In Conjunction with:

URS

March 4, 2011
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Waterfront Streetcar Systems

This report provides an assessment on the current conditions of existing Waterfront Streetcar (WFSC) Systems infrastructure, including the traction power substation, corrosion, the overhead contact system, and the Melbourne W2 Trolleys. It also provides a high level assessment for interfacing with the First Hill Streetcar Project currently in design by the Seattle Department of Transportation (SDOT). This assessment includes the systems interface as suggested by Alternatives 1 and 4, the employment of a signal system, and joint-use of the SDOT First Hill Streetcar maintenance facility. Finally, a high-level cost estimate is provided with a breakdown by each system for the reactivation of the WFSC system.

Traction Power Substation

The Waterfront Streetcar has one traction power substation (TPS) - WFSC RECT #20 located on the east side of the alignment between the Waterfront Landings Condominiums at Virginia Street and the BNSF tracks. The substation has a 500kW rectifier with a nominal output voltage of 600Vdc. It is equipped with a transformer/rectifier/switchgear unit, an ac supply cabinet for the incoming utility, battery and charger, remote terminal unit (RTU) and low voltage ac and dc electrical panels.

The current condition of the substation building enclosure is fair to good, with minor corrosion on the air intake louvers on the personnel entry doors and the ventilation screen on the north side of the building. These items can be easily repaired with new paint and/or new hardware and does not impact possible re-energization of the TPS.
There are some missing components in the TPS including batteries and charger for 125Vdc control power and a Device 82 reclosure relay. The 125Vdc is used for protective relaying devices, switchgear controls and RTU. The Device 82 is used to close the ac breaker remotely and after a load measuring test sequence. These components are readily available but must be replaced prior to energization for the protection of the traction system.

The ac supply cabinet and the transformer/rectifier/switchgear unit appear to be in good condition. No physical damage or corrosion was found on the equipment; although, the equipment and bus bars were dirty and should be properly cleaned before re-commissioning. The ac circuit breaker should also be lubricated and tested prior to initial re-energization of the transformer.

During the inspection, it was noticed the transformer was left unheated. Temperature variations during the winter and spring months may have left the transformer susceptible to moisture, which if not heated can lead to a failure. Heat should be applied within the TPS for several days to eliminate moisture and commissioning tests must be performed as recommended in the sections to follow prior to energization.
Positive and Negative Conductors
Waterfront Streetcar TPS has two sets of feeder conductors which connect the substation to the overhead contact wire. One feeder is connected at Alaskan Way & Virginia Street, and the other at Alaskan Way and South Main Street; both consist of 2-750kcmil aluminum cables each. The Virginia Street cables run underneath the Waterfront Landings Condominiums in duct banks before terminating at a feeder pole. The South Main Street cables utilize the Alaskan Way Viaduct and run beneath the lower deck to extend to the feeder pole. After inspecting the cables, they appear to be in good condition; though cable insulation tests should be performed to measure their serviceability and determine if some replacement if necessary.

Considering the South Main Street feeder is installed on the viaduct, the demolition of the structure will ultimately cause the streetcar to lose this feed. Feeders are typically installed and spaced along the alignment so that voltage provided to the vehicles is maintained above a minimum operating limit. Removing the feed may result in the traction power system not being able to sustain voltage on the contact wire to maintain operation in south end of the alignment. A detailed analysis of the system would be necessary to determine if this would be the case.

King County Metro International District Station (IDS) Substation
It may be advantageous to connect the unused traction power substation (TPS) in the Downtown Seattle Transit Tunnel (DSTT) which was decommissioned in 2005 when the electric trolley buses were removed from the DSTT. This could provide a potential source of power for the northerly end of the WFSC line. The substation is in excellent condition and has the proper dc
voltage required for operation of the waterfront line. It is a short distance away for the terminus of the WFSC and the connections to such could be made with minimal investment.

Utilization of the IDS substation could potentially eliminate the need for the 2,000 ft supplementary cable from the Waterfront Streetcar substation thus opening the potential for the short line operation between Jackson Street and the ferry terminal during construction of the viaduct replacement.

Routing of the positive and negative cables from the existing IDS to the WFSC could potentially utilize the existing DSTT tunnel conduit, an existing feeder conduit run to the street or by installing new conduits. This is partially discussed in the OCS section to follow, but would require further study and investigation to determine its feasibility. The total distance from IDS substation to the WFSC is approximately 250 cable feet.

Re-commissioning Tests
In order to assure that the existing Waterfront Substation (#20) equipment is serviceable, it will be necessary to perform a series of electrical equipment tests primarily consisting of the following:

- Ac Switchgear Dielectric Test – Measures the insulation of the Ac Switchgear.
- Transformer Turns-to-Turns Ratio (TTR) – This test measures the turns-ratio of the transformer. A ratio that does not correlate to the design ratio may indicate a short inside the transformer.
- Transformer Hi-Pot – Measures the insulation level of the transformer.
- Rectifier Hi-Pot – Measures the insulation level of the rectifier.
- Control Wire Megger – Measures the insulation resistance of the low voltage control wire.
- Operational Tests of all Controls and Indications
- Protective Relay Test and Set – Verifies the protective devices are suitable for use.

In the event test results indicate equipment will not be serviceable, replacement of components may be all that is necessary to re-commission the substation. A complete replacement of the substation appears to be unlikely.

Corrosion
Rails are an important component to the traction power system in that they act as the negative return path to the TPS from the vehicles. Being the rails are not insulated and on occasion embedded in the ground, there is some concern for stray current and corrosion associated with operating the streetcar system.

Open Ballasted Track
After inspecting the track, the existing open ballasted track appears to provide minimal stray current control. This condition has existed for years since the inception of WFSC operation. Some stray current control could be provided through the insulating base pad beneath the concrete ties, spring clips with rail plastic insulators, and re-leveled ballast 1” below top of rail. But this assumes the tracks are clean of debris.

In addition, bolted rail joints are missing bonds and cross bonds have been cut out along the alignment. These bonds should be replaced in order to maintain equal potentials on all rails and a low resistance path for return current to the substation. Missing bonds will exacerbate the stray current issue as current will find alternative paths through the ground to return to the substation. Bolted rail joints are common failure areas and rail breaks are a significant source of stray current. The use of rail insulators and ballast tamping will help to control stray current.
**Existing Paved Track**

The existing paved track installation does not provide any stray current control since embedded rails are not encapsulated with rubber rail boots and paved track slabs are not encased with insulating membranes. Paved track infill surface pavement material (concrete or asphalt) is in direct contact with the rails. This type of track construction will lead to significant levels of stray current as track buried directly in concrete/asphalt is essentially grounded. This condition has also existed since the inception of the WFSC operation.

Trolley operations typically display lower levels of stray traction current due to their less frequent service and low power draws in comparison to light rail transit systems. Substations placed closer together also help to reduce the levels of stray traction current.

![Figure 4 – Partially Embedded Track with Debris between Rails](image-url)
The Overhead Contact System (OCS) is the collection of overhead wire, crossings, insulators, poles and cantilevers used to deliver power the waterfront streetcar. The wire extends from Broad Street and Alaskan Way on the north end, to 5th Ave S and South Jackson at the south terminus. The overall condition of the OCS is good with no items requiring immediate attention; however, the OCS should be closely inspected and maintained as necessary to check the details of the system prior to its reactivation.

Required OCS inspections and maintenance for commissioning:
- Re-registering of the contact wire
- Insulator checks
- Cleaning insulators and crossings
- Replacing damaged insulators
- Checking contact wire wear
- Removal of debris on the wire
- Checking feeder cable connections to the contact wire
- Loop test – Checks for circuit continuity

Alternative 1 – Tie at 5th Ave S and S Jackson
As for new OCS required at the interface reflected in Alternative 1, the design effort would require incorporating OCS crossings for the existing Metro electric trolley bus (ETB) OCS and First Hill streetcar OCS before tying the Waterfront OCS into the eastbound and westbound First Hill Streetcar tracks. The design would also consist of new poles with the assumption that joint-use poles could be used to erect the portions of the installation. In addition, a section insulator and insulated rail joints would be required to isolate the two systems as the Waterfront Streetcar system is grounded and the First Hill Streetcar system is not. Additionally, the two systems utilize different operating voltages and dc overcurrent protection equipment.
Alternative 4 – Loop around 5th Ave S, S Jackson, and Occidental

For Alternate 4, new OCS must be designed and installed from 5th Ave S to 2nd Ave S in the westbound direction as the current design for the First Hill Streetcar is for wireless operation in this area. This design will require approximately seven crossings for the streetcar/ETB interfaces between 5th and 2nd Ave S, in addition to new poles, span wires, and pole foundations. Alternative 4 would also require section insulators and insulated rail joints to maintain separation between the two streetcar systems.

OCS Installation from International District Station (IDS) Substation

For the potential feed provided by Metro’s IDS substation as described herein, a new feeder pole would be installed at the northwest corner of 5th Ave S and S Jackson St where the existing ETB feeder is located. This would require that the existing pole be removed from its foundation, and the foundation core-drilled through deck of the Jackson Street Bridge. After completion of the drill, a feeder cable could be installed from the TPS below and out to the feeder pole. The cable would then be run aerially on a cross span to another OCS pole for connection to the Waterfront Streetcar contact wire across S Jackson Street near the Station.

Signals

Waterfront and First Hill Streetcar Interface at 5th and Jackson

If the Waterfront Streetcar and First Hill Streetcar alignment are conjoined for joint operation, the interface will require a signal system to control rail traffic between the two systems. An advanced interface system would require one powered embedded switch machine with an over-switch track circuit and a TWC loop at the Waterfront Jackson Street Station on 5th Avenue, and another switch on Jackson Street along the First Hill Streetcar alignment. The over-switch track circuit is used to prevent the movement of the switch under a trolley or streetcar and the TWC loops allow the trolley operator to set routes and request any special traffic phases to move a trolley to and from the First Hill Streetcar Line.

A low cost option would be to add a hand throw switch at the diverging points where the trolley would be exiting the First Hill Line and entering the Waterfront Line. Any special traffic phases could be requested by a key switch at the junction.

Street Crossings Equipment

If reactivation of the Waterfront Streetcar requires installation of additional street crossing equipment along Alaska Way, crossings might be required which could include two gate mechanisms with flasher assemblies to warn and protect the vehicles at the crossings. Most locations could also require two additional multi-flasher assemblies mounted on mast at the other two quadrants to warn and protect the pedestrian and bicycle traffic. Static signage, such as cross-bucks, number of tracks, look both ways and other pavement markings would also need to be added to each crossing.

In addition, gates and flashers would require a crossing case mounted at each crossing, which consists of track circuits, an electronic crossing controller, backup batteries and charger, an event recorder, and other equipment to interface with the gates, flashers, and rail connections for the track-circuits. Crossing cases would require a Seattle City Light power drop or an alternative power source along the right-of-way.

Crossings will also require total of approximately one hundred feet of conduit and cabling would need to be installed from the control case to the gate mechanisms and flasher units for each crossing. Also, a total of approximately five hundred feet of conduit and cabling would need to be
installed to make the four track connections for three track circuits that would be required at each crossing.

It should be noted that the WFSC has never employed the use of street crossing protection equipment.

**Lockable Key Switches**
Lockable key switches or pushbuttons would need to be added to the Maintenance Facility interface for the trolleys to call routes, if TWC equipment is not added to the trolleys.

**Vehicles**
The Waterfront Streetcar system had a fleet of five double-ended streetcars imported from Melbourne, Australia and typically had up to three cars running at one time when it was in operation. All five cars are rebuilt 1924-vintage double truck cars and can carry up to 43 seated and 40 standing passengers. Accommodations for one wheelchair space were added and original running boards and step-up entries were removed when the cars were rebuilt. Passenger stations utilize high-level platforms; thus it was not necessary to equip the cars with deployable ADA car-to-platform bridging ramps. The cars were also reconfigured with doors on only one side.

![Figure 6 – Waterfront Streetcar 482 Stored in Warehouse](image)

Figure 6 – Waterfront Streetcar 482 Stored in Warehouse
Field Inspection of the Streetcars

LTK personnel inspected the cars on February 22, 2011. The cars are in excellent condition, stored in a dry warehouse and exhibit no significant deterioration from storage. We were escorted by Mr. Elie Kourdahi, Vehicle Maintenance Manager at King County Metro – Central Base. Mr. Kourdahi was very knowledgeable on the condition of the cars; and in fact, wrote a comprehensive maintenance manual for the cars (they had not previously had one) complete with professionally drawn electrical schematics and videos on performing critical maintenance tasks.

Our inspection looked for:

- Wetness (due to storage), wood rot, and metal corrosion.
- Warped and/or delaminated wood panels and structures.
- Signs of leakage (staining, blistered paint)
- Condition of seats, glass and flooring.

None of the five cars exhibited any conditions that would prevent them from returning to service immediately. The worst damage from storage is very slight. One car is parked under a hatch in the warehouse roof that has leaked. Some staining on the side of the car is evident. This can be removed by wax and buffing, assuming it is attended to sooner than later. This was the only (isolated) damage we found.
Mechanical Condition
There was no power available in the warehouse to power up the vehicles and test them. Visual inspections indicate no missing parts or components, very little rust, and no oil puddles under the gear boxes. Components that could be moved by hand moved freely. Mr. Kourdahi stated that all cars were running when taken out of service, and had been maintained right up until end of service. We saw nothing that would indicate otherwise.

However, one issue that may be of concern is when a vehicle is allowed the sit without occasional movement, wheels and wheel bearings may exhibit flat spots. This is simply due to the weight of the car compressing the steel. It is not possible to see this damage, but noise of the wheel flats will be evident during operation. The wheels may be turned on a lathe to remove the flat spots. The bearings would likely continue operation, but with a possibly shortened life.

Electrical Condition
As mentioned above, we did not have power available in the warehouse to power up the cars. Our inspection was primarily visual. We note that all five cars appear to have all electrical equipment intact with no parts removed during storage. Electrical components and wiring appear to be in good condition. Exposed wiring did not exhibit any damage from storage.

One major issue with old motors and electrical devices when left in extended storage is their propensity to absorb moisture. Prior to application of high voltage dc power to the cars, motors should be dehumidified. This includes the application of low voltage power to the motors to dry the internal windings and thermal heat should be applied to the car’s interior. Finally, a general inspection should be performed prior to bringing an old electrical system back to life.

Spare Parts and Shop Equipment
It appears that all the basic tools and equipment necessary to maintain the cars were stored in the warehouse with a significant quantity of spare parts. The parts and tools are stored in large crates and were well protected. We looked into the crates but did not unpack them to get a true count of components. Nevertheless, we were satisfied that the condition of the cars, the parts, and the tools to allow for operations to resume.
**Reactivation Requirements**

All work should be performed by qualified personnel. All safe work practices and specific safety procedures regarding work on these vehicles should be reviewed prior to commencing the reactivation program. To put the cars back into service, aside from a good interior and exterior cleaning, the following minimum steps should be taken:

**Electrical:**
- Open all electrical boxes and pull covers from all electrical components. Inspect for corrosion (remedy if found) and pack with desiccant bags. Reclose covers. Desiccant bags should remain in place thru the reactivation period, being removed just prior to starting the cars.
- Install space heaters in the car interior. Heat car for 72 hours and bring to approximately 70° F.
- Block the rotor and apply a low voltage current source to the windings of the traction motors and compressor motor and heat up the motors. This will require special reactors or transformers and should be done only by a qualified electrician with experience in motor drying and repair.
- Inspect all wiring.
- Perform meg/ohm test on all power wiring.
- After completion of motor drying, perform meg/ohm test on all motor windings.
- Clean adjust and lube operator’s drum controller.
- Re-varnish controller drum.
- Clean & inspect arc shields.
- Re-attach trolley poles and pole ropes.
- Check trolley poles and shoes, and lubricate pole base.
- Check pole rope re-winder for proper operation.
- Clean line breaker contacts.
- Check resistor banks.
- Install new battery in each car.
- Check charging system and alternator.

**Mechanical:**
- Check all brake pads, replace as necessary.
- Check and adjust brakes.
- Lubricate all brake linkages.
- Change compressor oil.
- Drain air tanks.
- Inspect brake cylinder for moisture and re-lubricate rods and packing.
- Hand rotate air compressor, check for binding, pre-lube the cylinders, start under power.
- Pressurize system and check for leaks (air & fluid).
- Manually release safety valve to assure it works freely.
- Check all compressed air valves and brake controls for proper operation.
- Perform routine service on brake control valve.
- Perform static test on brake system to assure operation.
- Inspect wheel bogies for damaged or loose parts.
- Inspect & fill sanders.
- Inspect wheels for flat spots, cracks and spalling.
- Drain and refill bull gear lube to proper level.
- Lube motor journals, stuffing boxes.
- Lube and re-pack outer axle journal boxes.
- Lube bolster plates.
- Inspect undercarriage.
General Condition – Check all of the following:
- Lights.
- Gauges.
- Heaters.
- Air Leaks.
- Wipers.
- Whistles & Bells.
- Doors & Windows.
- P.A. System.
- Tachograph.
- Fire Extinguishers.
- Check Lifeguard Gates.
- After successful start-up and operation of each car, take to an outdoor location and check for roof and window leaks using a high volume water hose.

Car should be taken on its maiden run by a veteran operator who is knowledgeable in car’s operation and braking.

We estimate approximately two weeks per car to reactivate. The labor would involve at a minimum two qualified technicians and some allowance for materials. In addition to reactivation costs, there will need to be transport from the storage warehouse to the Waterfront track.

**Operating Voltage**

As a part of this study, we were asked about operating the Waterfront Streetcar on the soon to be built First Hill Streetcar line.

The Waterfront Streetcar electrical system is based on a 600 Vdc nominal power supply, which is meant to be more descriptive than scientific. A 600 volt traction power system is generally operates between 400 and 800 volts. The dc traction motors can generally handle up to 150% of nominal rating (or 900 volts) for brief periods; thus some safety margin is provided above the operating range.

A 750 Vdc traction power system operates in similar fashion with the lower voltage limit at around 525 Vdc and an upper limit at about 950 Vdc. The question of whether a 600 Vdc vintage car could operate on a 750 Vdc modern streetcar line does not have a single concise answer. Rather than go into great technical detail in this report, we provide the following comments:

Vintage cars could run the risk of being exposed to voltages near or above the upper limit of the operating voltage range due to the no-load voltage of a 750 Vdc system which rides around 795 Vdc. Operating conjointly with modern streetcars can further expose the vintage cars with voltages of up to 950Vdc from brake regeneration. If daily use of the 750 Vdc were anticipated, we would advise converting the car’s electrical components to accommodate the higher voltage.

To do a proper conversion, wiring and components should be replaced with 1000 V rated components to stay within electrical code practice. Traction motors and the compressor motor would also require re-winding and possibly a higher level insulation.

**Maintenance Facility**

Our current understanding is that there is a desire to put the cars into service in the near term. Thus, the choice of how and where to maintain the cars may be time critical. The features of such space must include:
• Protection from the weather, preferably a heated building with two interior tracks. Such building could be as small as 40 feet by 150 feet.
• Two interior tracks required.
• An inspection pit under one track to inspect brakes and make small repairs on undercar equipment.
• Room within the building to store parts and equipment.

We looked at the following possibilities for storage and repairs:

1. Joint-Use First Hill Streetcar (FHSC) Maintenance Facility
2. Use of a Temporary Structure at the FHSC Maintenance Facility Site
3. Use of a Temporary Structure adjacent to the WFSC alignment

**Joint-Use First Hill Streetcar Maintenance Facility**

This facility is currently under design and will be constructed in 2012 with scheduled availability in early 2013. This may not be soon enough to satisfy the needs of a near term operation. There are also several potential issues that would need resolution:

• The FHSC car house is not physically large enough to accommodate the addition of 5 cars. At minimum, two new storage tracks would be required off 8th street.
• We do not recommend outdoor car storage. These vintage cars do not fair well over time without heated storage and repair space. Thus, we would recommend the storage tracks be covered. The FHSC car house does not contain enough space to accommodate the addition of the 5 vintage cars. An addition to the FHSC car house covering the two tracks could be made.
• Space at the FHSC Maintenance Yard is at a premium. The additional storage tracks and building footprint will displace other yard activity. Some cost to aiding in displacement / relocation may be required of the Waterfront Streetcar by the City (FHSC was required to build a parking deck to accommodate displaced vehicles from the city storage yard).

**Use of a Temporary Structure at FHSC Maintenance Facility**

A faster approach with lower initial costs could be to use a stressed membrane structure. These are modern day versions of a circus tent built with a computer designed aluminum frame and a hybrid polyurethane membrane skin. These are used extensively by the military although they can be seen in use as churches, school additions, and even gambling casinos. They require very little time to erect, minimal foundation (can be anchored to a rigid concrete floor slab), and can be relocated at a later date. The dominant manufacturer of these structures is the Sprung Structures Company of West Jordan, Utah.

These structures are durable. They seem to stand up well to desert blowing sands in military use. An expected life of 20 years would be fair. Just like a metal building using sheet steel skin, the stressed membrane can be replaced and the life extended.
Figure 9 – Sprung Structures Assembly

Figure 10 – Sprung Structures Fully Assembled
Possibilities include the erection of such a structure at the proposed FHSC Maintenance Facility Site. To save in total cost, two of the cars could be left in long term storage while the line runs with two in service and one in reserve. This would reduce overall square footage of structure required. A 30-foot wide by 150-foot length over a single track could be purchased and erected for this application. Consideration should also be made for temporary toilet facilities (required for the workers under OSHA health and safety rules), lights, heat, and water utilities. A track turnout and new track in the FHSC site would be required for this type of arrangement.

**Use of a Temporary Structure Adjacent to the WFSC Alignment**

Further possibilities include the erection of a temporary structure near the WFSC alignment with a similar arrangement as mentioned above, i.e. 30’ x 150’ structure over a single track with a track turnout. This approach could be beneficial as it would not be dependent on the timing of FHSC construction. Further, the WFSC system would continue to operate under its original voltage and no retrofit for the vehicles would be required. This option would, however, require the WFSC to find an appropriate site to facilitate this type of installation.
# Reactivation Cost Estimate

Table 1 – Reactivation Cost Estimate Base Total and Options

<table>
<thead>
<tr>
<th>Traction Power Substation</th>
<th>Note</th>
<th>Alternative 1</th>
<th>Alternative 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>WFSC TPS Testing / Rehabilitation</td>
<td>1</td>
<td>$40,000</td>
<td>$100,000</td>
</tr>
<tr>
<td>Feeder Cable Testing / Replacement</td>
<td>2</td>
<td>$20,000</td>
<td>$40,000</td>
</tr>
<tr>
<td>Rail-joint / Cross bond Replacement</td>
<td>-</td>
<td>$20,000</td>
<td>$35,000</td>
</tr>
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</table>

**OCS**

| OCS Preventative Maintenance | -    | $10,000 | $12,000 | $10,000 | $12,000 |
| New OCS for FHSC Interface | 3    | $77,000 | $105,000 | $264,000 | $285,000 |

**Signal**

| Signal Equipment | 4    | $100,000 | $155,000 | $85,000 | $135,000 |

**Vehicles**

| Reactivation Maintenance | 5    | $60,000 | $60,000 | $60,000 | $60,000 |
| Transport to Alignment | 6    | $40,000 | $40,000 | $40,000 | $40,000 |
| 750V Modification | 7    | $300,000 | $500,000 | $300,000 | $500,000 |

**Base Total**

<table>
<thead>
<tr>
<th>Note</th>
<th>Alternative 1</th>
<th>Alternative 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$667,000</td>
<td>$1,047,000</td>
</tr>
</tbody>
</table>

**Maintenance Facility Options**

| Joint Use FHSC Facility | 8    | $1,250,000 |
| Temporary Facility at FHSC | 9    | $600,000 |
| Temporary Facility at Adjacent Locale | 10 | $600,000 |

**Traction Power Options**

| Substation Replacement | 11  | $500,000 |
| KCM IDS TPS Re-commissioning | 12 | $15,000 |
| IDS Feeder Install | 13 | $200,000 |

**Signal Options**

<p>| Gate Crossing Assembly | 14 | $130,000 |</p>
<table>
<thead>
<tr>
<th>Note</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Includes testing, replacement of missing parts, cleaning, heating, and maintenance of components. High includes replacement of the transformer.</td>
</tr>
<tr>
<td>2</td>
<td>Includes testing, splices, partial replacement of cable, and bonding for feeder cable only. High includes more extensive replacement and installation.</td>
</tr>
<tr>
<td>3</td>
<td>New OCS includes design, poles, crossings, and wire.</td>
</tr>
<tr>
<td>4</td>
<td>Includes powered switch, switch detection, signal aspects, signal case, push button box and track circuits. High includes TWC equipment and track circuits in place of the push button box.</td>
</tr>
<tr>
<td>5</td>
<td>Estimate is for all 5 vehicles, i.e. $12,000 per vehicle.</td>
</tr>
<tr>
<td>6</td>
<td>Estimate is for all 5 vehicles, spares, and equipment with warehouse modifications required to remove vehicles.</td>
</tr>
<tr>
<td>7</td>
<td>Estimate is $100,000 per vehicle. Mean estimate is for only 3 streetcar retrofits.</td>
</tr>
<tr>
<td>8</td>
<td>Joint-use facility costs include two new storage tracks, a carhouse expansion for vehicle storage, and cost for displacement/relocation of existing City facilities. Assumes track to FHSC Maintenance Facility is installed.</td>
</tr>
<tr>
<td>9</td>
<td>Includes temporary structure, track turnout, and single track.</td>
</tr>
<tr>
<td>10</td>
<td>Includes temporary structure, track turnout, and single track. No cost is included for property acquisition or lease.</td>
</tr>
<tr>
<td>11</td>
<td>Estimate reflects replacement of all equipment including prefabricated building. Does not include any site work for installation.</td>
</tr>
<tr>
<td>12</td>
<td>Assumes testing and cleaning costs only.</td>
</tr>
<tr>
<td>13</td>
<td>Includes cable, conduit, replacement pole, and demolition from surface to IDS TPS below 5th Ave South.</td>
</tr>
<tr>
<td>14</td>
<td>Gate crossing cost is for one complete assembly at one intersection. Includes gates, mast and foundation, flashers, signage, battery/charger, test and commission, signal case, event recorder, controller, transmitters and receiver, conduit, wire, bells, surge arresters, equalizers, and design.</td>
</tr>
</tbody>
</table>