I-5 Lid Feasibility Study

Technical Feasibility Memorandum

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City of Seattle

Technical Feasibility Memorandum
I-5 Lid Feasibility Study
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Prepared for:

Seattle
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Prepared by:

WSP

OJB
Magnusson Klemencic Assoc.
EnviroIssues
Framework
HR&A Advisors
Shiels Obletz Johnsen

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For further information about this report, contact:

David Driskell, Deputy Director, OPCD

Lyle Bicknell, Principal Urban Designer, OPCD

(206) 684-0763
Lyle.Bicknell@seattle.gov

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Acronyms and Abbreviations

AFFF	Aqueous Film Forming Foam
AHJ	Agency Having Jurisdiction
As	Acceleration Coefficient
ASTM	American Association of State Highway Transportation Officials
AWT	Alaskan Way Tunnel
BDM	Bridge Design Manual
BDS	Bridge Design Specifications
BODTF	Basis of Design for Technical Feasibility
CCTV	Closed-Circuit Television
CIP	Cast-In-Place
COVID	Coronavirus Disease
EVS	Emergency Ventilation System
FACP	Fire Alarm Control Panel
FEE	Functional Evaluation Earthquake
FFFS	Fixed Firefighting System
GDM	Geotechnical Design Manual
GIS	Geographic Information System
GS	Guide Specifications
HVAC	Heating, Ventilation, and Air Conditioning
I-5	Interstate 5
IBC	International Building Code
ITS	Intelligent Transportation System
LCS	Lane Control Signs
LED	Light Emitting Diode
LFS	I-5 Lid Feasibility Study
LL	Live Loads
LRFD	Load and Resistance Factor Design
M	Magnitude or Million
MEP	Mechanical, Electrical, Plumbing
N/A	Not Applicable
NB I-5	Northbound Interstate 5
NFPA	National Fire Protection Agency
O&M	Operations and Maintenance
PGA	Peak Ground Acceleration

PSF	Pounds per Square Foot
PSRC	Puget Sound Regional Council
R&R	Repair and Rehabilitation
ROM	Rough-Order-of-Magnitude
SAB	Structural Assessment Boundary for the LFS
SB I-5	Southbound Interstate 5
SCADA	Supervisory Control and Data Acquisition
T	Structural Period
TMC	Traffic Management Center
UL/FM	Underwriting Laboratories/Factory Mutual
UPS	Uninterruptible Power Supply
USD	United States Dollars
USGS	United States Geological Survey
WSCC	Washington State Convention Center
WSDOT	Washington State Department of Transportation
εcu	Ultimate Compressive Strain

S Executive Summary

S.1 Background

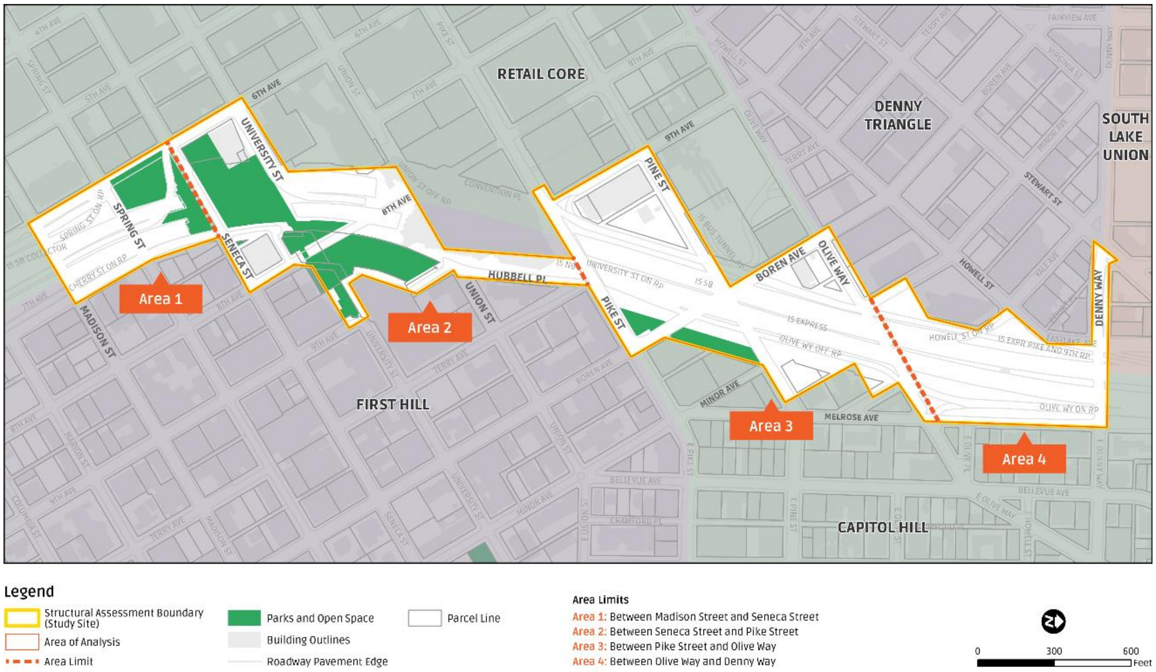
The Interstate 5 (I-5) Lid Feasibility Study (LFS) was commissioned in February 2019 through the City of Seattle's Office of Planning and Community Development as part of the "community benefit agreement" related to the expansion of the Washington State Convention Center (WSCC). The funds for the LFS were awarded to the City of Seattle through the WSCC Community Package to explore the feasibility of building a new lid or lids across I-5, expanding from the existing lids of Freeway Park and the WSCC. These funds were secured through the efforts of community members who have been exploring and advancing the proposal to lid (i.e. overbuild or cap) I-5 through downtown Seattle, Washington.

The project is designed to understand the range of technical and financial feasibility of lidding the freeway, and to look at opportunities for maximizing public benefits. The technical aspect of the study identifies locations where the freeway can be spanned to support development, ranging from open space, or landscaping, to high-rise structures. The financial aspect analyzes feasibility related to the range of benefits of lidding with considerations on the real estate market, funding and financing options, construction and phasing, operations and maintenance (O&M) costs, as well as various governance models.

S.2 Introduction

This memorandum documents the approach, assumptions, and results of the technical assessment the consultant team conducted for the City of Seattle as part of the I-5 LFS in order to evaluate the concept of lidding the freeway through downtown Seattle. The technical feasibility analysis was performed within a Structural Assessment Boundary (SAB), consisting of 0.8 mile of I-5 from Madison Street (south end) to Denny Way (north end) and its immediate perimeter (Figure S-1)—a section presenting significant grade separation between mainline I-5 freeway lanes and surface streets through the heart of downtown Seattle.

Figure S-1. Structural Assessment Boundary



For the purpose of the feasibility study, the study site (or Structural Assessment Boundary) was divided into four areas of analysis. From south to north areas were comprised as follows: Area 1 is the section between Madison St. and Seneca St., Area 2 is the section between Seneca St. and Pike St., Area 3 is the section between Pike St. and Olive Way, and Area 4 is the section between Olive Way and Denny Way.

Determining the feasibility of spanning an interstate within a dense urban environment requires an understanding of the site and of the range of structural and technical considerations to lid the freeway. I-5 through downtown Seattle features extensive walls that support city streets on each side of the right-of-way, elevated viaducts, overpasses, on- and off-ramps, and city streets and buildings. There are also subsurface features (e.g., tunnels, utility mains, and laterals). This technical feasibility study consisted of the following:

- Data gathering
- Site reconnaissance
- Conceptual three-dimensional base mapping
- Development of conceptual geometric lid layouts, structure types, and framing
- Rough-order-of-magnitude (ROM) scoping-level cost estimating

The findings are based on engineering judgement supported by limited analysis suitable for developing ROM costs for the potential lid structures. Cost ranges are supported by metrics from recent relevant regional experience with work activities similar to those that would be required if a lid were to be constructed over I-5 through downtown Seattle.

The study is preliminary and pre-dates any planning, program definition, and design. This technical analysis identifies potential impacts and capital cost ranges for conceptual lid geometric layouts associated with different levels of development and structural load capacity. The study provides preliminary information to answer the questions “Where can a lid be built?” and “What can a lid support?” and provides parametric ROM cost estimates to address the question "How might different development program test cases perform?" to appraise the economic viability of the lid concept.

This study does not consider alternate alignments of I-5. Assessing feasibility based around the existing conditions was considered the most restrictive, meaning that other configurations could provide further opportunity. The study does not present any fatal flaws, recommendations or preferred alternatives; the study provides the City of Seattle, partner agencies, and project stakeholders with credible technical information and resources to assess the range of technical and financial feasibility of the lid concept and serve as a tool that can be used to inform future phases of work.

S.3 General Project Approach

The approach to the technical feasibility analysis was to first understand the site and identify potential impacts and considerations. The study delimitations restricted the feasibility analysis to the SAB established by the City of Seattle. This assessment started with data gathering, site reconnaissance, and conceptual three-dimensional base mapping. Following this, the consultant team performed the following

- Developed conceptual geometric lid layouts, and defined structure types and framing
- Conducted a parametric structural assessment based on the various potential load conditions
- Conducted the necessary coordination with partner agency representatives and technical experts to assess technical interdisciplinary requirements and capture the range of potential capital costs for the project
- Estimated ROM scoping-level costs; established a bookend analysis (maximum and minimum lid areas) to understand the implications for building both the most robust lid project and the leanest lid project, and still deliver a project that is aligned with the value proposition of this study.

This study, being the first of a potentially multi-phase effort, identifies issues needed to be satisfied to establish feasibility, but does not present recommendations to resolve impacts and resulting implications. Instead, the study identifies the potential impacts and costs from which the City of Seattle and the project stakeholders can assess the economic viability of the project and consider potential next steps based on credible technical information and resources.

S.4 Key Study Assumptions

The study incorporates some assumptions, which provided guidance to produce a consistent, evidence-based and technically sound feasibility study. The assumptions are for analysis purposes only and do not reflect decisions or commitments by WSDOT. Appendix A, "Basis of Design for Technical Feasibility Memorandum" presents a detailed list of assumptions. Key assumptions follow:

- The I-5 LFS does not make any decisions about the future of the I-5 corridor.
- I-5 will exist in its current configuration with no reduction to capacity with the exception that:
  - Permanent I-5 lane configuration modifications could be considered to create space for intermediate pier construction

- Temporary I-5 impacts may be permittable, including the following:
  - Long-duration lane closures to construct piers in the median of I-5
  - Short-duration multiple lane closures to demolish overpasses and off-ramps if desired
- Only projects constructed by April 2019 are included in the feasibility assessment; planned projects are not considered to be built.
- Existing structures are not assessed for deficiencies; Puget Sound Regional Council's 2018 State Facilities Action Plan was the basis for the I-5 asset analysis.
- Existing bridges, ramps, walls, or other structures (excluding buildings and tunnels) within the SAB can be considered for removal, modification, or replacement, if desired, *for the purpose of the analysis*.
- Removal of existing buildings or placement of new structures in private parcels is not permissible.
- Geometrical layouts are conceptual and solely for exploring the opportunities, constraints, and technical questions that will need to be examined in more detail if there are additional studies to lid I-5.
- The study assesses only structural modifications to the existing lids at Freeway Park and the WSCC necessary for potential edge integration with a future lid.
- No new subsurface explorations will be performed as part of this study.
- Existing road network has adequate capacity to support the lid development after construction.
- Existing utility systems (e.g., storm drain, sanitary sewer, water, electrical) have adequate capacity to support the proposed lid development.
- Fire life safety facility, components, and equipment, will be required.
- All cost and values used in the rough-order-magnitude cost ranges are reported in 2019 dollars and do not incorporate any current 2020 impacts from the COVID-19 pandemic.

The technical assessment acknowledges federal, state and local technical requirements for a project of this nature. Appendix A, "Basis of Design for Technical Feasibility Memorandum" provides a list of the known standards and design criteria the project would need to comply with or address.

This feasibility study was conducted in collaboration with the asset owners and does not predetermine the use or function of public assets. The following should be noted:

- Washington State Department of Transportation (WSDOT) is working with the City of Seattle to understand the requirements and constraints that would affect freeway lid feasibility in this study area.
- WSDOT recognizes the need to identify long-term plans for this segment of freeway, including consideration of its functional adequacy, asset management, and seismic resilience.
- WSDOT acknowledges that project feasibility or cost are to be determined and cautions against drawing firm conclusions or estimates at this level of detail.

- Any changes in ramp locations would require detailed network analysis of effects on freeway and local street function.
- More work would be needed to determine the best approach to long-term preservation or replacement of existing structures and meeting future seismic resiliency needs.

S.5 Basemap Development

The technical feasibility assessment—compiled and validated by the consultant team with information provided by asset owners—was performed using a basemap of the SAB and surrounding areas. Spanning an interstate within a dense urban environment requires an understanding of the site, especially I-5 through downtown Seattle, which features extensive walls supporting city streets on each side of the right-of-way, elevated viaducts, overpasses, on- and off-ramps, city parks, and city streets and buildings. There are also subsurface features (e.g., tunnels, utility mains, and laterals). Appendix B, "Basemap Development Methodology Memorandum" documents the basemap development process as part of the LFS.

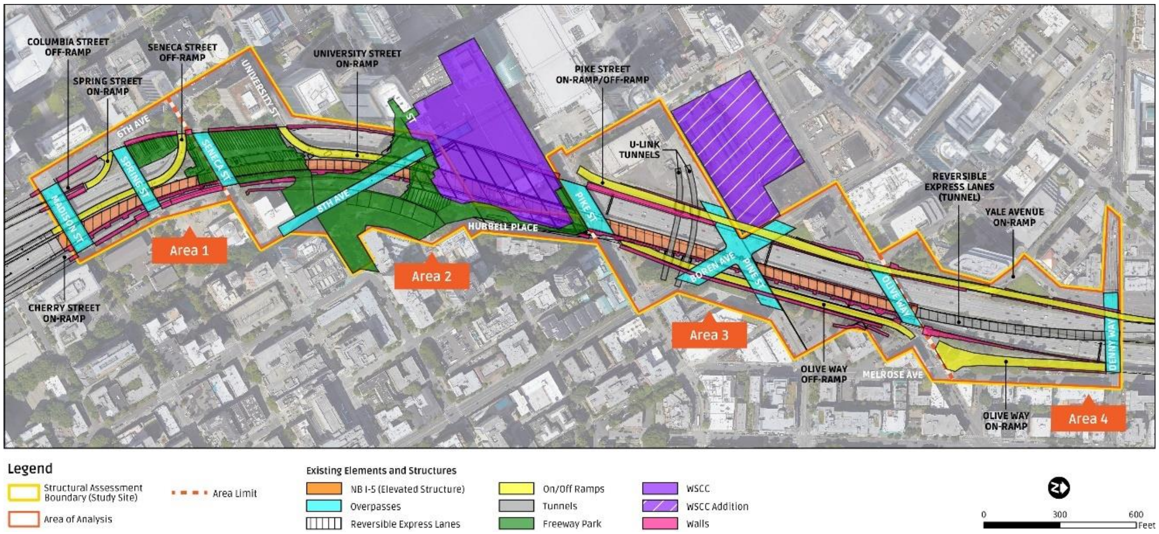
Requests were made to asset owners (WSDOT, Seattle Department of Transportation, Sound Transit, Seattle Public Utilities, Seattle City Light, and WSCC) to gather information they had within the SAB and surrounding area so that an approximate basemap could be compiled. The information received included GIS data, old surveys, Lidar, and scanned PDF drawings from the 1960s. Discrepancies with the information were encountered and refinements were made based on visual observations from photos or in-person site walks. For the purposes of multidisciplinary analysis and technical consistency, the SAB was divided into four sub-areas, hereafter referred to as areas, for analysis (see Figure S-1 and Table S-1). Noteworthy elements of the SAB include the following (see Figure S-2):

- Northbound I-5: This is an elevated bridge structure through the southern three sub-areas spanning over the I-5 reversible express lanes.
- Bridge Overpasses: Nine different bridges span I-5 within the SAB.
- On- and Off-Ramps: A series of on-and off-ramps to I-5 are within the SAB.
- Tunnels: Within Area 3, the Sound Transit U-Link tunnels pass underneath I-5 in an east-west manner; in Area 4, the reversible express lanes enter a tunnel that transitions the express lanes from under northbound traffic to under southbound traffic.
- Freeway Park: Located on an existing lid structure, Freeway Park encompasses most of Area 2 with some edging along its southern extents and box gardens extending into Area 1.
- WSCC: The center was built partially on a lid structure within Area 2. A new WSCC addition is being constructed just to the west of Area 3 near the intersection of Boren Avenue and Pine Street.
- Walls: I-5 was constructed by cutting into the hillside that once existed. As a result walls run north-south on both sides of the corridor throughout the entire SAB.

Table S-1. Delimitation of Structural Assessment Boundary Areas

SAB Sub-Area	Delimitation
Area 1	Madison Street to Seneca Street
Area 2	Seneca Street, Freeway Park, and the Washington State Convention Center, to Pike Street
Area 3	Pike Street to Olive Way
Area 4	Olive Way to Denny Way

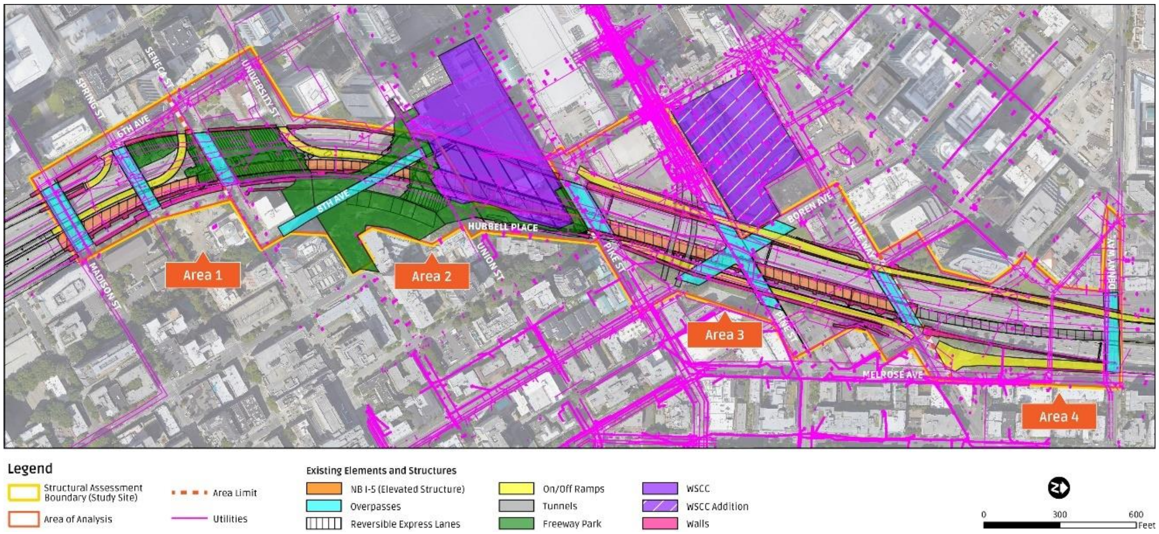
Figure S-2. Noteworthy Existing Elements and Structures within the Structural Assessment Boundary



In total, there are 15 independent bridge structures and 33 different wall structures (for a full list of WSDOT structures within the SAB refer to Appendix B, "Basemap Development Methodology Memorandum"). The bridge and walls consist of cast-in-place (CIP) construction. The bridges are CIP box girders, slabs, or t-beams. The walls are either CIP cylinder walls or conventional CIP retaining walls.

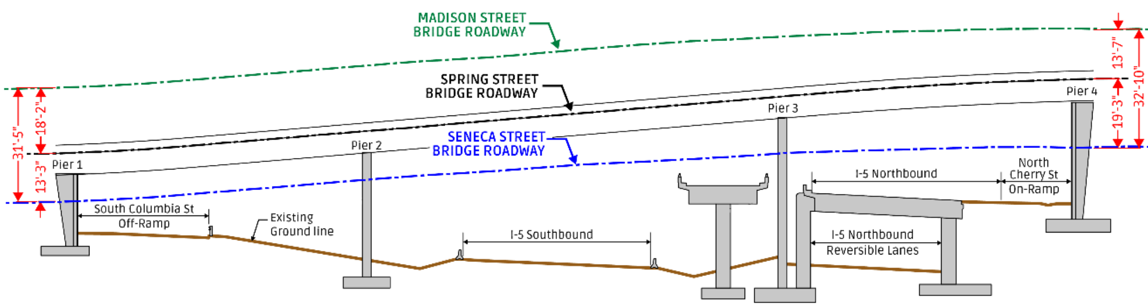
Shown in a separate figure for clarity, Figure S-3, a significant number of utilities exist within the SAB. Understanding what utilities exist, their service requirements, and their location, was important when determining potential pier locations for the lid structure.

Figure S-3. Utilities Located within the Structural Assessment Boundary



The topography of the site is also a major consideration. Seattle in general, and this site in particular, has significant changes in elevation both in an east-west and north-south direction, as well as between mainline I-5 and surrounding surface streets. For example, Figure S-4 illustrates the change in grades within Area 1 of the SAB; showing an east-west section at the Spring Street bridge with the dashed green and blue lines showing the grades of the adjacent bridges to the north and south.

Figure S-4. Grade Variation near Spring Street Bridge (looking north)



The profile of the lid structure(s) would need to meet vertical clearance requirements[1] over existing roadways, ramps, and bridge structures (i.e., northbound I-5). Some of the existing structures over I-5 do not meet vertical clearance design standards, which means that even if a similar structure were to be constructed, it would need to be raised from where it currently exists. Maintaining vertical clearances and tying the structure directly into the surrounding city street scape would be a challenge without unique edge integration in the existing urban context.

[1] WSDOT Design Manual M22-01.16 720.03(5)(b)(1): 16.5-foot minimum clearance for new bridge structures.

S.6 Lid Sub-Area Development

The conceptual-level basemap was used to develop potential lid structure spans for each sub-area of the SAB and to gain an understanding of the associated considerations. The approach for identifying potential pier locations and thus, lid span lengths, was to minimize traffic impacts to mainline I-5 and avoid interferences with existing conditions. Table S-2 shows the resulting span length ranges and Table S-3 shows the considerations tabularized by area.

Table S-2. Structural Assessment Boundary Potential Span Lengths per Sub-Area

Sub-Area	Span Length Range (Feet)
Area 1	80 - 120
Area 2	40 - 125
Area 3	50 - 145
Area 4	50 - 170

Table S-3. Considerations in Lid Development by Area

Component	Area 1	Area 2	Area 3	Area 4
Demolition/Replacement Elevated I-5 Overhangs	X	X	X	
Demolition/Replacement Overpasses	X		X	X
On/Off-Ramp Modifications	X		X	X
On/Off-Ramp Removal	X		X	X
Wall Removal/Modifications	X	X	X	X
Freeway Park/WSCC Modifications	X	X		
I-5 Channelization Reconfiguration			X	X
Utilities	X	X	X	X

A brief summary of the considerations is as follows:

- Demolition and Replacement of I-5 Elevated Structure Overhangs:
  - Required for long stretches of mainline I-5 in order to construct intermediate piers for the lid structure
  - Would be accompanied by temporary shoulder and lane closures
  - Affects existing sign bridges and illumination
- Demolition and Replacement of Overpasses:
  - Will require temporary lane closures if methodical demolition approaches are followed
  - Will require full closures if more efficient, yet robust, methods are followed

- On/Off-Ramp Removal:
  - Existing ramps constrain the site and affect the layout, functionality, and grade of the potential lid structures
  - Removal could benefit both arterial and freeway conditions but requires a detailed network assessment
  - Is in-line with the City of Seattle's long-term transportation plan
- Wall Removal/Modifications:
  - Upper portion of existing walls to be removed to create space for lid structure girders
  - New abutment/end pier required behind the existing wall to support new lid structure girders
  - Displacement controlled walls—construction of new abutment ahead of demolition of upper portion of existing walls to facilitate strutting and control displacements
  - Disruption to local city streets (e.g., traffic, utilities, businesses, residential) during construction
- Freeway Park and WSCC Modifications:
  - Requires demolishing up to Seneca Street in order to cleanly frame between Seneca and Spring Streets
  - Requires demolishing façade to form clean edges within Area 2
  - Requires demolishing and reconstructing a portion of Freeway Park to tie in with 8th Avenue
  - Permit widening and modifications to the existing north/south walkway and stairs between the WSCC plaza and Pike Street.
- I-5 Channelization Reconfiguration
  - Required for long stretches of mainline I-5 in order to construct intermediate piers for the lid structure
- Utilities
  - Significant amount of utilities relocated, replaced, or temporarily disrupted.

Based on the considerations above, a range in potential developable lid area was determined to understand the range in feasibility (see Figure S-5 and Figure S-6 for the maximum/most robust [17.4 acres] and minimum/ leanest [11.5 acres] lid areas, respectively). These figures also illustrate the edge condition of each lid geometric layout and their approximate grade separation to their immediate surroundings, assuming the lid is profiled to match surrounding grades to the degree possible. The maximum lid area assumes that ramps could be removed and the minimum lid area assumes that all the existing ramps would remain operational and considered either avoidance or enhancement to existing Freeway Park edging. With regard to any potential ramp removal, significant additional analysis would be required to demine operational impacts to I-5 and the downtown street network, including transit mobility, and related investments needed to mitigate those impacts. Those analyses and quantification of investments are beyond the scope of this analysis.

Figure S-5. Maximum Potential Developable Lid Area Considered

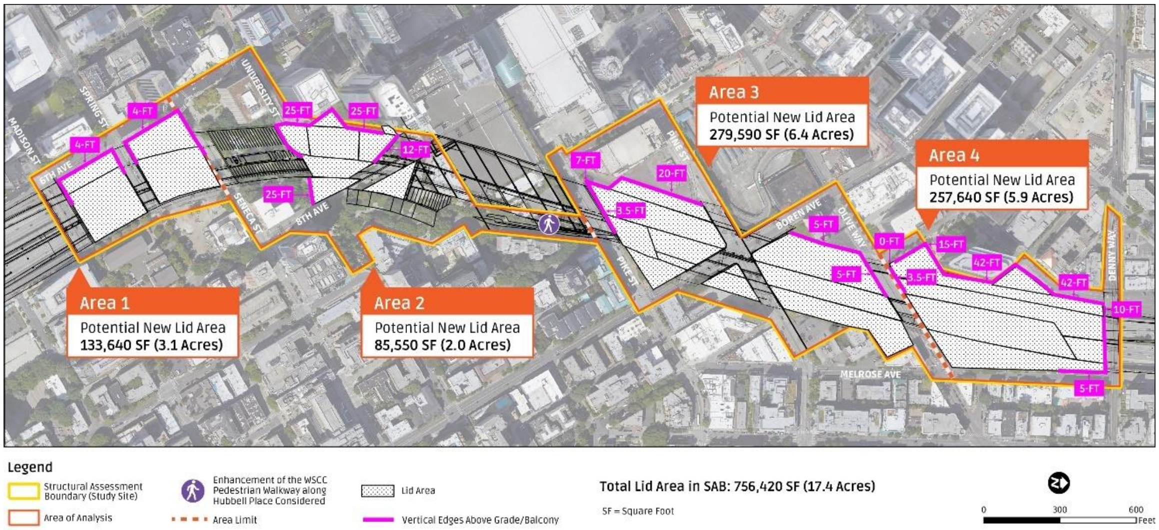
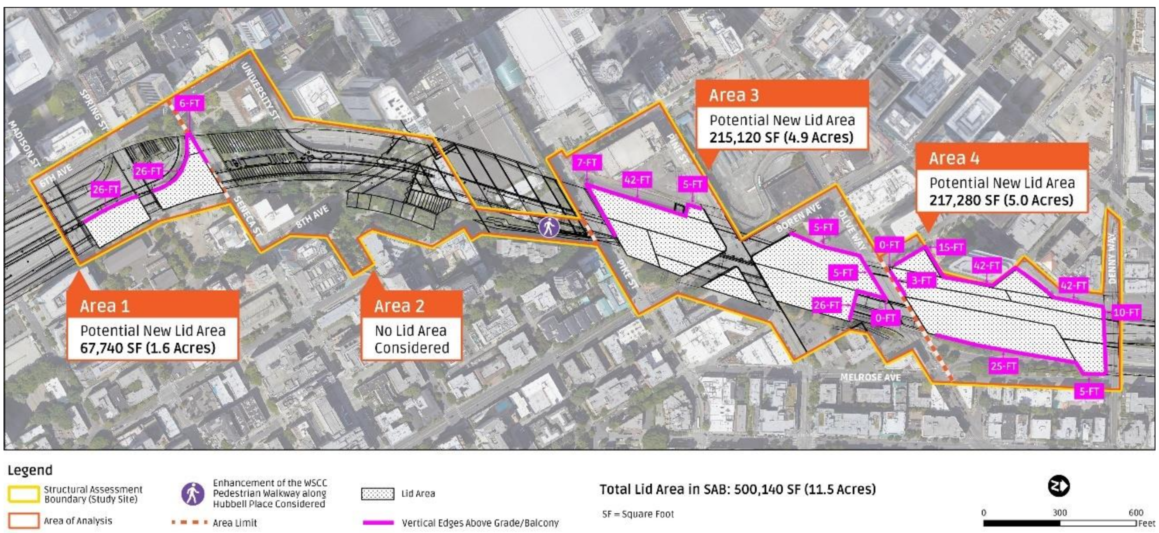


Figure S-6. Minimum Potential Developable Lid Area Considered



S.7 Lid Structural Assessment by Area

Based on the identified span configurations, potential structural framing alternatives were considered for various load levels: open space, low-rise, mid-rise, and high-rise development. Figure S-7 shows the magnitude of the load levels and their definitions.

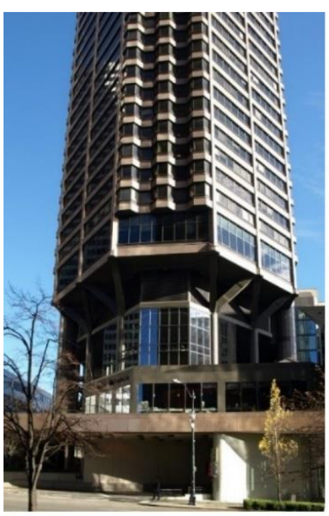
Figure S-7. Load Levels Considered in Feasibility Study

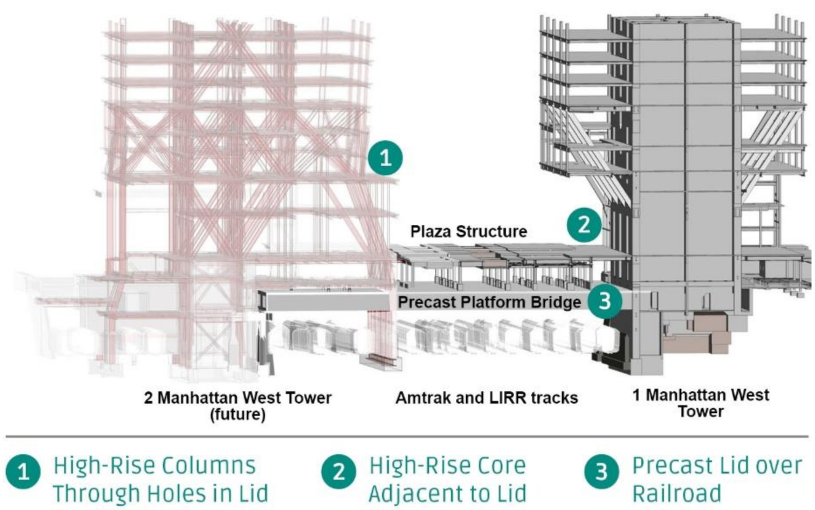
	Open Space Landscaping and pavilions (up to 3 stories)	Low-rise Residential 7 story (5 over 2) Structures	Mid-rise Residential/ Commercial 15 to 20 story Structures	High-rise Residential/ Commercial 45 story Structures
Dead Load (PSF)	1,000	600	2,650	6,815
Live Load (PSF)	250	430	1,150	2,100

Source: Magnusson Klemencic Associates, 2019

A vertical, gravity, parametric study was conducted considering the range in potential span arrangements and load levels. Only conventional bridge framing options were considered—namely, prestressed precast concrete girders and steel-plate girders. From a vertical development perspective, it was considered conventional to frame an opening within a lower story to allow for an at-grade off-ramp to pass through the building. Figure S-8 shows examples of conventional framing from the Manhattan West Towers in Hudson Yards in Manhattan and the Seattle Municipal Tower. Thought was given to other more creative and unique structure type and framing ideas; however, it was determined that to understand their feasibility would require a more in-depth assessment due to the geometric challenges and the vertical development load levels being considered. In addition, unique structure and framing types are likely more costly. The focus on conventional means of framing provided a basis for technical feasibility and facilitated initial discussions with project stakeholders and interdisciplinary team members. It's anticipated that alternate framing concepts will be investigated in future studies.

Figure S-8. Conventional Vertical Development Framing





Examples of conventional building framing considered: Seattle Municipal Tower (left) and the West Towers in Hudson Yards in Manhattan (right) (Petrov, Biswas, Johnson, & Seblani, 2019).

The resulting span capabilities for the various load levels for each structure type are shown in Table S-4 whereas Figure S-9 and Figure S-10 illustrate the maximum load levels for a given specific location within each area for the maximum and minimum areas considered. For the highest load levels at the span ranges of interest, most of the lid structure would need to be steel-plate girders; whereas, for lower load levels within the span ranges of interest, the lid structure could be prestressed precast concrete.

Table S-4. Span Capabilities for Conventional Girders

Conventional Precast Girders				Conventional Steel Plate Girders			
Lid Depth (Feet)	Girder Spacing (Feet)	Load Level	Maximum Span Length (Feet)	Lid Depth (Feet)	Girder Spacing (Feet)	Load Level	Maximum Span Length (Feet)
4	5	Open space	75	4	5	Open space	76
		Low-rise	65			Low-rise	76
		Mid-rise	N/A			Mid-rise	42
		High-rise	N/A			High-rise	32
	12	Open space	55		12	Open space	36
		Low-rise	45			Low-rise	42
		Mid-rise	N/A			Mid-rise	N/A
		High-rise	N/A			High-rise	N/A
9.33	5	Open space	160	13	5	Open space	153
		Low-rise	130			Low-rise	168
		Mid-rise	N/A			Mid-rise	120
		High-rise	N/A			High-rise	105
	12	Open space	115		12	Open space	131
		Low-rise	85			Low-rise	152
		Mid-rise	N/A			Mid-rise	104
		High-rise	N/A			High-rise	82

Figure S-9. Highest Load Levels for Maximum Potential Developable Lid Area Considered

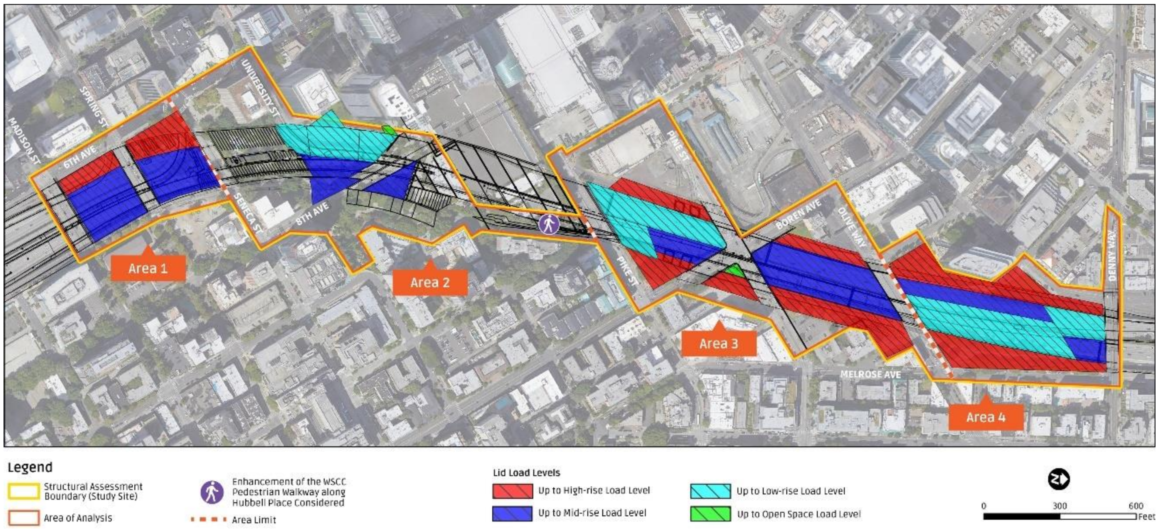
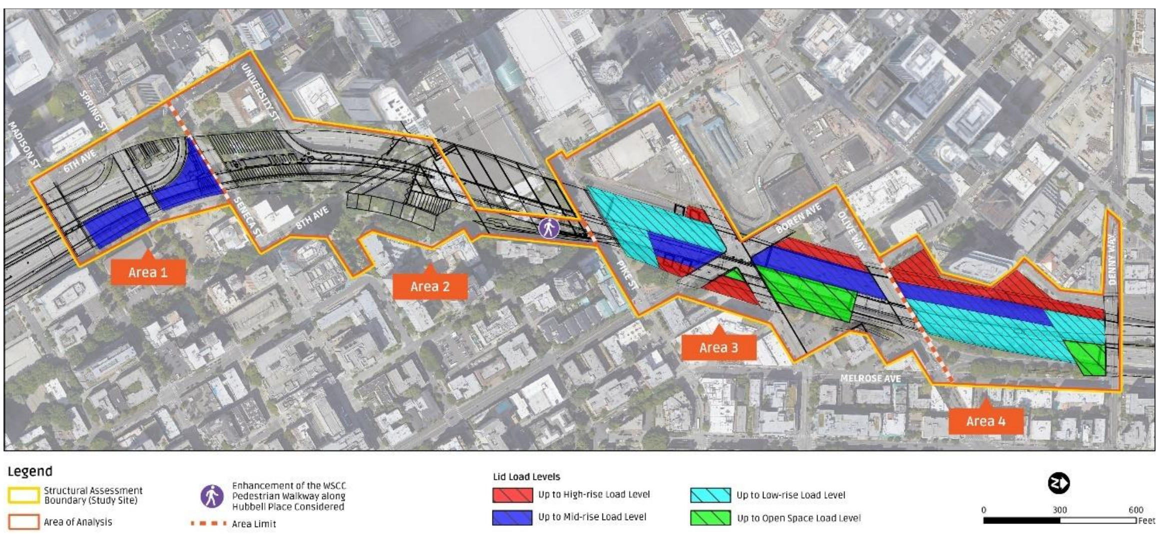


Figure S-10. Highest Load Levels for Minimum Potential Developable Lid Area Considered



Significant costs exist in the below grade structural supporting elements of the lid structure. This is partially due to the larger vertical loads (i.e. potential vertical development) and the fact the structure is located in a high seismic region. Preliminary sizing of the supporting elements was determined from a lateral, seismic, parametric study considering ranges in the critical design parameters including tributary seismic mass, variations in column heights, and pier type. The vertical development was considered seismically independent from the lid structure, with its mass being lumped at the level of the lid surface for evaluation of the lid structure itself. Drilled shafts were assumed for the subgrade structural supports for the lid structure based on their small footprint, which is desirable of support elements being constructed within WSDOT right-of-way to minimize the disturbance to the traveling public along I-5.

It was determined that, with consideration of vertical development loads, the length of the drilled shafts were controlled by vertical (axial) loads. Extrapolation was required beyond soil-structure interaction charts developed based on existing geotechnical exploration data gathered from nearby projects. Extrapolation beyond available information introduces risk into the estimate since material quantities are based on unknown conditions. As an alternate method, additional drilled shafts could have been introduced into the study to keep demands within the depths of the existing geotechnical information; however, the spacing of the drilled shafts became unrealistic, and the rule of thumb is that length is more affordable than additional drilled shafts.

S.8 Assessment of Technical Interdisciplinary Requirements

Building a lid structure cannot be considered without close coordination with supporting technical disciplines. Discipline-specific assessments were performed to approximate costs and identify considerations and opportunities in addition to requirements for future phases of technical evaluation. These include utility impacts, life-safety requirements, constructability staging and phasing, roadway civil engineering considerations, and geotechnical and environmental studies.

Furthermore, lid-to-building interface and integration with the urban context was also analyzed. The assessment also analyzed technical constraints and opportunities for integration of the lid structure with urban development of various load levels.

These include the following:

- WSDOT Civil Engineering (roadway, geometrics, Intelligent Transportation Systems (ITS), illumination, utilities, and drainage):
  - Requirements for roadway illumination under the new lid were considered from a cost perspective; however, a detailed assessment was not conducted. Consideration was given to needing to address light levels on the northbound and southbound I-5 roadways upstream and downstream from the northern and southern limits of the new lid for nighttime illuminance; as well, lighting under the existing I-5 Seneca Street–University Street and 8th Avenue–Pike Street lids in conjunction with the new tunnel lighting.
  - Allowances have been made for potential impacts of the lid structure and associated substructure on existing ITS devices, such as ramp meter signals, variable message signs, and closed-circuit television (CCTV) cameras. Allowances were also made to account for ITS equipment cabinets and associated power and communications infrastructure—including conduits, pull boxes, cable vaults, and mainline and distribution fiber-optic communication cable—based on potential conflict with the lid structure.
  - Existing overhead and ground-mounted signs within the project limits were considered based on potential conflicts with the lid structure. An allowance was made for replacement with new signs attached to the ceiling of the lid.
- Mechanical/Electrical/Plumbing (MEP)/Tunnel (heating, ventilating, and air conditioning; lighting; Fire and Life Safety (FLS) Assessment): The focus of the tunnel MEP and FLS effort was to provide guidance on system requirements and to identify potential impacts on the project that could affect its feasibility. In this context,

"mechanical" refers to an emergency ventilation system (EVS) designed for maintaining a tenable environment in the event of fire. The size and complexity of the system can vary greatly, depending on tunnel configuration, length, fuel load, and other factors. The term "electrical" generally refers to power and control systems to support tunnel operations. Required electrical systems would vary according to what other systems are being provided and required to be supported. Plumbing systems required for a cover structure usually are limited to roadway drainage. The major contributor to drainage loading would be the tunnel sprinkler system. FLS systems encompass all the combined systems that ensure safety in the event of an incident. The primary system assumed is a fixed firefighting system (FFFS), more commonly known as a deluge sprinkler system. The design of this element would be closely coordinated with other systems, including EVS, alarm, system controls, notification, egress, and drainage. The way in which these systems interact would be considered and could have a significant impact on the scope and cost of construction. The focus of the feasibility study was to identify the major tunnel systems, assess their requirements, describe ways they could affect the project, and provide a cost allowance.

- Site Civil Engineering (grading, utilities, and drainage): The civil engineering analysis reviewed the existing conditions with respect to roadway, bicycle, and pedestrian connectivity along with the topographic conditions and the wet utility infrastructure systems (storm drain, sanitary sewer, and domestic water) within and adjacent to the project limits. This analysis resulted in a preliminary understanding of the constraints and opportunities presented by the existing conditions. These results supported cost allowances for the range in potential lid development scenarios considered.
- Building Structural Engineering and Architecture: Depending on the load levels, building structures could be constructed and supported by the lid structure. No assessment of the building structures was conducted; however, cost-per-square-foot metrics were provided.
- Geotechnical Engineering: The geotechnical engineering evaluation reviewed available subsurface information to develop geotechnical inputs to support the conceptual-level design of the lid structure foundation and side walls. Geotechnical inputs included seismic ground motion parameters, axial and lateral capacity for drilled shafts with various diameters, and lateral earth pressure diagrams for retaining wall design.
- Environmental Assessment: I-5 is a federal facility under the stewardship of the Federal Highway Administration (FHWA). As a federal facility, compliance with the National Environmental Policy Act (NEPA) is required when a federal action (such as funding, permits, or policy decisions) is taken. Therefore, prior to FHWA and WSDOT being able to fund, permit, or approve a modification to I-5, the NEPA process would need to be completed. During the NEPA process, compliance with other federal regulations and Executive Orders, such as those dealing with the National Historic Preservation Act and Environmental Justice, would occur. In addition, within the State of Washington, state and local agencies are required to comply with the State Environmental Policy Act (SEPA); the NEPA and SEPA processes can be combined. No specific environmental assessment was conducted as part of this phase of work beyond acknowledging these requirements.

S.9 Potential Rough-Order-of-Magnitude (ROM) Cost Ranges

Due to the preliminary nature of the project, ROM cost ranges were estimated in lieu of specific cost estimates on any given test case because this study would not be programming the lid nor does it have the level of detailed information for the consultant team to assume more than is actually known at this stage in the project. Metrics-based methods were used for development of the ROM cost ranges for the project were used in-lieu of a quantity-based estimate in-line with the standard WSDOT approach due to the preliminary nature of the project (i.e. pre 10% design with only limited supporting quantity determinations). Being metric based, quantity-based item specific costs do not exist, only allowances exist for various types of work based on past experience. As the project moves forward, it will be required to develop quantity-based item specific estimates in-line with the WSDOT standard approach.

The ROM cost ranges are intended to capture the full spectrum of potential costs for the project based on its intended function (i.e. ability to support various ranges of vertical development). A 20-percent contingency was included in-lieu of broken out contingencies for design and construction as is typically done with quantity-based estimates in-line with the WSDOT standard approach. This was done since costs from real comparable projects were used. Typical quantity-based cost estimates developed from a preliminary design would include contingencies on the order of 40 percent, along with construction contingencies between 5 and 15 percent, resulting in a total contingency, design plus construction, of around 50 to 60 percent. The design contingency would ultimately go to zero when the design of a project is completed. As noted, since the metrics were based on actual constructed projects, it was deemed appropriate to waive the design contingencies in order to not artificially inflate the costs.

The ROM cost ranges developed for the study did not use WSDOT's Cost Estimate Validation Process and it did not perform any formal risk modeling. Future phases of the project will consider more robust analytical tools for developing cost estimates as sufficient detail is developed. The comparable projects used to develop the estimate do not necessarily capture the complexities of working along the I-5 corridor through downtown Seattle. Such complexities include:

- Challenging site topography
- Uncertainty in soil conditions and seismic hazards
- Difficulties with constructing around vertically layered structures
- Neighborhood impacts
- High traffic volumes on I-5
- Constrained right-of-way within a built-out dense urban environment
- Utility and drainage impacts
- Multi-agency coordination
- Forward compatibility
- Contracting methods
- Third-party involvement
- Aging existing infrastructure; replace or safeguard
- Project schedule, phasing, and duration

To illustrate the potential impacts associated with project complexities, costs were reported with and without a 30-percent risk allowance. It should be understood that this is just an allowance and not an accurate reflection of actual costs. Determining the magnitude of the actual increase in costs associated with the project complexities would be hard to estimate without conducting the next steps identified in the LFS Technical Feasibility Memorandum and conducting a formal risk analysis.

WSDOT has provided input on the cost assumptions at various points during our technical review and determined that they do not have enough information to provide detailed recommendations on project costs. WSDOT recommended consideration of a 50 percent increase to our cost estimate ranges based on the 20 percent contingency allowance and 30 percent risk allowance, consistent with considerations on other planning level studies. As the I-5 lid cost assumptions are based on other completed large capital projects in the region, and not planning estimates, including the SR 99 tunnel, we consider our underlying estimates to already include the impact of realized contingency and risk. We are considering the 50 percent increase to be the high bookend of our range in cost estimates.

Furthermore, ROM costs are based on the capital improvements required to support the construction of the improvements over I-5 and do not assume the rebuilding of I-5, including walls, elevated structures, and overpasses, which total 48 independent structures. The 48 existing I-5 structures evaluated were built in the 1960's with most of the assets operating past their designed life by 2035. We assume that further evaluation will occur as part of I-5 master planning which has yet to commence. The master planning and initial design analysis could conclude that many of these assets will need to be replaced to address deterioration and/or improve operating performance of I-5 through downtown Seattle. There could also be an alternative recommendation that some or all of the assets will not require replacement but may still require significant investments to continue their operation during the 100-year evaluation period modeled in the financial analysis. We refer to the costs of replacing these assets without the lid improvements as our "no-build" alternative, assuming that escalating operating and maintenance and repair and rehabilitation costs will be comparable to full asset replacement. The no-build case is used as the basis for estimating the incremental costs of three test cases. In all likelihood the rebuilding of some or all the I-5 assets would occur as part of the construction of the lid, reducing the overall cost of construction and mitigating construction impacts on I-5 operations. For purposes of our analysis we do assume the replacement of some critical support structures that will be required to construct some of our test case scenarios; however, we do not assume the full reconstruction of all the I-5 assets.

Three different types of costs were considered: capital costs, O&M costs, and repair and rehabilitation (R&R) costs. Annual O&M and R&R costs were taken from databases developed for the State Route 99 Alaskan Way Tunnel (SR99 AWT). The SR99 AWT costs were chosen over other comparable projects because it contained recent knowledge of fire, life, and safety features and is the most representative in scale. The O&M and R&R costs provided input into the life-cycle and economic models being developed outside of the technical team.

From a life-cycle cost perspective, the project was estimated to be constructed in four phases, with each phase being three to four years. Each phase was assumed to overlap by two years, resulting in a total construction duration of 12 years. The anticipated asset life was set to be 75 years to comply with the standard design life of a bridge as defined by the American

Association of State Highway Officials. Reference should be made to the final I-5 LFS report for details on the life-cycle and economic assessment.

This study was designed to explore the range in technical feasibility of lidding the freeway, to understand the implications for building both the most robust lid project and the leanest lid project, and still deliver a project that is aligned with the value proposition of this study. These two bookends of analysis in turn become financial bookends to answer the question on cost range for lidding I-5 through downtown Seattle.

The capital costs considered construction costs, right-of-way costs, and other variable costs. All costs are presented in 2019 dollars. As illustrated in Table S-5, the ranges in cost accounted for the following:

- Difference in developable lid area
- Load levels accommodated by the lid structure
- Consideration of ramp removal
- Lid Structure Seismic classification
- Discipline-specific considerations

Table S-5. Considerations for Capital Cost Parameter Ranges

Consideration	Robust Lid Project	Leanest Lid Project
Lid Area	Maximum	Minimum
Load Levels	Maximum	Open space
Ramp Removal	Yes	No
Lid Structure Seismic Classification	Critical	Essential
Discipline Specific (e.g., Fire, Life Safety, Utilities, Constructability, etc.)	High End	Low End
Overpasses Remain in Modified Form	Yes	
Pedestrian Access Improvement at WSCC (Hubble Street)	Yes	

For the robust lid project, the maximum lid area carried the highest load levels it could carry based on the following:

- Assumed steel-plate girders spaced reasonably close together
- Classified the structure as critical
- Assumed that the existing on- and off-ramps could be removed as it made sense from a lidding perspective
- Considered the high end of the range for estimated costs of off lid impacts (i.e. roadway civil, site civil, utilities, etc.).

For the leanest lid project, the minimum lid area carried the lowest load levels (i.e., open space loads) based on the following:

- Maximized the spacing of precast prestressed concrete girders
- Classified the lid structure as seismically essential

- Assumed that the existing on- and off-ramps remained in-place
- Considered the low end of the range for estimated costs of off-lid impacts

In an attempt to be as realistic as possible when comparing the I-5 lid project to other projects, the construction costs were broken into the following 11 different categories based on type of construction:

- **Demolition:** The configuration of the lid structure constructed would have an impact on existing infrastructure. At a minimum, there would be select demolition of bridge overhangs (on ramps, overpasses, and mainline I-5) and wall structures. To maximize developable area, there may be complete demolition of ramps and walls.
- **Structures:** This work includes lid structure, improvements to the existing overpasses to create Complete Streets with adequate shoulder and sidewalk widths; north/south pedestrian access at the WSCC spanning over Pike Street (span over Pike Street only applicable when test case allows for high buildings to connect with structure).
- **Streetscapes and Park:** This work includes slab waterproofing, drainage mat, drainage structures and pipe, topsoil, plants, pathways and furniture.
- **Civil/Roadway:** This work includes erosion control, removal and replacement of asphalt roadways and shoulders and removal and replacement of concrete roadways.
- **Drainage:** This work includes connections to existing drainage structures, new drainage structures, new pipe runs, shoring and excavation for drainage structures and pipe, plugging existing pipes and cleaning existing drainage systems.
- **Traffic:** This work includes illumination systems, traffic signal systems, interconnect systems, ITS, temporary illumination, concrete curb and gutter, concrete sidewalk, curb ramps, concrete driveway entrances, permanent signing and pavement markings.
- **Utilities:** This work includes relocating and protecting all existing wet and dry utilities within or adjacent the project footprint. This cost is based on three recent projects with significant relocation of utilities.
- **Mechanical, Electrical, and Plumbing:** It is assumed that fire-life safety features would be incorporated into the project. These would include an EVS, FFFS, structure fire durability protection, and the associated power and controls, including back-up generators. The existing fire-life safety systems located in the WSCC would need to be replaced in their entirety. . It is assumed that a new maintenance facility would be constructed and inclusive of parking, shop, lockers, duty stations, crew space and a loading dock; see overall feasibility document for additional details.
- **Traffic Control:** This work includes providing all resources needed for construction traffic control operations on and near I-5. This lump sum cost is based on current and recent projects constructed on I-5 and abutting I-5 in the Tacoma area.
- **Federal and State Asset Replacement:** This work refers to assumed costs for replacing I-5 in-kind. The cost ranges are presented without assumed costs for federal and state asset replacement.
- **Vertical Development:** This work refers to the construction of vertical buildings on top or adjacent to the lid structure. The cost ranges were prepared without assumed costs for vertical development.

Total costs were extracted from other similar projects by category and normalized based on the area (square footage) of work being conducted. The normalized costs were applied to the square footage of work on this project to develop a cost value.

Right-of-way costs considered potential temporary easement needs, aerial easements, and permanent acquisitions, and were based on values of the assumed impacted parcels. The easement and acquisition needs are not yet known, but some were assumed in order to provide an allowance for the range in costs estimated. Input on the values assigned were estimated and referenced as part of the land valuation analysis included in the LFS.

An allowance was also made for other variable costs accounting for construction administration and inspection costs, the cost of construction support services, third-party review costs, and owner (internal agency costs spent on a project) costs. A lump sum value of 30 percent was used.

The resulting range in capital costs in 2019 USD is $855 million (leanest lid project cost range) to $2,863 million (robust lid project cost range), excluding vertical development and federal and state asset replacement. Table S-6 shows the breakdowns per lid area and includes the normalized dollars-per-square-foot value assumed for both the leanest and robust lid project estimates.

Table S-6. Capital Cost Breakdown per Lid Area (2019 USD)

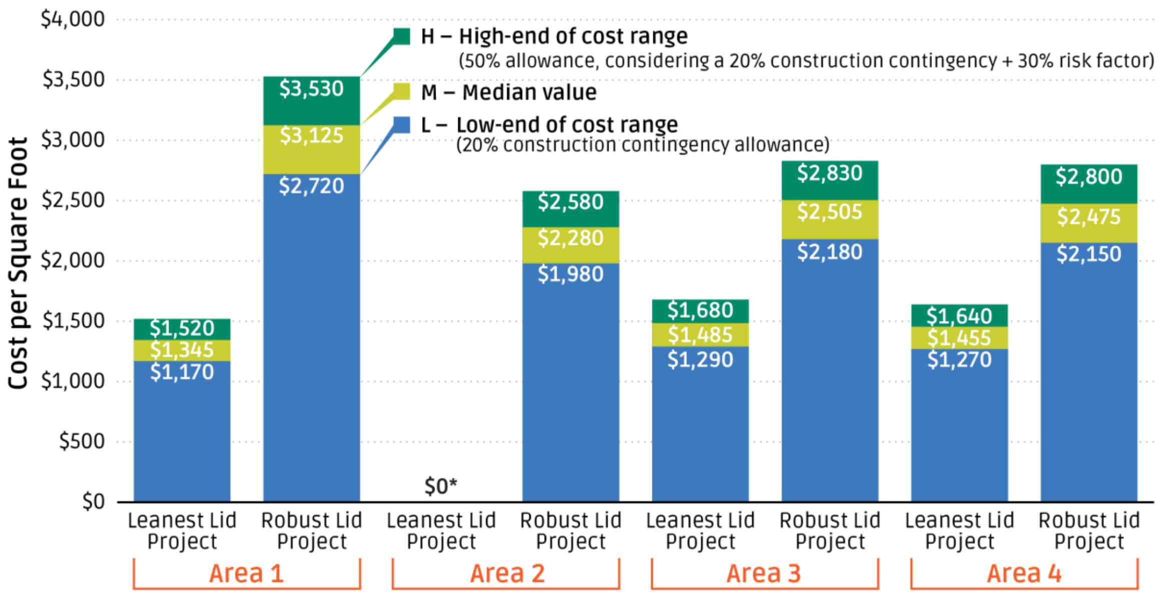
Lid Area of Analysis	Robust Lid Project (Maximum lid area and load considered)			Leanest Lid Project (Minimum lid area and load considered)			Lid Project Cost Range
	Area (SF)	Cost including 20% construction contingency ($)	Cost including 20% construction contingency & 30% risk allowance ($)	Area (SF)	Cost including 20% construction contingency ($)	Cost including 20% construction contingency & 30% risk allowance ($)	Cost Range ($)
Area 1	133,640	472 M	614 M	67,740	103 M	134 M	103 M - 614 M
Area 2	85,550	221 M	286 M	N/A	*33 M	*42 M	*33 M - 286 M
Area 3	279,590	791 M	1,027 M	215,120	361 M	468 M	361 M – 1,027 M
Area 4	257,640	721 M	936 M	217,280	358 M	464 M	358 M – 936 M
Total	**756,420**	**2,205 M**	**2,863 M**	**500,140**	**855 M**	**1,108 M**	**855 M - 2,863 M**

**Cost consideration for enhancement of the WSCC pedestrian walkway along Hubble Place.*

Range of financial bookends of analysis, expressed in capital costs per lid area corresponding to the maximum (Figure S-5) and minimum (Figure S-6) potential developable lid area considered in the technical feasibility assessment. Cost breakdown is absent of right-of-way costs and federal and state asset replacement but includes other variable costs and are expressed in 2019 USD.

Figure S-11 shows the construction costs-per-square-foot ranges per area for both the leanest and robust lid project estimates and 20 percent contingency and 20 percent contingency plus 30 percent risk. The construction costs per square foot are largely controlled by the structures costs and the load intensity within an area, as shown in Figure S-9 for the robust lid project range.

Figure S-11. Construction Cost-per-Square-Foot Ranges per Area (2019 USD)

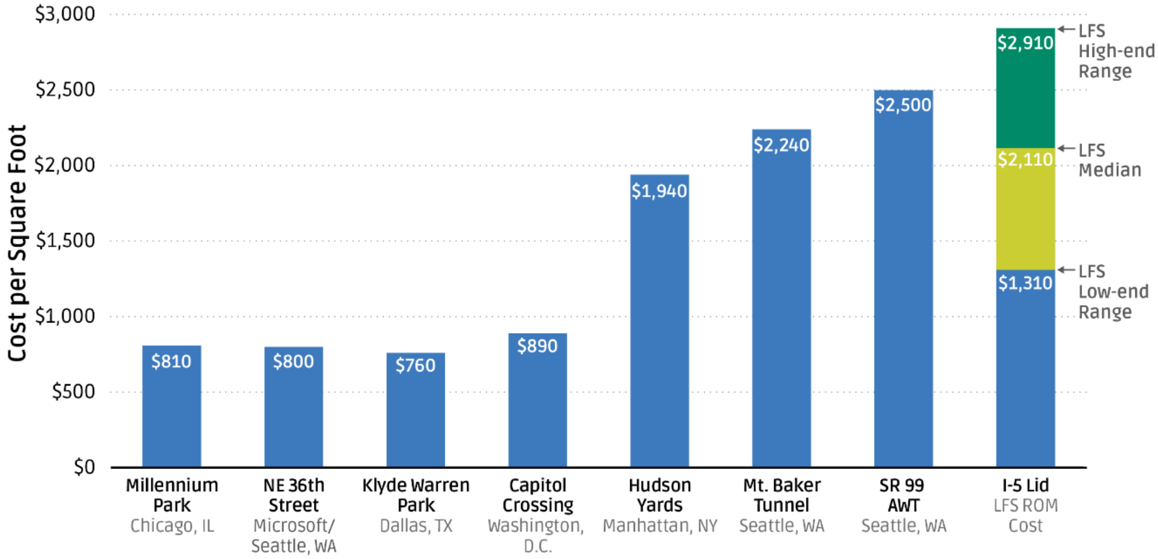


The costs-per-square-foot ranges are construction costs, and thus are not inclusive of right-of-way costs, federal and state asset replacement, and other variable costs.

*Area 2 includes lump-sum construction costs of $25M (at 20-percent) and $32M (at 50-percent compounded contingency allowance and risk factor) for enhancement of the WSCC pedestrian walkway along Hubble Place.

In addition to category-specific cost inputs from other recent and relevant projects, the total resulting costs were compared to local, regional, and national comparable projects on a normalized dollar per square-foot basis. Figure S-12 shows the findings of this comparison. The low end of the range is higher in cost but in close agreement with other comparable projects supporting open space loads. The higher cost is likely due to the need to account for project contingency, however, and the project length, and the need for fire, life, safety components, estimated to be between 4 percent and 12 percent of the total construction costs for the leanest and robust lid project estimates, respectively. The high end of the cost range falls between the cost of Hudson Yards, a similar lid structure supporting vertical development, and the SR99 AWT tunnel costs.

Figure S-12. Normalized Cost-per-Square-Foot Comparison of Representative Projects (2019 USD)



Comparable costs are representative of construction costs, and not capital costs. Other variable and right-of-way costs are not included.

A no-build cost assessment was also conducted to reflect the costs of existing I-5 operations. Details of the no-build cost assessment can be found in the life-cycle and economic assessments located in the overall LFS report.

S.10 Considerations and Next Steps

To define a comprehensive feasibility analysis would require considerable additional in-depth studies, which were beyond the scope of this project. From a technical perspective, these studies would include, but are not limited to, the following:

- Evaluation of Alternative Alignments of I-5: This consists of localized impacts to the current alignment of I-5.
- Alternate Channelization Configurations of I-5
- Transportation and Traffic Network Studies (inclusive of consideration of potential ramp removal): This includes, but not limited to, understanding the impacts to freeway, arterial streets, local transportation, rail service, and evaluation of alternate ramp locations and circulation routes during and after construction.
- Geotechnical Explorations
- Environmental study (inclusive of impacts to cultural resources): A NEPA/SEPA evaluation or planning document would be needed that adheres to Planning and Environmental Linkages guidelines.
- Noise Analysis: A noise analysis will needed to understand noise impacts with the lid concepts. Lidding can reduce noise in locations but concentrate it in others.
- Master Plan and Implementation Considerations: selection of a procurement method; design-build, general contractor/construction management, design-build bid, or an array of public private partnerships, as well as developing a project schedule. Having a

master plan would be important in maximizing function of the project through coordinating the interests, responsibilities and investments of tentatively multiple agencies, developers, and asset owners.

- Evaluation of Edge Integration: The actual details of the project would be tied to the master plan and implementation considerations utilized to deliver the lid project. The most structurally efficient system would have the lid structure be integrated with private development (i.e., buildings) along its edges, if the lid were conceived to support an array of land uses other than open space.
- Evaluation of Unconventional Structural Framing Methods: More unconventional and unique framing options may be suitable for a lid project. Unconventional and unique framing options would most likely be more costly than the conventional methods considered as part of this study. As part of a future study, as the urban context analysis, policy goals, and project delivery options are better understood, it would be advisable to explore these alternatives.
- Seismic Hazard: The seismic performance of a lid structure supporting building structures in a high seismic region would need to be defined. Decisions would also be needed regarding magnification of the design seismic hazard as a result of basin effects.
- Freeway Park Modifications and potential considerations around the historic designation process is being explored.
- Existing Structures Monitoring Program: It would be important to define the baseline conditions of what exists to-date in order to define impacts related to construction. One of the key elements would be the existing cut walls on both the east and west side of the interstate, which are displacement controlled walls that stabilize the soils.
- Signing, Fire-Life Safety, and MEP Systems: It would be necessary to coordinate location of system components to minimize impacts on vertical clearance envelopes and required profile of the potential new lid structure.
- Detailed Structural Assessment and Design: Only a preliminary sensitivity assessment was conducted to determine ranges in potential member sizes for developing ROM cost ranges. A detailed structural assessment and design should be conducted in later phases of the project.
- Liquefaction and Lateral Spreading Assessment: Liquefaction and lateral spreading potential are known to exist in the area and could significantly affect the foundation costs and feasibility.
- Tunnel Impacts: It would be necessary to determine how close new lid foundation elements could be constructed relative to the existing U-Link and I-5 Express Lane tunnels.
- Ambient Air Quality Analysis: This analysis would be performed to determine if smoke stacks are needed at the portals of the lid structure.
- Asset Management: constructing a new lid structure over existing aged infrastructure will have an impact on access, maintenance, and cost for repairs, improvements, or replacement.

The work to-date is preliminary and is intended to be the initial step of a longer process that would inform the intricate and multi-layered decision-making framework necessary to move this project from ideation to implementation. This document presents only the preliminary technical feasibility analysis that was conducted as part of the I-5 LFS. Other considerations would be required to inform the overall feasibility of the project, including an alternatives analysis, governance models, project delivery options, regulatory considerations, funding and financing options, agency alignment, and investment priorities in the region.

S.11 Key Takeaways

From a technical perspective, some key takeaways from this analysis were identified:

- Based on the work conducted for this study it is technically feasible to construct a lid over I-5 through downtown Seattle, similar to the existing lids of the WSCC and Freeway Park.
  - From an engineering perspective, it is achievable to build a set of lid structures within the study site capable of supporting various load levels of development.
- Existing overpasses and structures along the SAB pre-dated current vertical clearance requirements. Any new lid structure would require meeting the 16-foot 6-inch minimum vertical clearance over existing I-5 structures, representing significant challenges for edge integration with the surrounding urban context, and presenting grade differences ranging from 5 to 15 feet from lid surface to the adjacent street grid and bridge overpasses, and up to 45 feet above the adjacent street grid below, when trying to mimic the existing bridge overpass grades to the extent feasible.
- The potential lid configurations resulting from the present technical assessment are not flat or contiguous surfaces from edge to edge, given the topographical conditions of the site, and the constraints existing structures and ramp access impose. This could significantly affect the connectivity and accessibility potential for active transportation linkages both east-west and north-south.
- Lid edge integration challenges could be addressed by incorporating buildings and/or vertical circulation mechanisms across the SAB. A solution that involves buildings would require significant consideration on planning and project delivery alternatives, to ensure capital cost efficiencies could be achieved integrating the structural elements of both the lid and the buildings.
- Based on the conceptual geometric lid layouts developed, the maximum lid area potential for a robust lid project within the study site (considering the theoretical removal of all ramps) is 17.4 acres and the minimum lid area for the leanest lid project, (with all ramps remaining) is 11.5 acres. The cost per square foot of the lid is not equivalent across the four areas of the SAB given the specific challenges and opportunities each area presents.
- The load capacity of the potential lid configurations is not even across the SAB nor within each lid section. This would present important considerations in terms of the potential development program and capacity.
- The ROM cost estimates do not include potential impacts that would result from removing ramps to increase lid area development potential. A robust transportation and traffic network study would be necessary to evaluate the operational feasibility because

this could have significant costs to replace the function of access to downtown streets. In addition, this study would be necessary to inform constructability and staging alternatives if this project were to advance to further stages of engineering and design.

- Given that lidding mainline I-5 would change the configuration of the freeway from exposed open-air lanes to a 0.8-mile “tunnel”, building a lid on this site would require installing a Fire and Life Safety (FLS) system.
  - A FLS system requirement represents between 4 percent (leanest lid project estimate) to 12 percent (robust lid project estimate) of total construction costs for the lid project.
- Costs included in this memorandum are parametric and should not be taken as absolute. This analysis also does not consider the economic or societal benefits that could also result from developing this project. This will be discussed in the final LFS report. Further studies will be required to capture these benefits, including those related to a transportation and traffic network study.
- The technical feasibility assessment was performed agnostic of urban context, environmental considerations, noise impacts and user experience implications. Nonetheless, lid sub-area geometric layouts were developed through an iterative approach with the needs identified for urban design best practices, which would be explored in the development program test case framework analysis of the LFS. Future phases of work should consider impacts of technical decisions through a place-based approach. Consideration to the LFS guiding principles established as part of the I-5 Lid Feasibility Study Committee is recommended.

1. Background

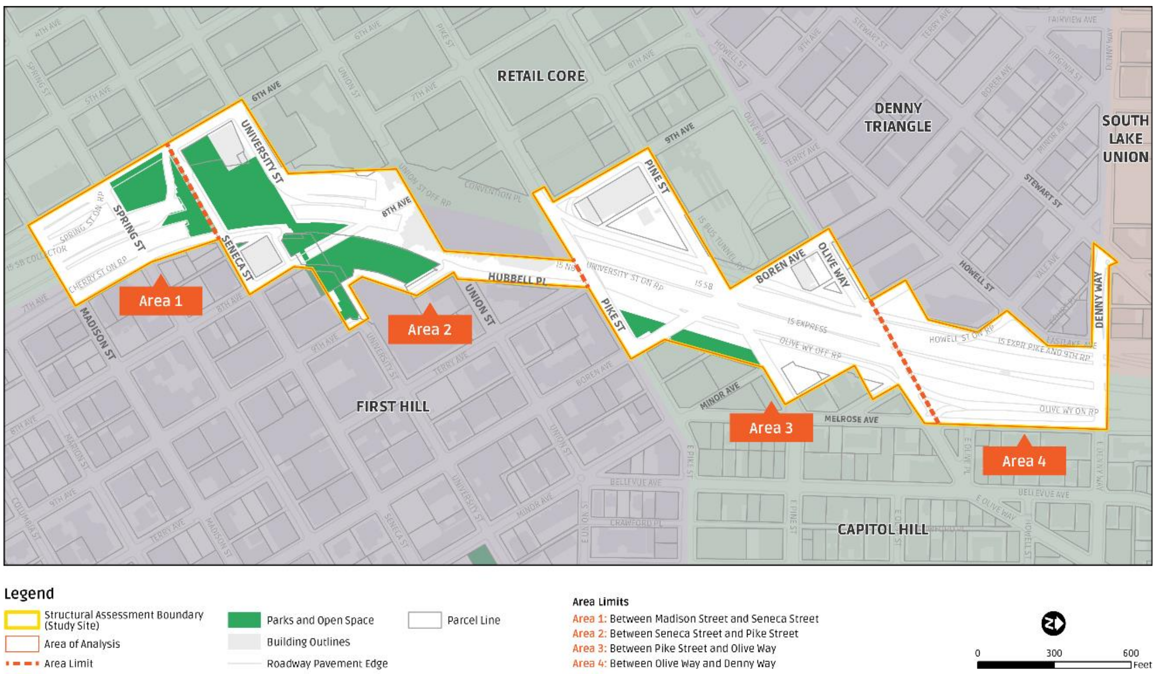
The Interstate 5 (I-5) Lid Feasibility Study (LFS) was commissioned in February 2019 through the City of Seattle's Office of Planning and Community Development as part of the "community benefit agreement" related to the expansion of the Washington State Convention Center (WSCC). The funds for the LFS were awarded to the City of Seattle through the WSCC Community Package to explore the feasibility of building a new lid or lids across I-5, expanding from the existing lids of Freeway Park and the WSCC. These funds were secured through the efforts of community members who have been exploring and advancing the proposal to lid (i.e. overbuild or cap) I-5 through downtown Seattle, Washington.

The project is designed to understand the range of technical and financial feasibility of lidding the freeway, and to look at opportunities for maximizing public benefits. The technical aspect of the study identifies locations where the freeway can be spanned to support development, ranging from open space, or landscaping, to high-rise structures. The financial aspect analyzes feasibility related to the range of benefits of lidding with considerations on the real estate market, funding, and financing options, construction and phasing, operations and maintenance (O&M) costs, as well as various governance models.

2. Introduction

This memorandum documents the approach, assumptions, and results of the technical assessment the consultant team conducted for the City of Seattle as part of the I-5 LFS, in order to evaluate the concept to lid I-5 through downtown Seattle. The technical feasibility analysis was performed within a Structural Assessment Boundary (SAB), consisting of 0.8 mile sunken portion of I-5 from Madison Street (south end) to Denny Way (north end) and its immediate perimeter (Figure 2-1)—a section presenting significant grade separation between mainline I-5 freeway lanes and surface streets through the heart of downtown Seattle.

Figure 2-1. Structural Assessment Boundary



For the purpose of the feasibility study, the study site (or Structural Assessment Boundary) was divided into four areas of analysis. From south to north areas were comprised as follows: Area 1 is the section between Madison St. and Seneca St., Area 2 is the section between Seneca St. and Pike St., Area 3 is the section between Pike St. and Olive Way, and Area 4 is the section between Olive Way and Denny Way.

Determining the feasibility of spanning an interstate within a dense urban environment requires an understanding of the site and of the range of structural and technical considerations to lid (i.e. overbuild or cap) the freeway. I-5 through downtown Seattle features extensive walls that support city streets on each side of the right-of-way, elevated viaducts, overpasses, on- and off-ramps, and city streets and buildings. There are also subsurface features (e.g., tunnels, utility mains, and laterals). This technical feasibility study consisted of the following:

- Data gathering
- Site reconnaissance
- Conceptual three-dimensional base mapping
- Development of conceptual geometric lid layouts, structure types, and framing
- Rough-order-of-magnitude (ROM) scoping-level cost estimating.

The findings are based on engineering judgement supported by limited analysis suitable for developing ROM costs for the potential lid structures. Cost ranges are supported by metrics from recent relevant regional experience with work activities similar to those that would be required if a lid were to be constructed over I-5 through downtown Seattle.

The study is preliminary and pre-dates any planning, program definition, and design. The technical analysis identifies potential impacts and capital cost ranges for conceptual lid geometric layouts associated with different levels of development and structural load capacity. The study provides preliminary information to answer the questions "Where can a lid be built?" and "What can a lid support?" and provides parametric ROM cost estimates to address the question "How might different development program test cases perform?" to appraise the economic viability of the lid concept.

This study does not consider alternate alignments of I-5. Assessing feasibility based around the existing conditions was considered the most restrictive, meaning that other configurations could provide further opportunity. The study does not present any fatal flaws, recommendations, or preferred alternatives; the study provides the City of Seattle, partner agencies, and project stakeholders with credible technical information and resources to assess the range of technical and financial feasibility of the lid concept and serve as a tool that can be used to inform future phases of work.

2.1 Basis of Technical Feasibility

Appendix A provides a detailed Basis of Design for Technical Feasibility (BODTF) for this study. The BODTF serves as the design criteria and documents the proposed approach, assumptions, and standards used for the technical feasibility assessment.

The approach to the technical feasibility analysis was to first understand the site and identify potential impacts and considerations. The study delimitations restricted the feasibility analysis to the SAB established by the City of Seattle. This assessment started with data gathering, site reconnaissance, and conceptual three-dimensional base mapping. Following this, the consultant team performed the following:

- Developed conceptual geometric lid layouts, and defined structure types and framing
- Conducted a parametric structural assessment based on the various potential load conditions
- Conducted the necessary coordination with partner agency representatives and technical experts to assess technical interdisciplinary requirements and capture the range of potential capital costs for the project
- Estimated ROM scoping-level costs; established a bookend analysis (maximum and minimum lid areas) to understand the implications for building both the most robust lid project and the leanest lid project, and still deliver a project that is aligned with the value proposition of this study.

This study, being the first of a potentially multi-phase effort, identifies issues needed to be satisfied to establish feasibility, but does not present recommendations to resolve impacts and resulting implications. Instead, the study identifies the potential impacts and costs from which the City of Seattle and the project stakeholders can assess the economic viability of the project and consider potential next steps based on credible technical information and resources.

Owing to the preliminary nature of the analysis, the study incorporates some assumptions, which provided guidance to produce a consistent, evidence-based and technically sound feasibility study. The assumptions are for analysis purposes only and do not reflect decisions or commitments by WSDOT. Appendix A, "Basis of Design for Technical Feasibility Memorandum" provides a detailed list of assumptions. Key assumptions follow:

- The I-5 LFS does not make any decisions about the future of the I-5 corridor.
- I-5 will exist in its current configuration with no reduction to capacity except that permanent I-5 lane configuration modifications could be considered to create space for intermediate pier construction.
- Temporary I-5 impacts may be permittable, including the following:
  - Long-duration lane closures to construct piers in the median of I-5
  - Short-duration multiple lane closures to demolish overpasses and off-ramps, if desired
- Only projects constructed by April 2019 are included in the feasibility assessment; planned projects are not considered to be built.
- Existing structures are not Puget Sound Regional Council's 2018 State Facilities Action Plan assessed for deficiencies; was the basis for the I-5 asset analysis.
- Existing bridges, ramps, walls, or other structures (excluding buildings and tunnels) within the SAB can be considered for removal, modification, or replacement, if desired, *for the purpose of the analysis*.
- Removal of existing buildings or placement of new structures in private parcels is not permissible.
- Geometrical layouts are conceptual and solely for exploring the opportunities, constraints, and technical questions that will need to be examined in more detail if there are additional studies to lid I-5.
- The study assesses only structural modifications to the existing lids at Freeway Park and the WSCC necessary for potential edge integration with a future lid.
- No new subsurface explorations will be performed as part of this study.
- Existing road network has adequate capacity to support the proposed lid development after construction.
- Existing utility systems (e.g., storm drain, sanitary sewer, water, electrical) have adequate capacity to support the proposed lid development.

The technical assessment acknowledges federal, state, and local technical requirements for a project of this nature. Appendix A, "Basis of Design for Technical Feasibility Memorandum" provides a list of the known standards and design criteria the project would need to comply with or address.

This feasibility study was conducted in collaboration with the asset owners and does not predetermine the use or function of public assets. The following should be noted:

- Washington State Department of Transportation (WSDOT) is working with the City of Seattle to understand the requirements and constraints that would affect freeway lid feasibility in this study area.

- WSDOT recognizes the need to identify long-term plans for this segment of freeway, including consideration of its functional adequacy, asset management, and seismic resilience.
- WSDOT acknowledges that project feasibility or cost are to be determined and cautions against drawing firm conclusions or estimates at this level of detail.
- Any changes in ramp locations would require detailed network analysis of effects on freeway and local street function.
- More work would be needed to determine the best approach to long-term preservation or replacement of existing structures and meeting future seismic resiliency needs.

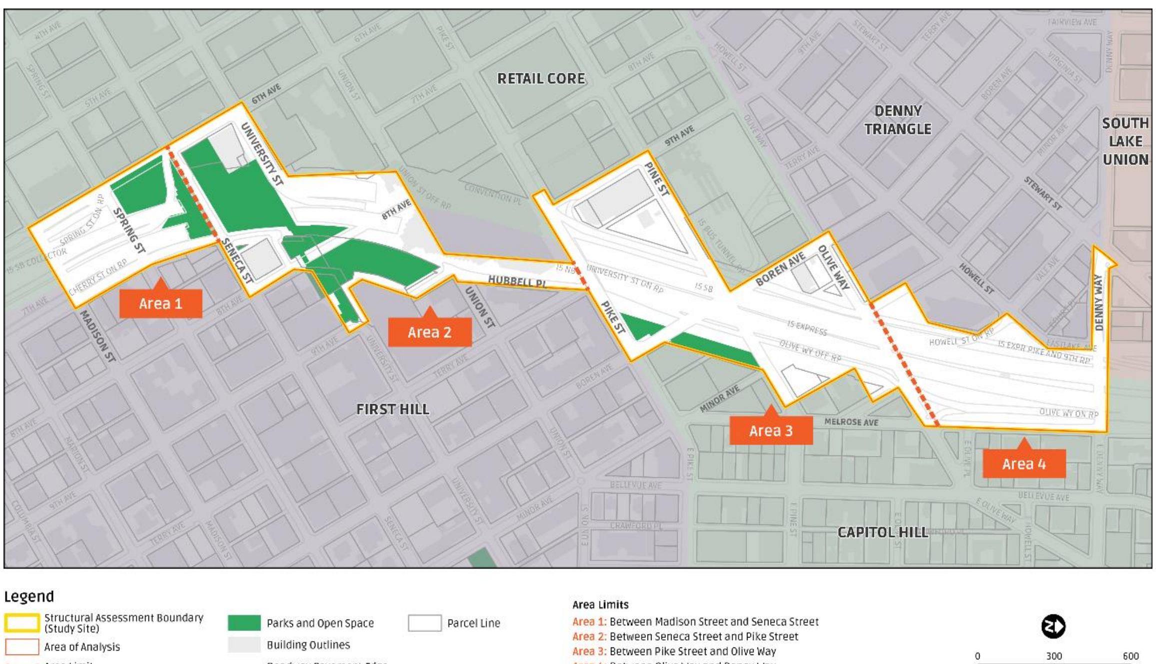
3. Build Zone Assessment for Lid Development

Spanning an interstate within a dense urban environment requires an understanding of the site—especially I-5 through downtown Seattle, which features extensive walls supporting city streets on each side of the right-of-way, elevated viaducts, overpasses, on- and off-ramps, city parks, and city streets and buildings. There are also subsurface features (e.g., tunnels, utility mains, and laterals). As part of the Build Zone Assessment, information requests were made to asset owners (WSDOT, Seattle Department of Transportation, Sound Transit, Seattle Public Utilities, Seattle City Light, and WSCC) to gather information they had within the SAB and surrounding area so that an approximate basemap could be developed. The basemap was used to gain an understanding of the existing site conditions and identify important considerations if a lid structure were to be constructed.

3.1 Structural Assessment Boundary and Area Definitions

The SAB defined for the project site extends from Madison Street (south end) to Denny Way (north end). The SAB was broken out into four areas with divisions near Seneca Street, Pike Street, and Olive Way. Figure 3-1 illustrates the SAB limits and area definitions. Appendix C, "Diagrams of Lid Area Concepts" provides a more detailed SAB figure that includes elevations, areas in square feet, number of I-5 lanes, and sub-areas.

Figure 3-1. Structural Assessment Boundary



For the purpose of the engineering feasibility, the study site was considered the Structural Assessment Boundary (SAB). The SAB was analyzed in four areas of lid development as shown in the present figure.

Note: Private parcels, and existing buildings and lids were not considered to be affected or intervened for the purposes of the engineering feasibility analysis. Only edge integration with the existing lid of Freeway Park was assumed.

Table 3-1. Delimitation of Structural Assessment Boundary Sub-Areas

SAB Sub-Area	Delimitation
Area 1	Madison Street to Seneca Street
Area 2	Seneca Street, Freeway Park, and the Washington State Convention Center, to Pike Street
Area 3	Pike Street to Olive Way
Area 4	Olive Way to Denny Way

3.2 Basemap Development

No field survey was conducted as part of this contract. The technical feasibility assessment—compiled and validated by the consultant team with information provided by asset owners—was performed using a basemap of the SAB and surrounding areas. Spanning an interstate within a dense urban environment requires an understanding of the site, especially I-5 through downtown Seattle, which features extensive walls supporting city streets on each side of the right-of-way, elevated viaducts, overpasses, on- and off-ramps, city parks, and city streets and buildings. There are also subsurface features (e.g., tunnels, utility mains, and laterals). Appendix B, "Basemap Development Methodology Memorandum" documents the basemap development process as part of the LFS.

Requests were made to asset owners (WSDOT, Seattle Department of Transportation, Sound Transit, Seattle Public Utilities, Seattle City Light, and WSCC) to gather information they had within the SAB and surrounding area so that an approximate basemap could be compiled. The information received included GIS data, old surveys, Lidar, and scanned PDF drawings from the 1960s. Discrepancies with the information were encountered and refinements were made based on visual observations from photos or in-person site walks.

Appendix B, "Basemap Development Methodology Memorandum" provides a detailed description of the basemap development. In general, it includes the following:

- Review and inventory of the received existing documentation/information, including existing survey, geographic information systems, structural as-builts, utility as-builts, existing geotechnical borings, and explorations within the project footprint
- Documenting how the information was used, flagging the level of confidence in the accuracy of the information received, and denoting what information was received but not used in the development of the basemap.

The developed basemap consists of multiple files broken-up by specific features (e.g., channelization, existing structures, storm drainage, and electrical and communication lines).

The primary objective of the basemap development was to gain an understanding of the existing site conditions for the purpose of developing lid area concepts and listing out associated considerations. The findings are noted in the following subsections.

3.3 Existing Conditions

The developed basemap provided a good general understanding of the existing conditions in and around the site, which consists of the following:

- Walls, tunnels, mainline I-5, on- and off-ramps, and overpasses
- An existing fire-life safety system for the existing WSCC
- Significant utilities
- Variations in soil conditions

The following subsections present noteworthy existing condition elements per engineering discipline.

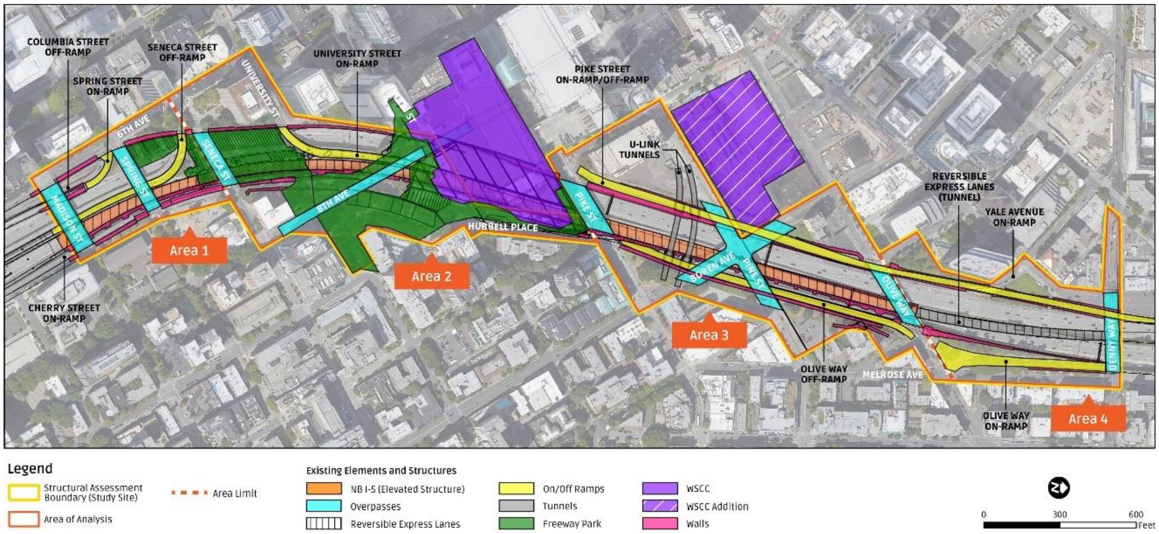
3.3.1 Structural

Table 3-2 summarizes existing structures within the SAB, and Figure 3-2 provides a spatial reference to their proximity in the SAB.

Table 3-2. Existing Structural Features within the Structural Assessment Boundary

Component	Area 1	Area 2	Area 3	Area 4
NB I-5 (Elevated Structure)	X	X	X	
Overpasses	X	X	X	X
Reversible Express Lanes	X	X	X	X
On- and Off-Ramps	X	X	X	X
Tunnels			X	X
Freeway Park	X	X		
WSCC		X		
WSCC Addition			X	
Walls	X	X	X	X

Figure 3-2. Existing Elements and Structures within the Structural Assessment Boundary



The following subsections briefly discuss each of these structural features, with Freeway Park, WSCC, and the WSCC Addition being lumped into one subsection titled “Existing Elements and Structures” (Section 3.3.1.1).

A general observation was that the topography along the SAB is highly variable and creates challenges for the new lid structure that would affect its functionality. Figure 3-3 illustrates the significant north-south and east-west grade variations along the length of the SAB. Figure 3-4 further illustrates the grade variation via a cross-section of the SAB in Area 1 near Spring Street.

Figure 3-3. Topography through the Structural Assessment Boundary

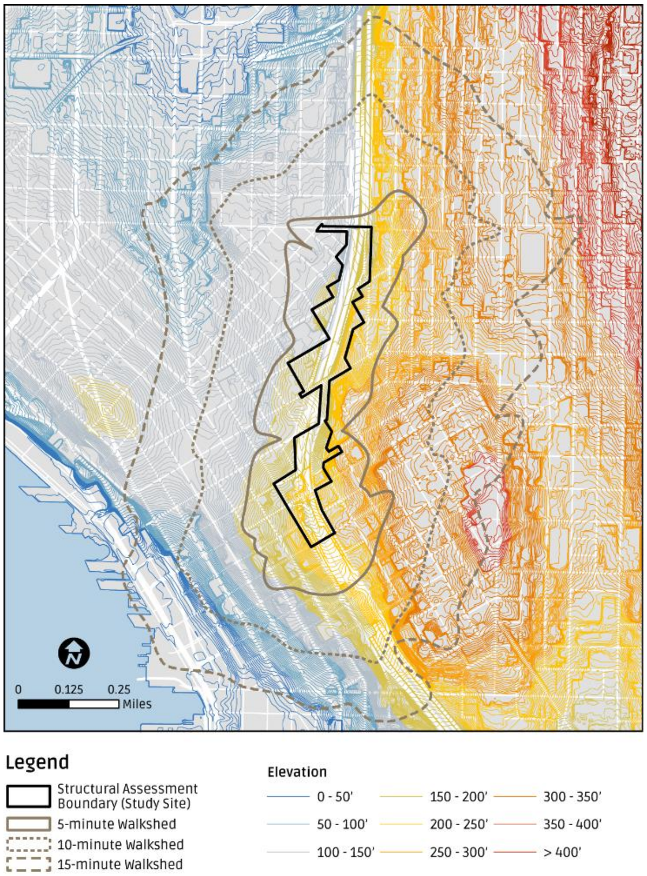
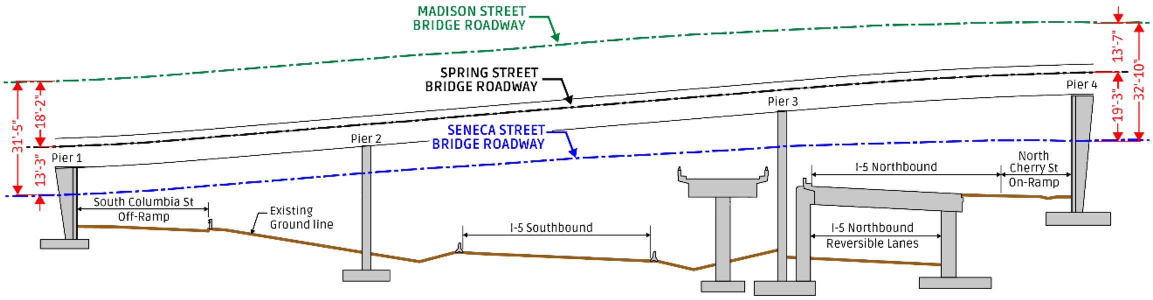


Figure 3-4. Grade Variation near Spring Street Bridge (Looking North)



The topography would create challenges in framing a new structure over the existing infrastructure and in maintaining minimum clearances. The lid framing could be built flat but would create large balconies with adjacent streets on the west edge of mainline I-5. The new lid could be framed to follow the grade variation of the site to minimize balconies; however, this would create a variable sloped lid surface that would not easily accommodate new vertical development. The existing topography of the site would be a big consideration for the new lid structure during design and would require unique solutions to maximize functionality.

3.3.1.1 Existing Elements and Structures

A number of existing elements and structures were identified within the SAB. Two of these—Freeway Park and the WSCC exist—within Area 2 of the SAB. The structures pertaining to either element were assumed to remain outside of some potential edge integration to Freeway Park. Freeway Park, which hosts a fair amount of open space and box gardens, has been nominated to be included in the National Register of Historic places. This would create additional considerations if modification or partial removal would be desired to construct a new lid structure. This would need to be considered as part of future studies.

Freeway Park consists of precast girder superstructure spanning I-5. Precast fascia edge panels are attached to the girders of Freeway Park, which act as an architectural façade and retain the landscaping on top of the lid.

The WSCC was built in 1980s, is just north of Freeway Park in Area 2, and supports a sliver of Freeway Park—a trail that runs north-south and connects to Pike Street. The trail is narrow and hosts a series of blind spots. The trail also requires the use of stairs for access to/from Pike Street.

The WSCC expansion is currently being constructed and is farther north in Area 3 of SAB between Boren Avenue and Pine Street. Sound Transit owns the property between the WSCC and the WSCC expansion (along the west side of the SAB), and it was assumed that this property would not be considered as developable for part of a potential new lid area.

3.3.1.2 Bridge Overpasses

Nine overpasses span mainline I-5. The overpasses consist of CIP concrete box girder superstructures supported by concrete columns on spread footings or pile-supported footings. See Figure 3-2 for overpass locations within the SAB.

Several locations exist where the vertical clearances below the soffit of the overpasses do not meet the WSDOT Design Manual minimum vertical clearance requirements of 16 feet 6 inch for new bridge structures. Table 3-3 identifies the locations with inadequate vertical clearance:

Table 3-3. Existing Vertical Clearances

Area	Location	Vertical Clearance	Notes
1	Madison Street Bridge	15.26 feet	Over Columbia Street
	Spring Street Bridge	16.32 feet 15.79 feet	Over Columbia Street Over Seneca Street Off-Ramp
	Seneca Street Bridge	15.79 feet	Over Northbound I-5, west lanes
	I-5 Northbound	15.27 feet	Over Reversible Express Lanes
2	7th Avenue Bridge	16.00 feet	Over Hubbell Place
	8th Avenue Bridge	15.17 feet 15.00 feet	Over University Street On-Ramp Over Union Off-Ramp
	I-5 Northbound	15.27 feet	Over Reversible Express Lanes

Area	Location	Vertical Clearance	Notes
3	Boren Avenue Bridge	15.25 feet	Over Pike Street On-and-Off Ramp
	Pine Street Bridge	16.18 feet	Over Pike Street On-and-Off Ramp
	Olive Way Bridge	16.18 feet 15.85 feet	Over Pike Street On-and-Off Ramp Over Northbound I-5, West Lanes
	I-5 Northbound	15.27 feet	Over Reversible Express Lanes
4	Yale Avenue On-Ramp	15.1 feet	Over Pike Street On-and-Off Ramp
	Denny Way Bridge	15.14 feet 16.47 feet 15.58 feet	Over Eastlake Avenue, West Lanes Over Northbound I-5, West Lanes Over Olive Way On-Ramp
	Tunnel	15.04 feet	Over Reversible Express Lanes in Tunnel

The vertical clearances shown in Table 3-3 are based on as-built drawings and construction drawings. Confirmation of vertical clearances through survey would need to be conducted in future phases of the project.

The new lid structure would need to meet the WSDOT Design Manual minimum vertical clearance requirements, which means that the new lid would need to be raised at locations with vertical clearance deficiencies, and thus, would be grade separated from existing overpasses. Vertical clearances requirements may need to be greater than the minimum due to mechanical, ventilation, and fire-life safety equipment requirements below the lid. There would be specific locations under the new lid and overpasses where the vertical clearance is greater than the minimum. Coordinating below-lid equipment would be necessary to minimize the required elevation of the new lid structure.

3.3.1.3 On-and-Off Ramps

Seven on-and-off ramps are along the length of the SAB. The Seneca Street off-ramp and University Street on-ramp are CIP box girder bridges. The Spring Street on-ramp is a CIP slab bridge and Yale Avenue is a CIP tee-beam bridge. The remaining ramps are slab on grade. See Figure 3-2 for the on-and-off-ramp locations along the SAB.

3.3.1.4 Mainline I-5

Mainline I-5 runs north-south through the entire length of the SAB. Through Areas 1, 2, and 3, I-5 northbound is an elevated bridge structure with mainline northbound traffic operating on the bridge deck and the reversible express lanes operating below. In Area 4, northbound I-5 is at-grade with the reversible express lanes in a tunnel that transitions from being under northbound I-5 to southbound I-5. Southbound I-5 is always at-grade throughout the SAB. The northbound I-5 bridge structures are conventionally reinforced concrete box girders.

3.3.1.5 Walls

Mainline I-5 was cut through the city when it was constructed in the 1960s, resulting in walls along the east and west edges of I-5. Approximately 33 walls are along the length of the SAB with wall types primarily consisting of cylinder walls and cantilever retaining walls.

The cylinder walls were added during the construction of I-5 to prevent lateral movement of the adjacent hills and buildings. The cylinder walls are CIP with 5.5-foot, 8.33-foot, and 10-foot diameters and ranging from 35 to 120 feet in length. Built-up steel I-beams are embedded in the center of the cylinders to provide flexural resistance and to connect the CIP fascia wall adjacent to the roadway.

The cantilever retaining walls are CIP and contain a range of structural systems: spread footings on soil with and without a passive pressure key, plumb and batter pile supported spread footings, and counterforts.

3.3.1.6 Tunnels

There are two tunnel systems within the SAB limits. The first tunnel system connects the I-5 northbound and southbound reversible express lanes between Olive Way and Denny Way. The tunnel is a CIP 4-sided tunnel constructed in approximately 30-foot long segments extending approximately 801 feet in length.

The second tunnel system is the Sound Transit U-Link tunnels south of the Boren Avenue and Pine Street overcrossings. The U-Link tunnels are two separate bored tunnels that run in the east-west direction under mainline I-5. The outer extents of the tunnels are approximately 20.5 feet in diameter. The top extents of the tunnels are approximately 15 to 40 feet below existing grade and a horizontal centerline spacing between the tunnels that ranges from 60 to 75 feet. Coordination with Sound Transit would need to occur during design to allow drilled shaft construction between the tunnels.

3.3.2 Geotechnical Information

The information request resulted in geotechnical reports from the WSCC expansion and the Sound Transit U-Link tunnels. Additional information was pulled from the Washington State Department of Natural Resources and previous projects in the area.

The information received was compiled and used as the basis for creating soil profiles, drilled shaft axial load charts, and recommended L-pile parameters. See Section 4.3.2 for details regarding the development of information used for the structural assessment.

3.3.3 Mechanical, Electrical and Plumbing (HVAC, Lighting, Fire Protection, Life Safety)

The new lid structure is expected to require an emergency ventilation system (EVS), fixed firefighting system (FFFS), structure fire durability protection, and power and controls for lighting and EVSs. The existing WSCC and lid structure contains the following systems:

- **Fire Protection Valve Room:** WSDOT has space located within the Convention Center complex housing fire protection equipment serving the existing lid. The space contains FFFS booster pumps, foam injection system storage tanks and pumps, deluge valves for roadway FFFS, control panels, and other assorted minor equipment.
- **Fire Protection System:** Existing Convention Center lid roadway fire protection systems have been in use for many years. If the lid is extended, new systems and arrangements would need to be coordinated to fit the new lid length and width. Spacing of zones, water supply orientation and location of deluge valve assemblies would need to be synchronized.

- **Foam Injection Systems:** The existing Convention Center lid FFFS is equipped with an aqueous film forming foam (AFFF) injection system to address gasoline tanker fires. The effectiveness of these systems in suppressing gasoline fires in recent testing is limited. These systems are expensive to install and require extensive regular maintenance. The foam agents are toxic and previous types have been banned. WSDOT has replaced recent foam agents with an approved revised formula. However, the new formula has been banned as well.

3.3.4 Civil - Utilities and Drainage

There are several existing utilities on site that include water, sewer, power, communications and gas. Most of these utilities are in city streets. Water lines do not cross over I-5 in the area of the lid study and generally stay on the city streets. I-5 separates the city water system into two different water pressure zones. The south pressure zone is located to the west of I-5 (326 feet pressure head) and the Volunteer Park pressure zone is located to the east of I-5 (530 feet pressure head). Most stormwater from the densely populated portions of Capitol Hill drain to the swale on Yale Avenue. The system crosses I-5 just south of Denny Way. West of the project area, the stormwater enters a combined sewer area. There are two sanitary sewer basins that cross the project limits. One basin crosses at Union Street and goes to the Westpoint Treatment Plant via the King County Central Trunk. This basin is considered controlled. The other basin crosses at Denny Way and goes to the Westpoint Treatment Plant via the Denny Way Regulator Station. The bridges over I-5 most likely contain electrical and communication conduit in the bridge rails. WSDOT also maintains its ITS and lighting systems along I-5.

3.3.5 Civil - Roadway and Traffic

The existing roadways within the project area are either asphalt or concrete. The vertical geometry of city streets within the area is challenging due to the aggressive grade of the terrain. High pedestrian traffic volumes in the area use existing facilities. Most city street intersections are signalized and would need to be evaluated for modification or replacement. Traffic volumes on city street and I-5 are extremely heavy, and impacts and mitigation measures would need to be addressed. Existing illumination systems on city streets and I-5 along with sign structures would need to be evaluated for upgrade or replacement.

3.3.6 Civil - Site

This item includes the existing site features such as roadway and pedestrian infrastructure, utilities, and drainage. The new lid would have an impact on the existing site features. The existing terrain slopes downward to the west and undulates north to south. Current traffic patterns, pedestrian routes, bicycle routes, and drainage flow could change if a lid were added over I-5.

3.4 Potential Lid Span Lengths

Development of the conceptual-level basemap (Section 3.2 above) provided a better understanding of the existing conditions (Section 3.3 above), which supported development of potential lid structure spans for each sub-area of the SAB. The approach for identifying potential pier locations and thus, lid span lengths, was to minimize traffic impacts to mainline I-5 and avoid interferences with existing conditions.

Table 3-4 shows the approximate width of mainline I-5 at intervals along the SAB. The approximate widths of mainline I-5 are measured perpendicular to the corridor. A girder framing orientation perpendicular to the I-5 corridor was assumed for this feasibility study. A girder framing direction parallel to I-5 would require deep crossbeams that spanned across I-5 to transfer the vertical and horizontal loads to a large foundation systems outside the intersate-5 lanes. Based on engineering judgement, framing parallel to I-5 would require unreasonable superstructure span lengths and foundations sizes to adequately resist the expected vertical and horizontal loads.

Table 3-4. Interstate-5 Width

Location	Width (Feet)
Madison Street	170
Spring Street	160
Seneca Street	218
8th Avenue	184
Pike Street	178
Boren Avenue & Pine Street	161
Olive Way	167
Denny Way	168

The widths shown in Table 3-4 are not unreasonable span lengths for typical superstructure types (i.e., precast girders and steel-plate girders) used in Washington State. However, the loads that the lid structure would support could be significantly larger than the typical AASHTO Load and Resistance Factor Design (LRFD) live loads used for new bridge designs. Therefore, a minimum of two spans would be required to lid across mainline I-5 to control the depth of the superstructure.

The following three typical locations were identified along the SAB where foundation elements could be constructed to create pier lines to support the girders of the lid superstructure:

- West of I-5 southbound lanes
- East of I-5 northbound lanes
- Between I-5 northbound and southbound lanes

Each area has specific site constraints and considerations that required unique pier line locations that deviated from the typical locations. Table 3-5 shows the resulting typical span lengths for each area.

Table 3-5. Potential Span Lengths for Each Sub-area of the SAB

Area	Span	Span Length Range (Feet)
1	Over James Street Off-Ramp	80 - 90
	Over I-5 Southbound	80 - 90
	Over I-5 Northbound	90 - 120
2	Over University Street	40 - 100
	Over I-5 Southbound	80 - 125
	Over I-5 Northbound	80 - 120
	Over Hubbell Place	40 - 65
3	Over Pike Street On-and-Off Ramp	50 - 60
	Over I-5 Southbound	90 - 145
	Over I-5 Northbound	75 - 130
	Over Olive Way Off-Ramp	50 - 70
4	Over Pike Street On-and-Off Ramp	50 - 60
	Over I-5 Southbound	80 - 145
	Over I-5 Northbound	90 - 170
	Over Olive Way Off-Ramp	60 - 160

Areas adjacent to existing overcrossings with significant skews were considered with the reported span length ranges. To maintain continuity between the existing overcrossings and the new lid, it was assumed that the new lid girders would need to be set at similar skew angles, thus, maximizing the potential girder lengths.

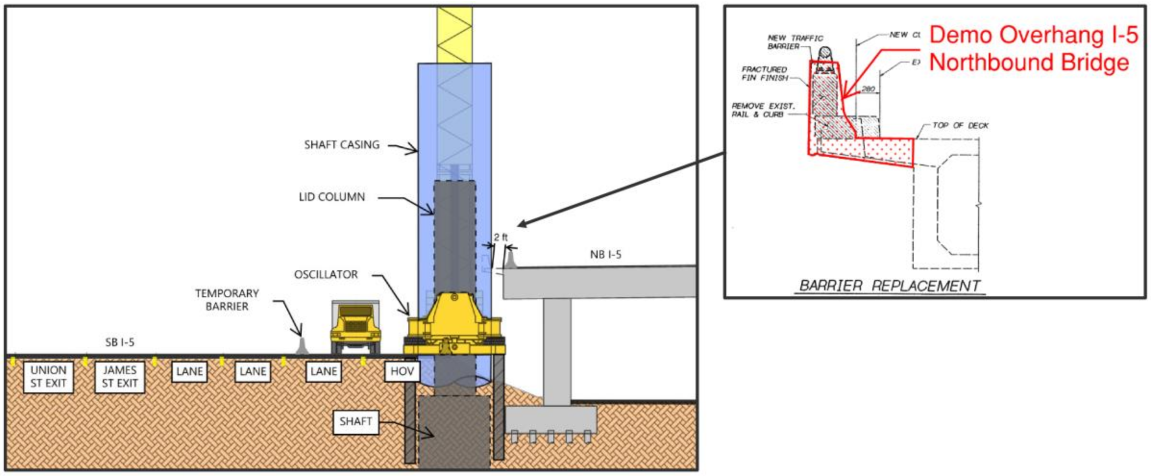
3.5 Considerations

One of the focus points in laying out potential lid structure spans was to minimize impacts. Due to the nature of this site, complete avoidance of impacts was not feasible. The following subsections present and describe noteworthy considerations that would need to be accounted for in more detail as the City of Seattle further develops the project.

3.5.1 Replace Northbound Interstate-5 Overhangs

An intermediate pier (consisting of a column and drilled shaft) would need to be located within the limits of mainline I-5 to reduce the superstructure span lengths and not further grade-separate the lid structure from the surrounding city streets and topography. This assumes that it is not desired to have above-grade stay cables or trusses. To minimize impacts to existing I-5 traffic, an intermediate pier could be constructed between the northbound and southbound lanes. The existing space between northbound and southbound lanes ranges from approximately 3 feet to 12 feet in width. As illustrated in Figure 3-5, this work most likely would require that the shoulder and some lanes along I-5 southbound be temporarily closed to locally demolish and replace the I-5 northbound overhangs while the intermediate pier is constructed. For additional constructability considerations, see Section 5.

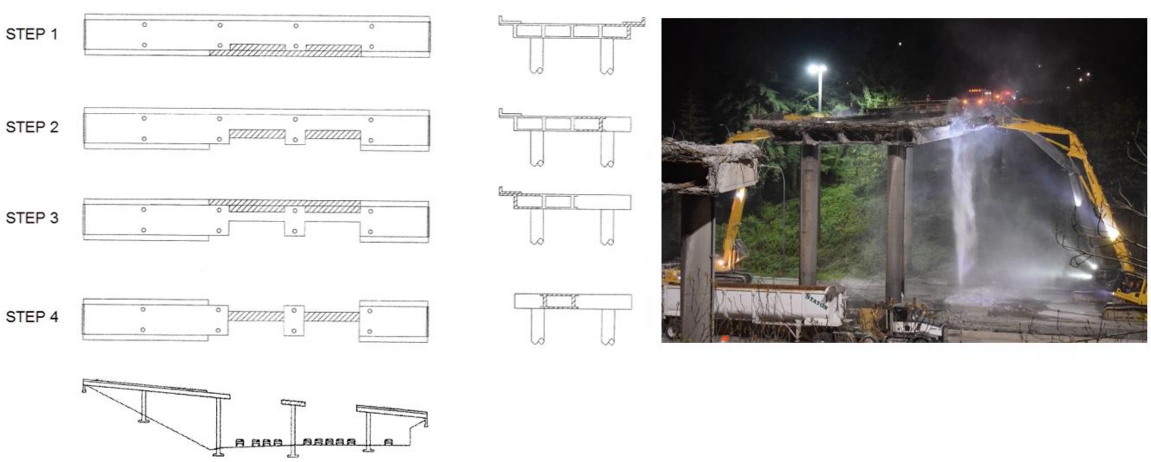
Figure 3-5. Replace Northbound I-5 Overhangs



3.5.2 Overpass Demolition / Replacement

The exiting overpasses that span I-5 have complex geometry (e.g., horizontal curves, kink points, high skews) that create unique challenges for constructing a new lid structure adjacent to the overpasses. Figure 3-6 shows potential demolition methods. The schematic illustrates a more methodical approach that would take longer and require more shorter duration closures of I-5, and the photo illustrates a more robust, brute force approach that would require fewer but longer duration closures. Demolishing the overpasses would open space along I-5 during the construction of the lid structure and permit more options for permanent channelization reconfigurations, pier locations, superstructure optimization, existing structure modifications, and edge integrations. For the purpose of this study, it was assumed that the overpasses would not be demolished and replaced in order to capture the most constrained conditions.

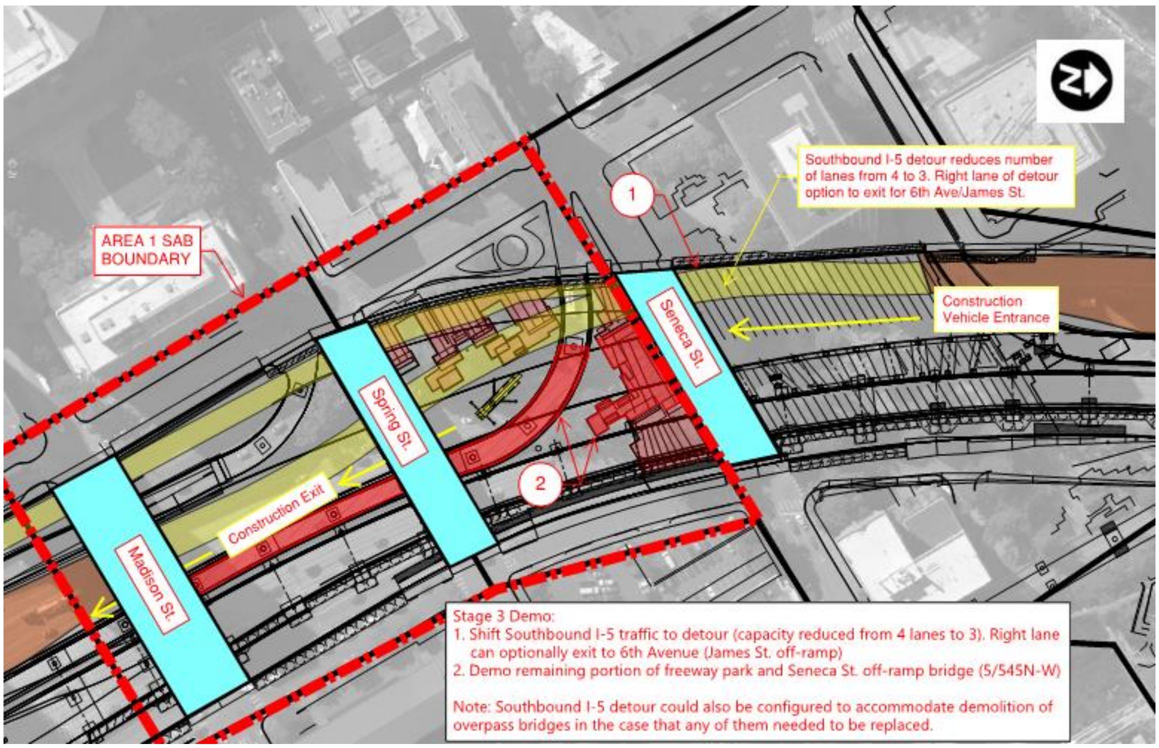
Figure 3-6. Overpass Demolition / Replacement



3.5.3 On- and/or -Off Ramp Demolition

Maximizing the amount of developable lid area—while preserving the function of the lid—could require demolition of existing on- and/or -off ramps due to vertical clearance requirements. As an example, leaving the Seneca Street off-ramp would not create much of a grade separation with the walls on the east side of I-5; however, it would require a grade separation up to 35 feet near the west walls due to the east-west grade variation. Therefore, the impacts of demolishing the Seneca Street off-ramp and the Spring Street on-ramp were considered for the purposes of this feasibility study. Figure 3-7 illustrates an example of the thought provided into how the ramp would be demolished.

Figure 3-7. Potential On- and/or -Off Ramp Demolition



3.5.4 Sound Transit U-Link Tunnels

The lid structure foundation elements would need to be constructed between the existing tunnels with enough clearance to avoid loading the Sound Transit U-Link tunnels. It has been assumed that the foundation elements can be placed between and adjacent to the existing U-Link tunnels. Coordination with Sound Transit and a geotechnical engineer during design would be critical to determine new foundation locations near the tunnels.

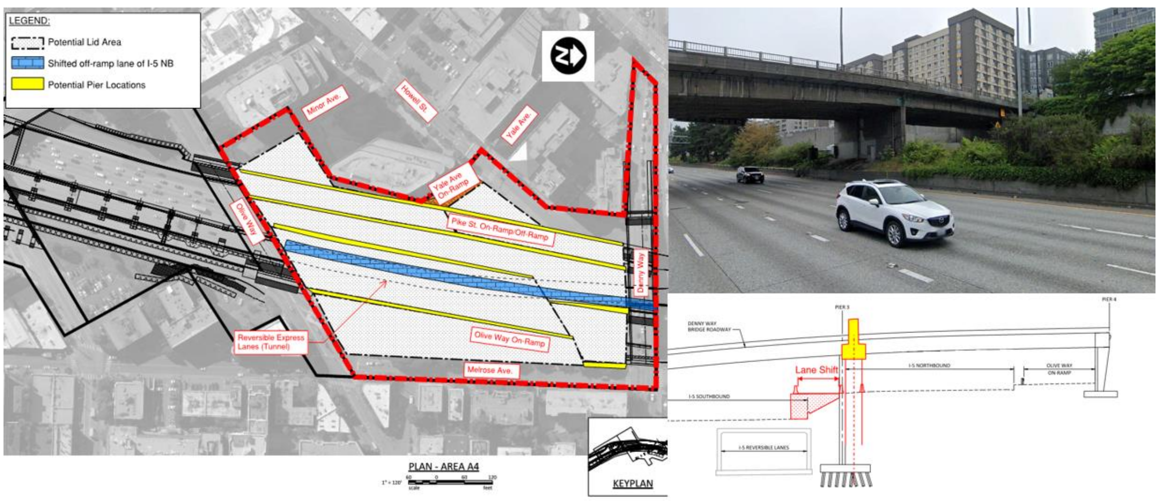
Deep crossbeams would be required to span over the tunnels to transfer the vertical and lateral loads to the foundation elements. Large foundation systems could be needed to support the additional loads from the crossbeams.

3.5.5 I-5 Channelization Reconfiguration

Temporary and permanent lane channelization reconfigurations would be required to minimize traffic impacts along mainline I-5 and facilitate construction of the new lid structure. Existing traffic lanes could be temporarily reconfigured to facilitate construction equipment for demolition or construction purposes while keeping some lanes open in order to reduce the need to completely close I-5.

Figure 3-8 shows an example of a permanent lane reconfiguration in Area 4, near where the reversible expressway tunnel switches from under I-5 northbound lanes to under the I-5 southbound lanes. The new lid structure intermediate pier would need to be split and offset from the space between the northbound and southbound lanes to prevent interferences with the tunnel. As a result, the existing Mercer Way off-ramp would need to be shifted. An idea would be to shift the off-ramp to the west side of the intermediate pier between northbound and southbound I-5 of the existing Denny Way overpass bridge. This would require building a new wall to the west of the existing pier because the I-5 southbound lanes are at a lower elevation than the northbound lanes.

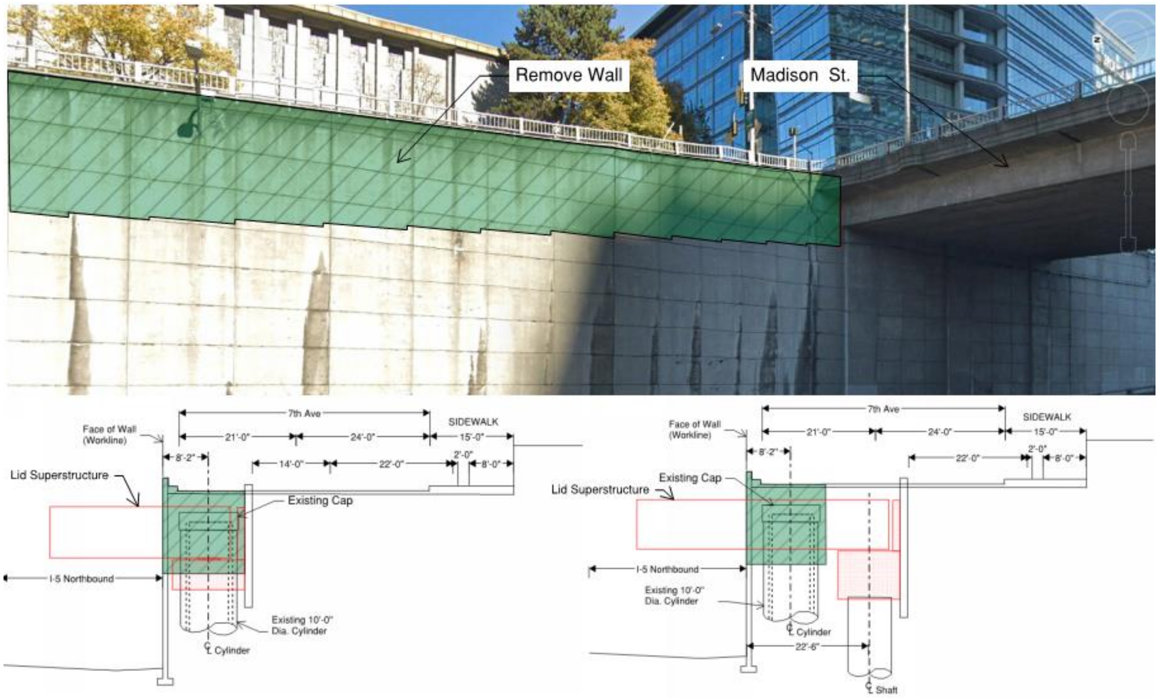
Figure 3-8. Example of I-5 Channelization Reconfiguration



3.5.6 Wall Removal / Modification

The new lid structure would require abutments supported by deep foundations to be constructed behind the existing walls located on the east and west sides of I-5. In addition to the deep foundations needing to support the vertical load demands from the lid structure, they would aid in not increasing the load demands on the existing wall systems. To facilitate construction, the existing walls would need to be partially demolished (see Figure 3-9). The existing walls are displacement controlled walls, which means that a temporary strut could be created ahead of partially demolishing the wall. It should be noted that modification to the existing walls could require complete rather than partial demolition. This will need to be considered in future studies.

Figure 3-9. Wall Removal/Modification



City streets exist adjacent to the walls, and these existing city streets contain utilities that service multiple facilities in the area. Temporary road closures and utility disruptions would be required to conduct this work.

There could be opportunities for the new lid structure to support on the cap of the cylinder walls. The new lid structure could provide stability to the east and west walls by acting as a strut. However, most of the walls were constructed in the 1960s and are approaching their design life. The original design of the walls was not intended for vertical or lateral seismic loads. For the purposes of this feasibility study, it was assumed that the existing cylinder walls could not be used to support the lid structure.

3.5.7 Freeway Park / WSCC Modifications

This study assumes that Freeway Park and the WSCC would remain, however, with several required or desired modifications. The following potential modifications are being considered:

- **Edge integration for lid structural framing.** Concrete fascia panels surround the perimeter of Freeway Park (see jagged orange lines in Figure 3-10). The concrete fascia panels have significant steps and edges that would make framing a new lid difficult. Removing the fascia panels would provide a clean edge for the new lid to frame into.
- **Removal of Freeway Park and box gardens between Spring Street and Seneca Street.** Precast girders on concrete pier walls and spread footings support Freeway Park. The box gardens and portions of Freeway Park (see orange shaded regions in Figure 3-11) would be removed to maximize the potential developable lid area and cleanly frame the new lid between Spring Street and Seneca Street.

- **Improving the north-south pedestrian route south of Pike Street and east of WSCC.** The existing walkway within this part of Freeway Park is narrow with blind spots that deter use of the pathway. Stairs at the north end of the pathway also limit the users of the pathway. Figure 3-12 shows a concept that would widen the existing walkway (cyan shaded area) and construct a flyover pedestrian bridge (orange shaded portion) over Pike Street to resolve the confined pathway and provide access for all. This concept would remove adjacent trees along Hubbell Place and would require permanent lane reconfiguration with removal of the on-street parking.

Figure 3-10. Required Edge Integration

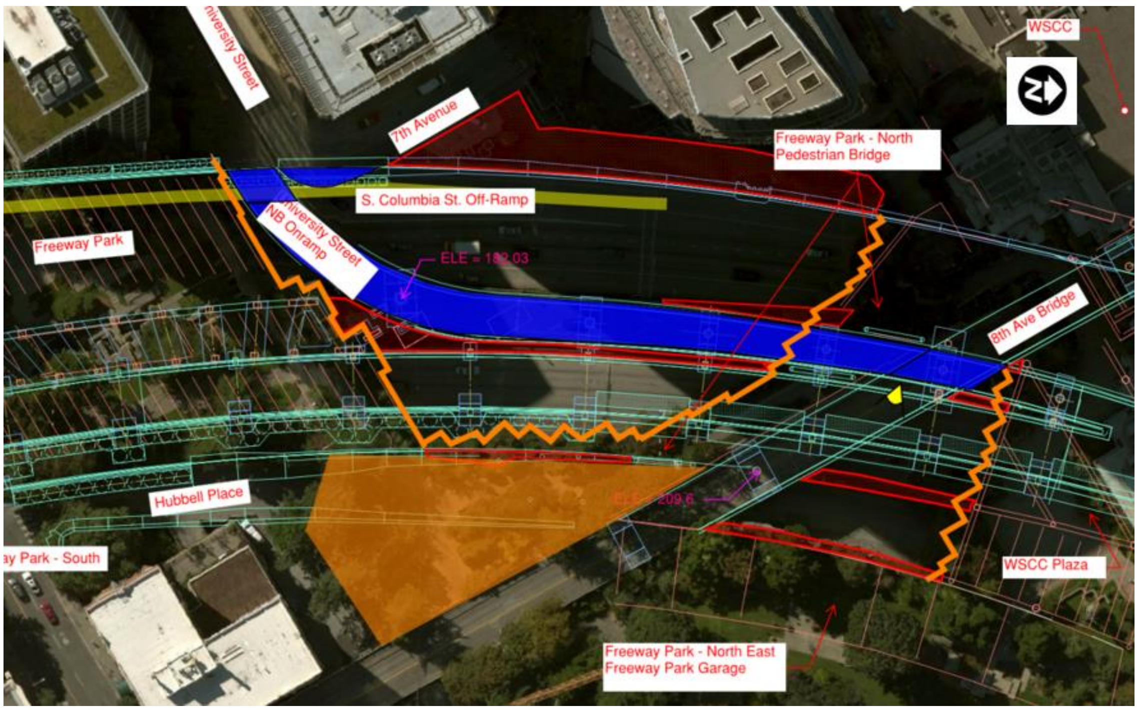


Figure 3-11. Consideration of Freeway Park's Box Gardens Removal for Lid Edge Integration

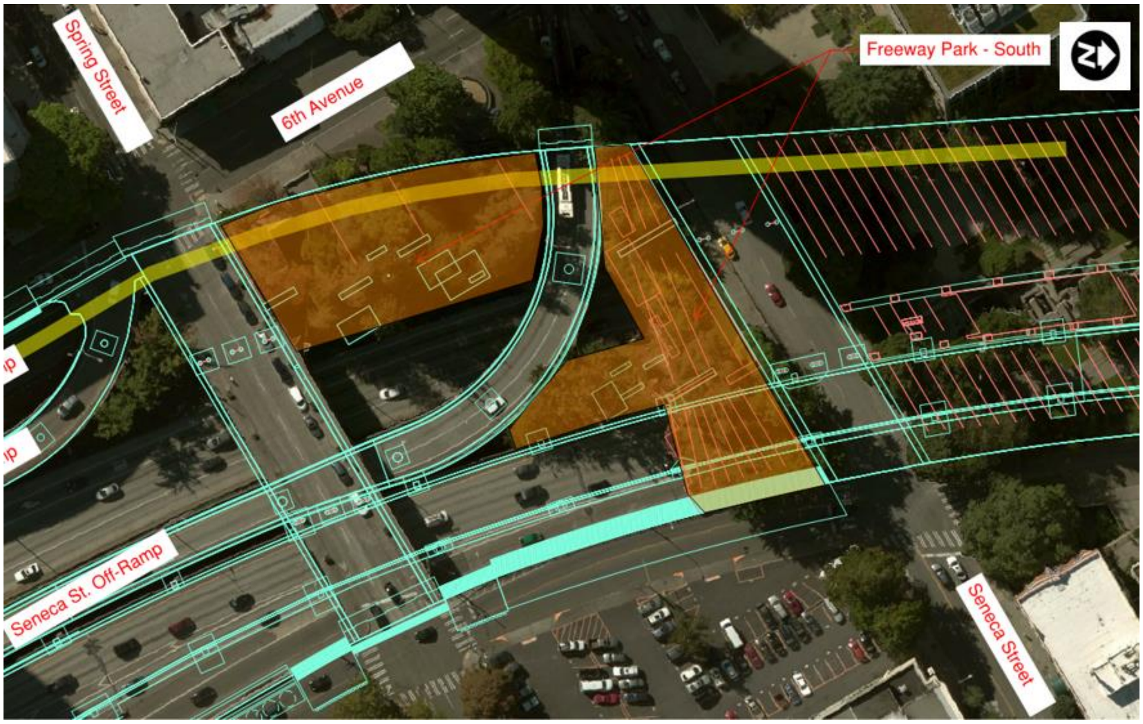
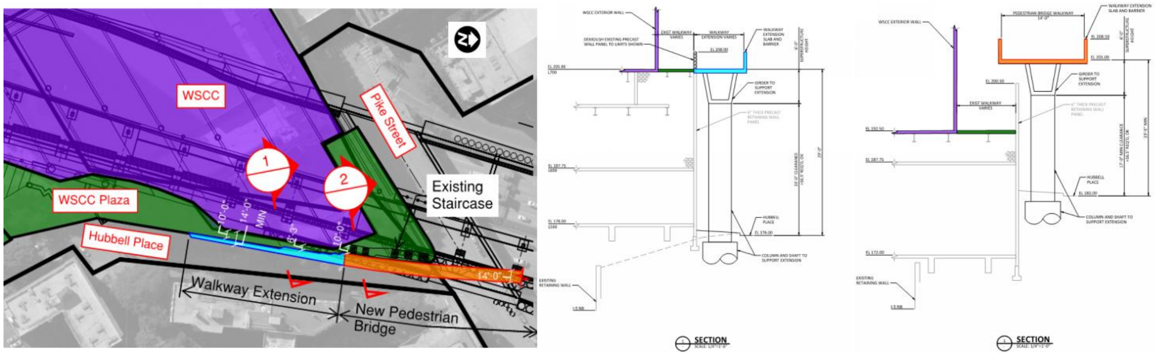


Figure 3-12. Path Widening and Pedestrian Bridge Over Pike Street



4. Lid Area Concepts

Lid area concepts were developed based on the build zone assessment summarized in Section 3. The resulting maximum potential lid area is 17.4 acres and is illustrated in Figure 4-1. Table 4-1 breaks out the total potential lid area (i.e., 17.4 acres) per SAB area. However, using the maximum potential lid area would require a thorough understanding of the considerations noted in Section 3.

Figure 4-1. Maximum Potential Lid Area

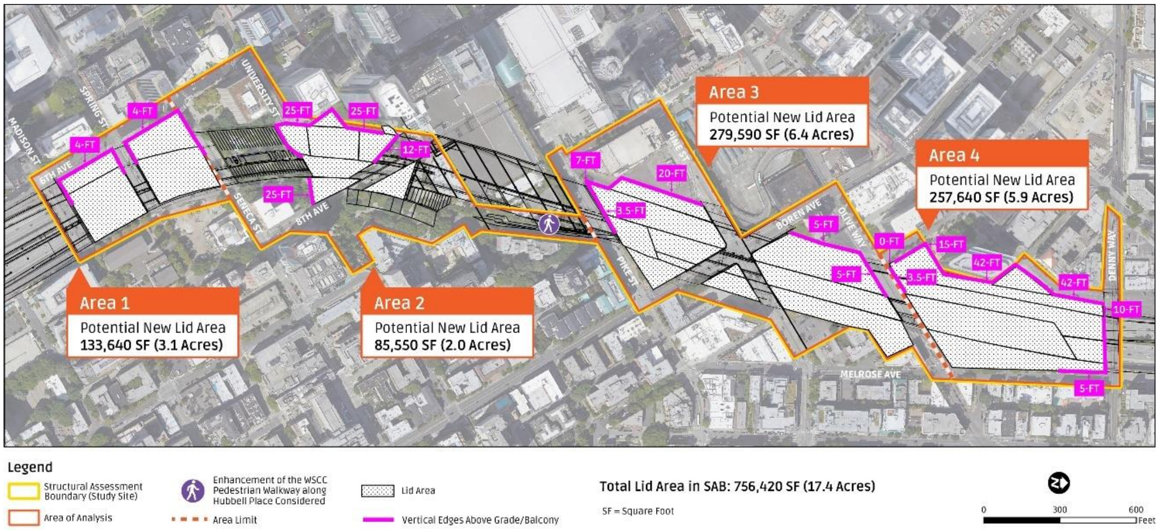
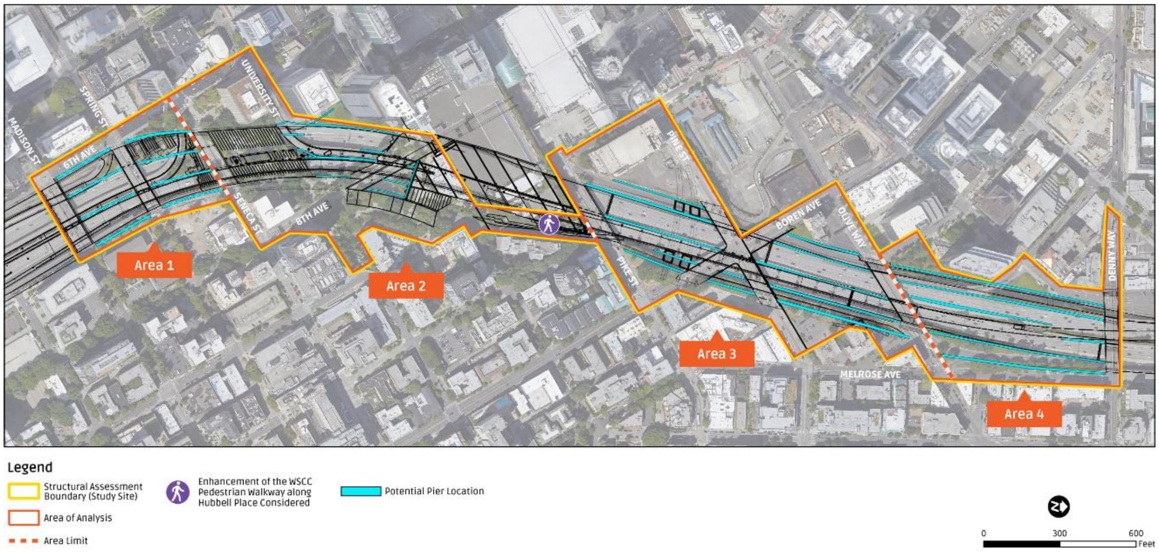


Table 4-1. Maximum Potential Lid Area

Area	Maximum Potential Lid Area	
	Square Feet	Acres
Area 1	133,640	3.1
Area 2	85,550	2.0
Area 3	279,590	6.4
Area 4	257,640	5.9
Total	756,420	17.4

Figure 4-2 shows the associated identified potential pier locations. Appendix C, “Diagrams of Lid Area Concepts” shows these pier locations per area and in more detail along with the considerations taken into account when defining the potential pier locations.

Figure 4-2. New Lid Structure Potential Pier Locations



4.1 Assumptions

Owing to the preliminary nature of the analysis, the study incorporates some assumptions, which provided guidance to produce a consistent, evidence-based and technically sound feasibility study. Appendix B "Basemap Development Methodology Memorandum" provides a detailed list of assumptions. Key assumptions follow:

- The I-5 LFS does not make any decisions about the future of the I-5 corridor.
- Conventional framing and structural elements are only considered for the lid structural systems.
- Existing structures are not being assessed for deficiencies; Puget Sound Regional Council's 2018 State Facilities Action Plan is the basis for the I-5 asset analysis.
- Existing bridges, ramps, walls, or other structures (excluding buildings and tunnels) within the SAB can be considered for removal, modification, or replacement for the purpose of the analysis. Removal of ramps, without replacement, would require additional analysis to address potential implications. This additional analysis is beyond this feasibility.
- The study does not assess structural modifications to the existing lids at Freeway Park and the Convention Center beyond potential edge integration with a future lid.
- The existing capacity of I-5 cannot be reduced.
- Permanent I-5 lane configuration modifications are permissible to create space for lid structural intermediate piers. Lane modifications may create islands between ramps and mainline I-5 lanes or between high-occupancy vehicles designated lanes and mainline I-5 lanes.
- Temporary I-5 impacts are permissible, including, but not limited to, long-duration lane closures (i.e. months) to construct piers within I-5 and short-duration multiple lane closures to demolish overpasses and ramps.
- No new subsurface explorations will be performed.
- The high-rise load level (see Section 4.2) will not be supported by the lid. High-rise loads will be supported only on soil adjacent to the lid.

4.2 Load Levels

Based on the identified span configurations, potential structural framing alternatives were considered for various load levels: open space, low-rise, mid-rise, and high-rise development. Figure 4-3 shows the magnitude of the load levels and their definitions.

Figure 4-3. Load Levels

	Open Space Landscaping and pavilions (up to 3 stories)	Low-rise Residential 7 story (5 over 2) Structures	Mid-rise Residential/ Commercial 15 to 20 story Structures	High-rise Residential/ Commercial 45 story Structures
Dead Load (PSF)	1,000	600	2,650	6,815
Live Load (PSF)	250	430	1,150	2,100

Source: Magnusson Klemencic Associates, 2019

4.3 Assessment

The assessment of the potential new lid areas includes considerations for structural, geotechnical, constructability, fire-life safety, site civil, and roadway civil aspects of the job. However, the primary assessment focuses on structural and fire-life safety considerations because there would be significant costs related to these components. The following subsections present the considerations included in the assessment, arranged per discipline.

4.3.1 Structural

A detailed structural computer analysis for each lid area was not conducted. Instead, a generalized structural assessment was run though simplified bounding and sensitivity analyses that were applied to lid area test concepts. The analyses considered a range of variables (i.e., geometric considerations, materials, loads) that bounded the potential site conditions determined from the existing conditions assessment (see Section 3). The range of variables consisted of the following:

- **Load Levels:** See Section 4.2 for definition of load levels. Load levels were applied to the entire span length.
- **Girder Type:** The structural assessment of the superstructure assumed that only conventional girder types would be used, consisting of wide-flanged precast concrete girders with a CIP deck and built-up I-beam steel-plate girders with a CIP deck. Additional concrete and steel girder types are available but were not considered as wide-flanged precast concrete girders, and steel-plate girders are the most conventional systems used in Washington State.

  A steel truss could be advantageous to reduce weight and provide additional stiffness directly below the vertical development. However, vertical clearances and unique framing considerations would need to be worked out. This may be an opportunity to investigate during design.

- **Lid Depth:** The analysis assumed that wide-flanged precast concrete girders from WF36G up to WF100G girders would be considered. The structural assessment of the steel-plate girders assumed built-up I shaped beams from a depth of 3 feet up to a depth of 14 feet. The upper bound girder depth was chosen as the point where increased girder depth would require horizontal web splices in accordance with WSDOT Bridge Design Manual Section 6.3.4.
- **Girder Spacing:** A girder spacing between 5 feet and 12 feet was used. This range in girder spacing is typical for precast concrete girders because 5 feet girder spacing results in back-to-back girders with minimal deck between girder flanges. The girder spacing of 12 feet was selected as the limit where transverse post-tensioning would be required in the deck in accordance with the WSDOT Bridge Design Manual. It should be noted that the steel-plate girder maximum girder spacing can be within the 12 to 14 feet range. However, girder spacing in excess of 12 feet was not considered because it was not practical for the load levels defined in Section 4.2.
- **Column Height:** The grade variation along I-5 and the east and west walls creates high variability of column heights along the SAB. The existing conditions assessment determined that column heights between 15 feet and 45 feet would be expected.
- **Columns:** Concrete circular columns 4 feet to 7 feet in diameter were assumed. Column diameters below 4 feet are not typical for bridge columns. Column diameters greater than 7 feet could create seismic demands that would be difficult to resist below ground. Pier walls could be advantageous from an FLS perspective. However, pier walls would require larger foundation elements and would have additional constructability impacts over conventional single-column single-drilled shaft construction.
- **Shafts:** Only drilled shafts were considered due to limited space to construct foundation elements. Shaft diameters equal to 6.5 feet, 8 feet, and 10 feet were used. Shaft diameters greater than 10 feet might be constructible adjacent to the I-5 east and west walls.

The results of the analyses consisted of data that was then used to size superstructure, substructure, and foundation components for quantity and ROM costs.

Figure 4-4. Precast Girder Typical Section

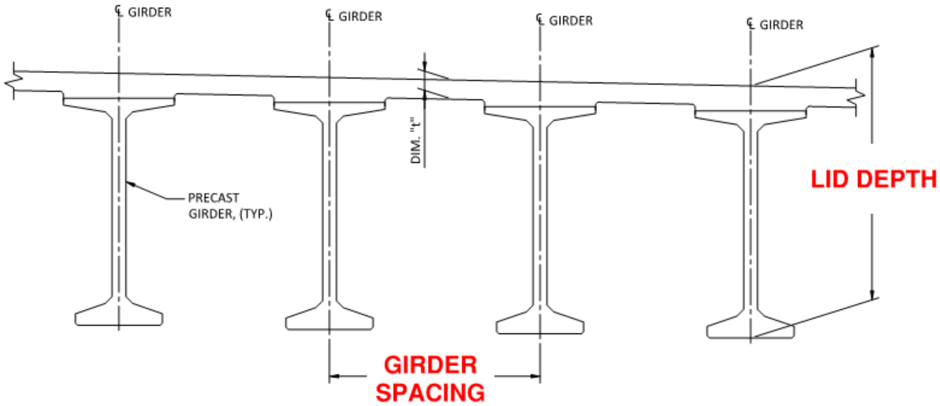
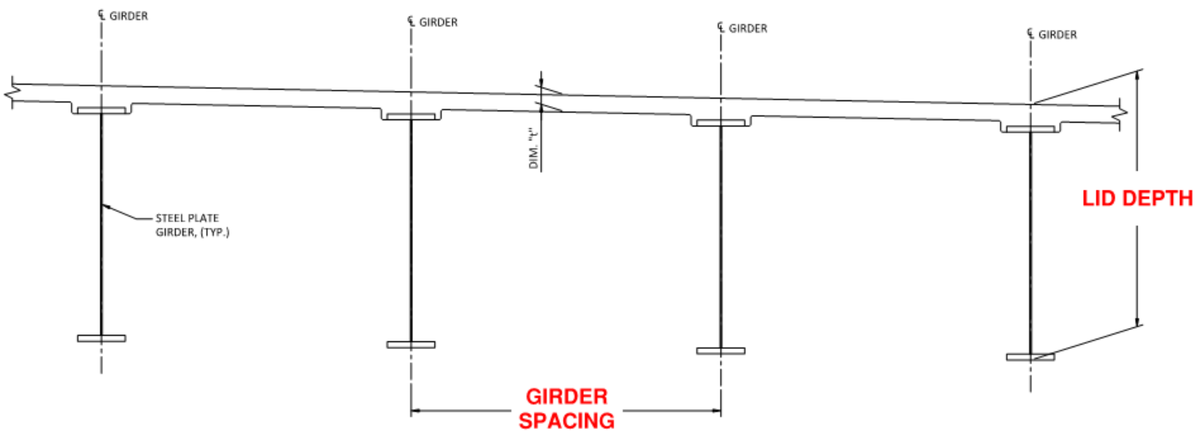


Figure 4-5. Steel-Plate Girder Typical Section



4.3.1.1 Vertical (Gravity) Analysis

The vertical analysis was conducted for the range of variables defined in Section 4.3. Details of the analysis are described below with the findings presented in Section 6.

Superstructure

The superstructure analysis approach consisted of maximizing the girder span lengths for an assumed set of bounding variables. The bounding variables considered in the analysis included girder type, girder depth, girder spacing, and load level (see Table 4-2).

Table 4-2. Superstructure Variable Analysis

	Precast Girder	Steel Plate Girder
Load Levels	All	All
Girder Spacing (Feet)	5, 12	5, 12
Girder Depth (Feet)	4, 9.33	4, 14

The following additional assumptions were made:

- Steel-plate girder deflection limit equal to span length divided by 1,000
- No amplification to live load demands due to impact

The precast girders were analyzed using the WSDOT program BridgeLink, and the steel-plate girders were analyzed using in-house spreadsheets. The girders were designed in accordance with AASHTO LRFD Bridge Design Specifications and the WSDOT Bridge Design Manual.

Specific analysis considerations are as follows:

- The superstructure analysis considered single spans up to a maximum of three spans. A sensitivity analysis was run with unbalanced uniform loads and unbalanced span lengths. It was determined that uniformly loaded spans with equal span lengths resulted in the highest demands on the girders. Therefore, it was assumed that the girders would be analyzed with identical span lengths with equal uniform loads applied across all spans. Partially loading spans to reduce demands were not analyzed.

- The demands from one, two, and three span analyses were enveloped and the span lengths were adjusted until a solution was found where all capacity-to-demand ratios were greater than unity. Enveloping the demands makes the maximum span lengths independent of the number of spans. While this is a conservative approach, longer spans could be acceptable if a site-specific analysis is run that accounts for the actual number of spans.
- The number of runs was reduced by analyzing only the minimum and maximum girder size and girder spacing. A solution for a girder size or spacing between these minimum and maximum ranges was estimated by linear interpolation.

Substructure

Multiple column bents were assumed for the assessment. Based on fire-life safety requirements, wall piers could be preferable to control ventilation requirements. The column diameter and percentage reinforcement utilized was determined from the preliminary seismic analysis (see Section 4.3.1.2 for details).

Crossbeam size and percentage reinforcement was selected based on engineering judgement and not based on specific calculations. The crossbeams were assumed to be dropped to provide a seat for the girders spanning between piers.

Foundation

The required shaft lengths were determined in accordance with WSDOT Bridge Design Manual Chapter 7.8. Vertical dead and live load were traced down to the top of the shafts and factored in accordance with AASHTO LRFD Section 10.3. The Service and Strength demands were compared to the axial load charts provided by the geotechnical engineer (see Appendix D, “Preliminary Geotechnical Information”) and a shaft length was selected. Group reduction factors were calculated in accordance with WSDOT Bridge Design Manual Section 7.8.1 and applied by amplifying the axial load demands. Change in axial force demands associated with the design seismic event were not checked, but should be as the design progresses into future phases.

It was determined that the required shaft lengths are controlled by vertical strength loads. To minimize the vertical demands on the shafts, the drilled shafts were spaced at two diameters apart, measured centerline-to-centerline. A group reduction factor of 0.9 was used for this shaft spacing and thus, the demands were increased by 11.1 percent. Where axial load demands exceeded the axial load charts, linear interpolation beyond the chart limits was used to determine the required shaft lengths. Geotechnical input will be critical during the design process (future phases of design) and could require deeper explorations. Shaft lengths were increased by one shaft diameter beyond the extrapolated axial load charts to account for additional demands from the net weight of the shafts (i.e., weight of concrete minus weight of soil removed).

4.3.1.2 Seismic Analysis

The seismic assessment was conducted using single degree-of-freedom systems configurations independent of the specific lid areas and potential pier locations. Instead, a range of tributary mass, column heights, and fixity conditions (i.e., free top and fixed top) were run, and column and shaft sizes, and associated reinforcement, was determined for quantities and ROM costs.

The seismic analysis was performed in compliance with the WSDOT Bridge Design Manual Chapter 4 and the AASHTO Guide Specifications for LRFD Bridge Design Specifications criteria (checks for displacements, displacement ductility, column shear, shaft flexure/shear, minimum strength, and p-delta effects). The implications of the seismic analysis are presented in Section 6.

The following seismic analysis assumptions were made:

- Type 1 earthquake resisting system: ductile substructure with essentially elastic superstructure in accordance with AASHGO GS Section 3.3.
- Deviations from the balanced stiffness requirements will be permissible. The unbalanced stiffness and careful consideration of mass redistribution should be accounted for during design. There are several ways to modify the structural stiffness to create a more balanced system. This includes, but is not limited to, sliding bearings, isolation bearings, geometric optimization, or column/shaft silos.
- It was assumed that vertical development (i.e., buildings) would not be seismically integrated into the lid superstructure; the mass of the vertical development was lumped in at the center of gravity of the superstructure.
- Live loads do not participate in the seismic mass of the lid.
- The increase in axial load at the plastic mechanism along a pier line is negligible.
- Column heights can be artificially lengthened though the use of column silos where applicable.
- Liquefaction and lateral spreading are common considerations for the Seattle area. However, liquefaction and lateral spreading were not specifically addressed as part of this feasibility study, but should be addressed in future phases of design.

Seismic Hazard

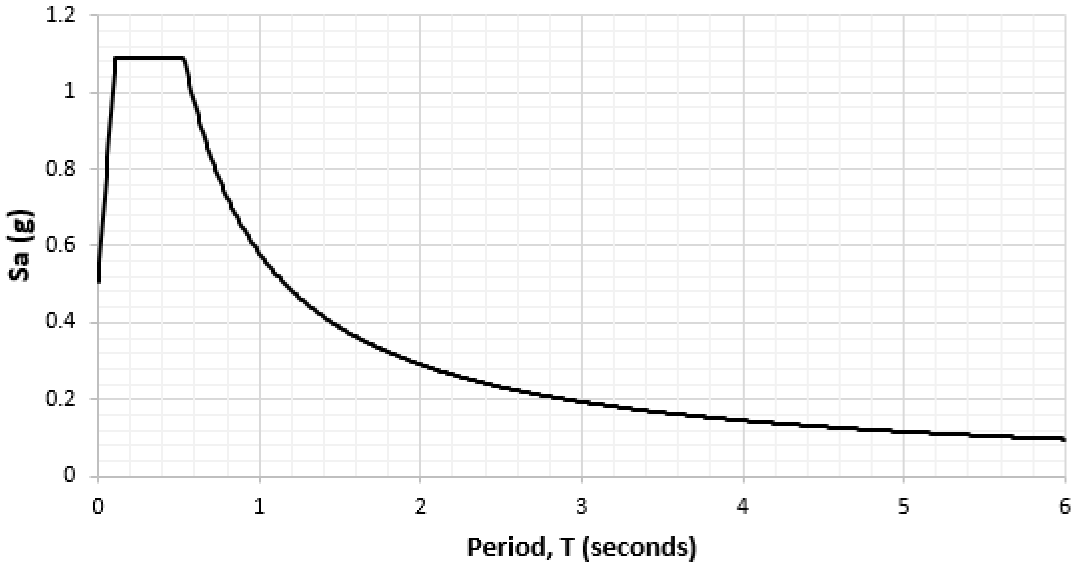
The seismic hazard, shown in Figure 4-6, was calculated in accordance with the WSDOT Bridge Design Manual Section 4.1.3 for the Safety Evaluation Earthquake, which is based on a 7 percent probability of exceedance in 75 years (975-year return period). The Functional Evaluation Earthquake (FEE) was not checked as part of this study; however, it should be included in future phases of design.

The WSDOT program SPECTRA was used to determine the seismic hazard per WSDOT Bridge Design Manual Section 4.2.3. The following uniform hazard parameters were used for the seismic assessment:

- Site Class = D (per Geotechnical recommendations)
- As = 0.505g
- SD1 = 0.582g
- SDS = 1.090g

The analysis was conducted using U.S. Geologic Survey seismic hazard maps from 2014 that do not include Seattle basin effects or the M9 Cascadia subduction fault. Consideration of basin effects and the M9 Cascadia fault could affect the ROM quantities; however, this feasibility study does not evaluate the magnitude of the potential impacts. This should be considered in future phases of design.

Figure 4-6. Seismic Hazard



Performance

The lid structure was assumed to be designated as “Essential” in accordance with the WSDOT Bridge Design Manual Section 4.1. However, it is understood that a “Critical” designation could be required due to International Building Code (IBC) requiring a “Critical” designation for the vertical development (i.e., buildings) on top of the lid. Therefore, it was assumed that the lid structure would be “Critical” for the high development scenario and “Essential” for the low development scenario. WSDOT Bridge Design Manual Section 4.1.2 defines the criteria for “Essential” and “Critical” with a maximum displacement ductility limit. For the Safety Evaluation Earthquake, displacement ductility demands were limited to 1.5 and 3.5 for the critical and essential designations, respectively.

The displacement capacity was determined using a reduced ultimate curvature per AASHTO GS Section 4.8. The reduced ultimate curvature was based on the SR520 RFP design criteria for essential bridges. Table 4-3 shows the associated reduced concrete and steel limits.

Table 4-3. Reduce Concrete & Steel Strain Limits

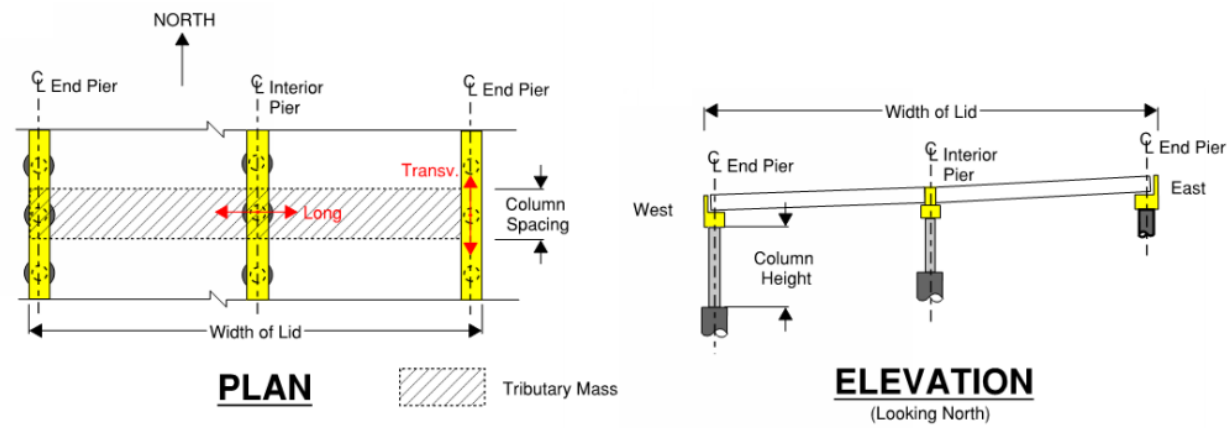
Material	Type	Reduced Strain Limit
Concrete	Confined	$0.67*\varepsilon_{cu}$
Steel	#4 to #10	0.060
	#11 to #18	0.050

Modeling

The preliminary seismic assessment was analyzed using in-house spreadsheets, considering a single degree-of-freedom system consisting of a drilled shaft, column, and lumped tributary mass at the superstructure center of gravity. The dead load of the vertical development was included in the seismic assessment mass and lumped at the superstructure center of gravity.

A sensitivity study was conducted near Denny Way to determine the amount of tributary mass that distributes to an end pier and interior pier. The Denny Way location was selected for the sensitivity study due to the largest variation in potential unbalanced stiffness, and thus, unbalanced mass distribution. Figure 4-7 illustrates the model that was run.

Figure 4-7. Tributary Mass Ratio Sensitivity Model



Both longitudinal and transverse analyses were run and the resulting maximum base shear for an interior pier and end pier were used to calculate the tributary mass ratio. Table 4-4 summarizes the resulting tributary mass ratios.

Table 4-4. Resulting Tributary Mass Ratio

Pier Type	Tributary Mass Ratio
Interior Piers	0.6
End Piers	0.4

Key considerations associated with the preliminary seismic analysis include the following:

- The seismic analysis was run using column heights equal to 15 feet, 30 feet, and 45 feet to capture the range in behavior. Engineering judgement and linear interpolation was used to determine quantities for column heights identified above.
- L-Pile parameters were developed for the different soil layers by the geotechnical engineer. L-pile models were created for each of the four areas using an equivalent average soil profile between the east and west walls.
- Lateral P-y modification factors of 0.80 and 0.30 were used in accordance to AASHTO Section 10.7.2.4 for the longitudinal (i.e., perpendicular to I-5) and transverse (i.e., parallel to I-5) seismic

directions, respectively. The factors were applied to uniformly to all the soil layers except for the glacial till. A P-y modification factor of 1.0 was used for the glacial till layer, where applicable.

- The seismic analysis was run using a pinned (i.e., rotational release) top of column fixity and a fixed (rotational restraint) top of column fixity.
- An equivalent drilled shaft depth-of-fixity (DOF) was calculated for a range of plastic shear demands. The maximum moment, maximum shear, depth to maximum moment, and depth-to-zero slope was output for the range of applied demands. An applied moment was not coupled with the applied shear for determining the outputs. Simplified assumptions, to be discussed later, were made to produce conservative designs. The DOF used for the purposes of assessing displacement demands and capacities were based on an average DOF between the point of maximum moment and point-of-zero slope, enveloped for each of the four areas. The range in potential foundation stiffness should be considered during the design process.
- A seismic ratio of 1.45 was used for the seismic analysis to calculate displacement demands and capacities. The seismic ratio is the column axial load divided by the tributary seismic mass. A range of expected vertical axial demands and tributary seismic masses was estimated using calculated loads for a range of potential span configurations. The seismic ratio could range from 0.5 to 1.45. A seismic sensitivity analysis was run using a seismic ratio equal to 0.5, 1.0, and 1.5 for an assumed axial load. A higher seismic ratio required more material quantity to satisfy all of the WSDOT Bridge Design Manual Section 4 and AASHTO GS design checks. Therefore, the higher expected seismic ratio was used as the basis of the analysis. It should be noted that the actual column dead load and seismic mass should be calculated during design.

There are several limitations to the seismic analysis conducted for this feasibility study. However, it is believed that the range in potential seismic behavior has been captured for the purposes of determining a range in ROM costs. The following limitations will require special attention or verification during future phases of the project:

- A single-degree-of-freedom analysis with lumped mass does not capture the behavior of the entire lid structure. The analysis neglects the influence of adjacent piers, orthogonal displacement demands, and participation of higher modes of vibration caused by unbalanced stiffness or mass. Consideration of these limitations would need to be understood and captured during the design phase.
- Coordination between the vertical development and the lid design would be critical to understand the seismic behavior of the combined systems. A lateral load path from the vertical development to the foundation would require careful consideration through specific foundation placement and load transferring elements. The interface of the vertical development and the lid is not conventional and could significantly affect the seismic behavior if made integral with the lid superstructure.
- The effects of liquefiable soils, lateral spreading, and Seattle basin impacts were not considered. It is expected these effects will increase the foundation quantities. To account for this uncertainty, the construction costs were increased by a risk factor that is inclusive of these effects. See Section 7 for additional details.

Superstructure

The superstructure of bridge structures is typically capacity protected. The lid structure is no different. That said, this feasibility study did not check the plastic overstrength forces imparted from the bridge substructure (i.e., columns). Based on the depth of the superstructure, capacity protecting the superstructure should not be a problem; however, capacity protection of the superstructure girders should be checked in future phases of design phase.

Substructure

The crossbeams were not checked for vertical demands or plastic overstrength forces from the columns. Instead, engineering judgement was used to select sizes and percent reinforcement for determining ROM costs. Detailed crossbeam design will be required for vertical and lateral load demands during future phases of the project.

The columns were designed and detailed in accordance with the WSDOT Bridge Design Manual and AASHTO LRFD Guide Specifications. Specific considerations included:

- The confinement used to calculate the plastic moment and displacement capacities was based on #7 spirals spaced at 3 inches on center. Additional confinement in the plastic hinge zones increases the plastic forces used in the shaft design and increases the available plastic curvature of the hinge. Alternative levels of confinement were not considered in the seismic analysis.
- Column shear capacity was checked in accordance with AASHTO Guide Specifications. The maximum displacement ductility in Section 4.10 was assumed. Additional shear capacity due to axial load was neglected and assumed to be zero.
- Column shear demands were capacity protected. Demands were calculated assuming a plastic mechanism in the column and amplified by an overstrength factor of 1.2. No further amplification associated with P-delta effects was considered.

Figure 4-8 illustrates the pier connections that were assumed when determining the distribution of vertical and seismic demands to the foundation elements.

Foundation

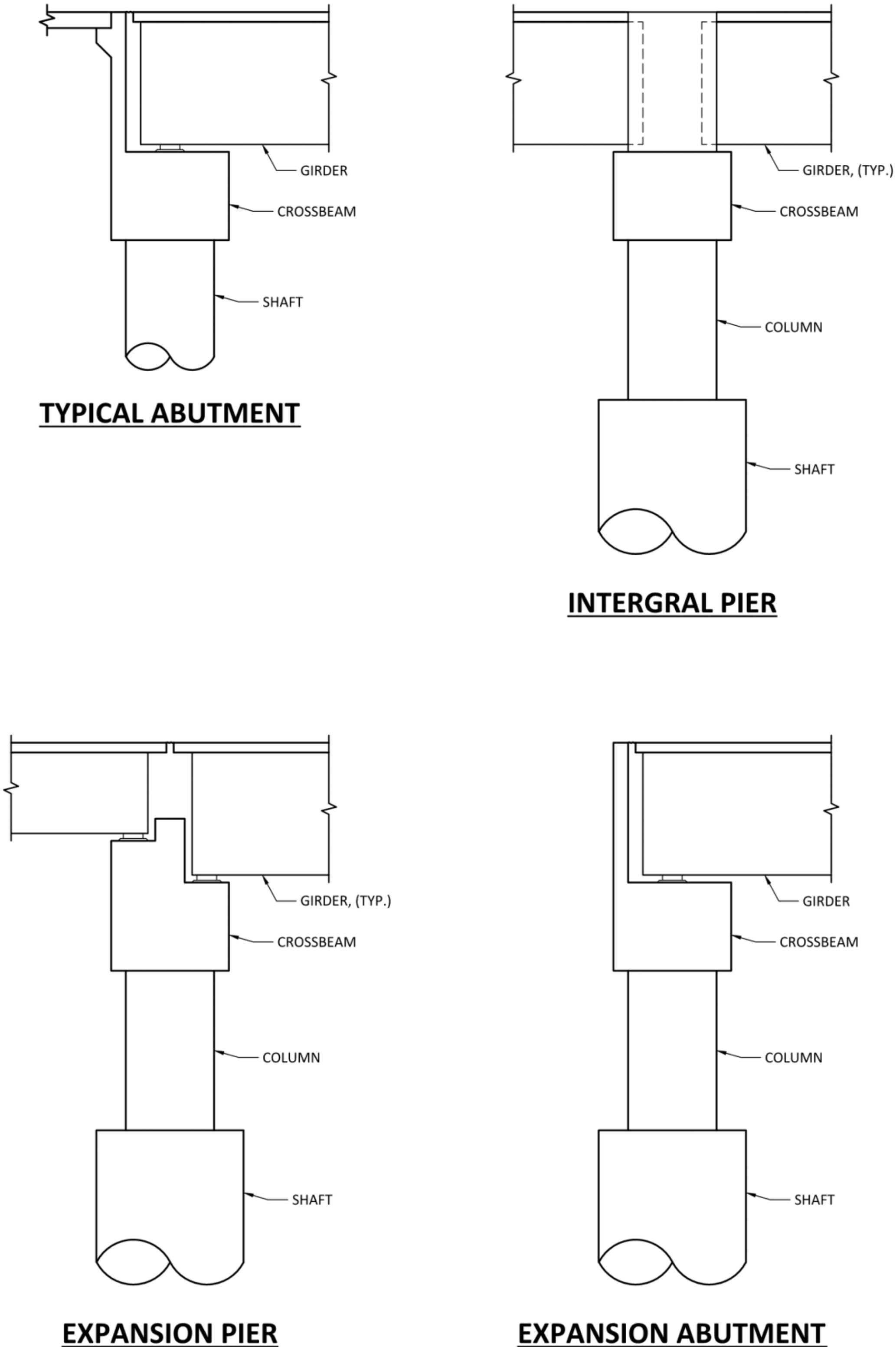
The shafts were designed and detailed in accordance with the WSDOT Bridge Design Manual Section 7.8. The shaft lengths were controlled by vertical demands and not by developing lateral fixity.

The shaft diameter and percentage reinforcement was controlled by the seismic demands from the column above. The shafts were designed for 1.25 times the moment demand in the shaft developed from the maximum of the following:

- 1.25 times the column elastic forces at the demand displacement if the column remains elastic, or
- 1.2 times the column plastic mechanism forces

The shaft capacity was based on ASTM A706 Grade 80 reinforcement for the longitudinal reinforcement. ASTM A706 Grade 60 reinforcement was used for the stirrups.

Figure 4-8. Assumed Pier Connectivity



4.3.2 Geotechnical

The geotechnical assessment consisted of developing recommendations for site class, soil profiles for each sub-area, drilled shaft axial load plots, and L-pile parameters. Impacts caused by lateral spreading, liquefaction, or wall recommendations were not considered explicitly in this feasibility study. Consideration of liquefaction, lateral spreading, and Seattle basin impacts will need to be evaluated further in future phases of design.

4.3.2.1 Site Class

Site Class D was recommended and used for the site location.

4.3.2.2 Soil Profiles

Appendix D, "Preliminary Geotechnical Information" provides soil profiles that were created for each of the SAB areas. The soil profiles included the following soil types:

- Fill
- Recessional Coarse-Grained Deposits
- Hard Clay-Lacustrine
- Glacial Till

4.3.2.3 Drilled Shaft Axial Capacity Charts

Appendix D, "Preliminary Geotechnical Information" includes the drilled shaft axial load plots created from the soil profiles for 6.5-foot-, 8-foot-, and 10-foot-diameter shafts. Two profiles with varying ground surface elevations were created to account for the variation in ground-surface elevation between the east and west edges of mainline I-5. Seven locations along the length of the SAB were selected, resulting in 14 unique drilled shaft axial capacity charts for each of the drilled shaft diameters; thus, 42 drilled shaft axial capacity charts were created.

4.3.2.4 L-Pile Input Parameters

Recommended L-pile input parameters were created for each of the soil layers defined in Section 4.3.2.2. Table 4-5 provides the parameters used for the L-pile analysis.

Table 4-5. Recommended L-Pile Input Parameters

Soil Type	Soil Model	Unit Weight (PSF)	Friction Angle (Degrees)	Soil Modulus, k* (PSI)	Undrained Shear Strength (PSF)	Strain E50
Fill	Sand (Reese)	120	30	18/15	–	–
Recessional Coarse-Grained Deposits	Sand (Reese)	125	36	120/75	–	–
Hard Clay-Lacustrine	Stiff Clay w/o Free Water (Reese)	125	–	–	6,000	0.004
Glacial Till	Sand (Reese)	135	40	260/140	–	–

*Above water soil modulus / below water soil modulus

Liquefied soils, lateral spreading, slope stability, lateral earth pressure recommendations were not provided for this feasibility study. These considerations are expected to be applicable to the design of the new lid structure and analysis of existing structural systems.

4.3.3 Mechanical, Electrical, and Plumbing (HVAC, Lighting, Fire Protection, Life Safety)

4.3.3.1 Fire Protection Systems

Fire protection systems for the I-5 LFS structure must include an automatic fire fighting system (sprinkler system) designed to suppress fire in a fire incident without human input and a manual system (standpipe) designed to provide responding firefighting personal with a source of pressurized water within the structure to support fire hose operations.

System Requirements

The primary national standard for fire protection system requirements in road tunnels is NFPA 502, “Standard for Road Tunnels, Bridges, and Other Limited Access Highways” (2017 edition). The standard provides performance goals and general guidance for system design. It references NFPA 13, “Standard for the Installation of Sprinkler Systems” for specific system requirements, including material properties, hydraulic performance, functional provisions for fire department interaction, system approval and occupancy classification. NFPA 13 also references other NFPA standards dealing with various system aspects such as water supply, alarm, testing etc. Similarly, NFPA 14, “Standard for the Installation of Standpipe and Hose Systems” provides specific requirements for the standpipe system. These requirements of these standards must be incorporated into the design basis.

The City of Seattle Fire Code requires that FFFSs—or more commonly, sprinkler systems—be provided in road tunnels. When liquid fuel cargoes are allowed passage, the City of Seattle has traditionally required that these include a foam injection system. These systems, referred to as AFFF systems, inject a foam fire suppressant liquid into the deluge water stream. They are intended to reduce the size of liquid fuels fires. The applicability of AFFF for this project would be considered along with current practice in the tunneling industry.

Fixed Firefighting System

The required FFFS system is an automatic deluge sprinkler type providing water spray capability over predetermined zones and covering the entire roadway surface area. Delivery of water to the roadway is controlled by deluge valves for each zone. In response to a fire incident within the roadway, two adjacent zones are activated to discharge water onto the fire. The FFFS must be provided with fire department connections to allow the responding fire department to boost system pressure. To the extent practical, the system would incorporate standard sprinkler system components, piping, valves, and appurtenances. Materials incorporated into the system must be UL/FM listed-approved. If exceptions are required, they must be submitted to the AHJ for approval. Critical Elements of the FFFS follow:

- **Water Supply:** System demand is based on delivering the minimum water application rate for all possible two-zone discharge scenarios. Water supply would be provided by the Seattle Public Utility. Typical tunnel fire suppression water demand would be in the range of 3,500 gallons per minute to 4,500 gallons per minute. For feasibility purposes, it is assumed that supply flow rate would be adequate to support the FFFSs and that no storage tanks or pumping systems would be required. Pumps would continue to be used to boost system pressure.

- **Backflow Prevention:** Backflow prevention devices are required by code at points of connection to the municipal water supply to protect from potential contamination of the system. These would be provided at each water utility connection to lid fire protection systems.
- **Fire department connections:** These connections must be provided at points of access of firefighting vehicles, which would usually be lid roadway portals. Fire department connections must be located within 100 feet of a fire hydrant.
- **Sprinkler Distribution Piping:** A sprinkler distribution piping network would extend throughout the lid structure in accordance with NFPA 13. Sprinkler nozzles would be located such that each covers approximately 130 feet^2 to 400 feet^2 depending on AHJ approved coverage category.
- **Deluge Valves Stations:** Zone water spray activation would be controlled by deluge valves, one for each zone. Deluge valves are typically located either in valve cabinets positioned along the roadway at 200-foot spacing or, if available, in a utility corridor running parallel to the roadway. There would commonly be one zone for every 100 feet of roadway in each direction.
- **Fire Alarm Control Panel:** A UL/FM listed panel is required to provide local manual control of fire suppression systems. All points of input and output to the fire alarm and fire suppression systems would be routed through the panel. Remote monitoring and system control would be provided via a SCADA link to the WSDOT central operation and control facility.

Fire Standpipe System

A dry standpipe must be provided to supply fire hose valve outlets located throughout the lid structure. Fire hose valves are in cabinets spaced at 275 feet along the roadway. As with the FFFS, the standpipe system would be provided with fire department connections at portal locations. Water supply and backflow prevention would be shared with the FFFS. Hydrants must be provided within 100 feet of the fire department connections.

Fire Protections Valve Room

Significant space would be required to house fire protection pumps, valves, and equipment related to roadway fire protection systems. Square footage will depend on the types of systems required to be provided. WSDOT has space located within the Convention Center complex housing fire protection equipment serving the existing lid. The space contains FFFS booster pumps, foam injection system storage tanks and pumps, deluge valves for roadway FFFS, control panels and other assorted minor equipment. The existing equipment appears to be in good condition. A detailed inspection was recently performed by WSDOT. It did not identify any major equipment issues. A follow up inspection should be performed for this project. If equipment is found to be past its reasonable service life, it should be replaced. If equipment and systems are found to continue to be serviceable for the foreseeable future, then systems added for the new lid can be combined with those serving the existing lid. These would effectively form one new fire protection system using the same water supply infrastructure, pumps, valving, power supply, and controls network. In either case, it is anticipated that the existing Convention Center valve room could be used to serve the new systems being provided. Because fire protection systems are required to serve only specific points on the roadway for any given fire event, basic infrastructure does not depend on overall length of roadway. With this assumption, the space provided for water supply, pumps, foam system, etc. would be adequate to serve new systems, and the existing valve room should be large enough to incorporate the limited amount of equipment needed for new systems. The exception would be FFFS deluge valve assemblies. Existing deluge valves are in the valve room. This is not a common arrangement and only practical when the valve room is near to the roadway being served. For the new lid structure, the valves should be located along the roadway as described earlier. Assuming this can be done, it is not anticipated that additional room would be required to house new lid fire protection systems.

Existing Convention Center Fire Protection Systems

Existing Convention Center lid roadway fire protection systems have been in use for many years. When the lid is extended, new systems and arrangements would need to be coordinated to fit the new lid length and width. Spacing of zones, water supply orientation and location of deluge valve assemblies would need to be synchronized. This work would by necessity require a good deal of rework of existing systems. As the existing systems are nearing the end of their useful life, it would be more cost effective in the long run and preferable from a system design prospective to completely replace existing roadway sprinkler distribution piping and standpipe piping and install new systems the entire length of the revised lid configuration. The cost estimate provided is based on this assumption.

Foam Injection System

The existing Convention Center Lid FFFS has been equipped with an aqueous film forming foam (AFFF) injection system to address gasoline tanker fires. The effectiveness of these systems in suppressing gasoline fires has been found in recent testing to be limited. The systems are expensive to install and require extensive regular maintenance. The foam agents used have been found to be toxic with some types having been banned. Improved alternative life-safety technologies have been developed since the inception of the use AFFF systems in road tunnels. Considering the risks and limitations associated with AFFF systems, the project proposes that the benefits and risks of their use be carefully vetted and compared to other methods. An alternative approach would be developed that addresses the life-safety and structural protection challenges associated with transport of liquid fuels. The alternative would propose a series of measures that, combined, provide an equal or superior level of protection. The measures would include provisions for rapid egress, technologies for rapid incident detection and response, effective public broadcast, effective roadway drainage, and the use of properly rated structural thermal protection materials. If it is found that the alternative can provide an acceptable level of life-safety and thermal structural protection, then it is proposed that the AFFF system not be extended to the new lid and that the existing system be removed. The elimination of the AFFF system would require the approval of both WSDOT and the AHJ.

Fire Alarm, SCADA, Traffic Control, Power, Fire Detection, and Alarm System

A fixed, firefighting suppression system must be installed over the covered lanes of I-5 for the lid facility. Accordingly, per NFPA 502, paragraph 7.4.4, an automatic fire detection system capable of identifying the location of a fire within 50 feet of the actual location is required. NFPA 502 paragraph 7.4.3 permits the use of closed-circuit television (CCTV) surveillance cameras to identify and locate fires if the road tunnels are under 24-hour supervision.

The following must be provided:

- CCTV coverage of all lanes of traffic beneath the lid facility. An automatic incident detection system if proposed to be provided as part of the CCTV system for generation of alarms such as for slow/stopped traffic, wrong way vehicle travel direction and pedestrian detection.
- Automatic fire detection system coverage of all lanes of traffic beneath the lid facility.
- Manual fire alarm boxes located along the tunnel roadways at intervals of not more than 300 feet, at the portals and cross passage means of egress per NFPA 502 paragraph 7.4.6.1.

The automatic fire detection system proposed would be a fiber-optic, linear heat detection based system. Detector placement over the center of each travel and breakdown lane would provide linear per lane-foot coverage in the lid tunnel. The system must be capable of detecting and identifying a fire location within 50 feet in the early stages of its development through adjustment of temperature detection set points. Linear heat detectors must be zoned so that the boundaries of heat detection zones correspond with the boundaries of fixed fire suppression system zones.

Activation of the linear heat detection system would send an alarm to the operator at the WSDOT Traffic Management Center (TMC), and would start a countdown timer with a duration of 180 seconds wherein if the operator does not override and cancel the alarm, the fixed fire suppression system would discharge the appropriate zones in the area for the detected alarm. This countdown timer is intended to allow the operator to visually confirm the location and severity of the fire incident via the CCTV system and to evaluate if discharging the system is warranted, and if not, override the automatic discharge of the system entirely, or manually initiate the system to discharge the zones that could be effective based on visual confirmation of the fire location.

The linear heat detection system must be a subsystem that is part of the lid tunnel facility main Fire Alarm Control Panel (FACP) arrangement. Interface to the fixed fire suppression valves for control and monitoring and other monitoring points for the system must be through the main FACP. The main FACP must be networked to the SCADA system primary and redundant programmable logic controller processors for communications between these two systems.

The main FACP must also have connectivity to the Seattle Fire Department. The main FACP and fire alarm and detection system installed must be modular, scalable, expandable and allow for future.

Local control panels dedicated for the fixed fire suppression system and the tunnel ventilation system would be collocated with the facility main FACP and the SCADA system operator interface workstation locally on site at the On-Site Command Post.

4.3.3.2 Structural Thermal Protection

Structural thermal protection is addressed in NFPA 502 where specific requirements are listed with the intent of preventing progressive structural collapse in a fire event. Thermal protection must be designed to limit exposure of steel reinforcement and beams to temperature below the value corresponding to the design allowable stress of the material. In tunnels equipped with FFFSs and not allowing passage of bulk liquid fuels, this can often be achieved by applying water spray alone and without the need for structural insulation. Where liquid fuels are present and much higher temperatures can be developed for a longer duration, thermal protection is much more challenging. In concrete structures, it could be possible to adequately protect underlying reinforcement by adding thicker than typical concrete cover, which can be in the range of 3 to 4 inches of cover. More typically, some form of thermal insulation board is required. It has been assumed that thermal insulation board would be required.

4.3.3.3 Roadway Lighting

The purpose of a “tunnel” roadway lighting system is to provide adequate visibility within the tunnel for an approaching motorist. The lighting system should provide enough illumination so the motorist can see within the tunnel to detect objects and other vehicles from outside the tunnel. The daytime artificial lighting system must have enough illumination to allow the eye to easily adapt to the lower lighting level within the tunnel coming from the outside daytime condition (high ambient lighting). Not providing the adequate artificial lighting produces what is referred to as a “black hole effect” where the portal of the tunnel is dark and potential obstructions within are not visible to the approaching driver. This effect also tends to cause traffic disruptions because drivers will not feel confident in driving at their current rate of speed going into the tunnel and will slow down therefore causing traffic delays.

The level required for daytime supplemental lighting is best determined by the stray light equivalent veiling luminance (Lseq) method used both in the IESNA and CIE documents. A road tunnel is divided into four lighting zones (Approach, Threshold, Transition, and Interior). These zones are based on the adaptation speed of a human eye. The length of each zone differs based on an adaption curve. The light source proposed for the I-5 LFS would be solid-state technology or light emitting diode (LED). LED sources are well established and used in many road tunnels and desirable for its energy efficiency, having higher lumens per watt then other light source technologies currently available. LEDs provide a variety of color temperatures and good color rendering, both aiding in color contrast and visibility. LEDs have a long life at 100,000+ hours and do not require “re-lamping.”

For the roadway under the lid, a mix of counter-beam and symmetrical lighting systems is anticipated, but would be confirmed during final design. The proposed lighting control system would utilize a fully dimmable adaptive solution that would accommodate changes to ambient exterior daytime luminance outside the lid. This would be achieved with a luminance meter located outside each portal to continuously measure the luminance at each portal and provide the required level of lighting for safe entry. By providing continuous measurements of the portal luminance, the system would be able to provide enough light, without over-lighting the tunnel. Locating a luminance meter at each portal would also allow for more control, gradual transition of light levels, because the position of the sun could leave a portal in shadow requiring less light and the opposite portal in direct sun and would reduce energy consumption.

4.3.3.4 SCADA System

A Supervisory Control and Data Acquisition (SCADA) system must be provided for the control and monitoring of the fire alarm and detection system and traffic warning system that are being implemented.

A comprehensive SCADA system must be established to provide remote monitoring and controlling of the subsystems, equipment and local facilities, from the WSDOT TMC. The SCADA system installed must be modular, scalable, expandable, and allow for future expansion.

The architecture of the SCADA system would employ a fail-safe topology. Each programmable logic controller would be designed with a redundant “hot-standby” configuration, capable of seamless transfer of data upon failure of the main processor. Additionally, the programmable logic controller would be equipped with redundant power supplies. The SCADA system would employ a universal remote input/output network protocol, allowing different network devices the ability to communicate with the programmable logic controller. Remote input/output (RIO) cabinets would be distributed throughout the lid tunnel facility and ancillary spaces to minimize hardwire cable runs between field devices and the SCADA system. Each RIO cabinet would be designed to accommodate the required number of points for the digital input, digital output (DO), analog input, and other data modules as needed. The RIO cabinet would be housed in a NEMA 4X cabinet sized to accommodate the required number of input/output modules.

The subsystem field devices and equipment that are to be monitored by the SCADA system would incorporate provisions for communication data channel link and control, and indication, via normally open and normally closed contacts, transducers, and auxiliary relays, to provide control/indication.

The SCADA system would have operator interface for control and monitoring locally at the Lid Structure On-Site Command Post, adjacent to the main FACPs, as well as control and monitoring remotely from the WSDOT TMC.

In the past, WSDOT has had a separate control system that was fire alarm based, such as by Simplex, dedicated for the fire suppression system, with another control system provided by a 3rd party, controlling the other MEP sub systems, such as lighting, ventilation, traffic controls, cameras and other systems that react to a fire event, with select integration between the two for a full sub system response. During the detailed design phase, further development of the system will be determined after discussion with the AHJ, as to whether two separate control systems are needed as in the past, or if a single integrated SCADA control platform is acceptable.

4.3.3.5 Traffic Control System

Tunnel entry portal signs, lane control signs and signals would be mounted on and near each entry portal that display messages when the tunnel is closed due to an incident in accordance with NFPA 502, paragraph 7.6. Lane control signs (LCS) would be placed over each travel lane at the entrance portals to stop traffic from entering the tunnel, as well as inside the tunnel for stopping traffic approaching an incident location, and expediting the flow of traffic downstream of an incident location.

Typical WSDOT implementation use lane control signs that are blank out signs that display “tunnel closed” during a fire/hazmat event. Usually there is one at the portal face and there are typically two upstream of the portal, one on each side of the road, generally controlled by the SCADA system. The tunnel portal signals are typically a signal head over each lane to stop traffic, controlled by the SCADA system. During the detailed design phase, further development of the type and placement of traffic control devices will be determined after further discussion with WSDOT and the AHJ for incidents and associated responses.

Dynamic message signs with lanes use signals would be placed out on the main line approach roads to indicate tunnel closure and alert motorists to seek an alternate route around an incident in the lid tunnel on other roadways.

Mainline entrance ramps before the tunnel entrance portals would be provided with blank out signs with flashers indicating that the tunnel is closed and not to use entrance ramp.

These traffic control devices would be directly controlled and monitored by the lid tunnel SCADA system, automatically through the lid tunnel fire alarm and detection system, as well as manually through interface to the local operator workstation at the On-Site Command Post or remotely from the WSDOT TMC.

Operation of these traffic control devices associated with the lid tunnel would also be coordinated with the overall WSDOT regional ITS incident responses, such that the operation of ITS devices outside the purview of the lid tunnel would respond to allow a larger, coordinated response to an incident in the lid tunnel, by beginning diversions of traffic using exits and other roadway routes farther away from the lid tunnel.

During the detailed design phase, further development and discussion with WSDOT may require in the northbound direction an extension of WSDOT ATM system which would include lane control signs, side mounted signs and VMSs, all controlled as a part of the existing ATM system with WSDOT software.

4.3.3.6 Normal and Emergency Power

The worst-case loading scenario is during ventilation fan operation with a fire within one section of the lid structure while traffic is operating in the non-incident section of the lid structure with ventilation fans operating in a direction to prevent the entrance of smoke that is being ejected into the non-incident section of the lid structure.

Two medium voltage service entrances are proposed with associated distribution switchgear, transformers, and utilization voltage unit substation switchgear for normal utility power distribution. The utilization voltage switchgear would have feeder circuit breakers for major loads such as normal tunnel lighting panelboards, as well as the normal source for motor control centers for the tunnel ventilation jet fans, and would be configured such that half of the total connected load would be split between two arrangements. Automatic transfer schemes are proposed for the medium-voltage switchgear, and utilization voltage switchgear, such that loads would continue to be supplied upon the loss of a medium-voltage service, medium-voltage feeder, or utilization voltage transformer.

The use of the two separate, physically diverse, utility services, could qualify as an emergency power source per NFPA 70, Article 700, if acceptable to the AHJ. The second service would allow for an alternate emergency source of power for lid system loads in the event of the failure of the normal utility service supply. This would support the capacity required for the loads to classify as emergency loads per NFPA 70 and 502. An automatic transfer scheme that senses voltage and frequency for both sources would be provided to allow for the automatic transfer between the two sources.

The life safety Uninterruptible Power Supply (UPS), with normal and bypass feeders derived from both sources, would serve select tunnel emergency lighting fixtures, the fixed fire suppression deluge valves, the fire alarm and detection system, the SCADA system, and the tunnel traffic warning system.

An emergency lighting panelboard would be connected directly to the output of the UPS for the emergency lighting circuits, as well as a distribution transformer for utilization power for the fixed fire suppression deluge valves, the fire alarm and detection system, the SCADA system, and the tunnel traffic warning system.

The second utility service as an alternate emergency power source, complying with NFPA 502 paragraph 12.4 and 70 Section 700 requirements, would allow the UPS battery protection time to be a duration only required to supply power during the transfer time from the normal utility source to the second utility service emergency source, and back, such that the life safety loads would not see a momentary outage during the transfer.

All circuiting for emergency loads, regardless of phase, would be 1-hour fire rated in a manner as described in NFPA 502 paragraph 12.1.2. DP1181 indicates the circuits in the tunnel requiring this fire rating.

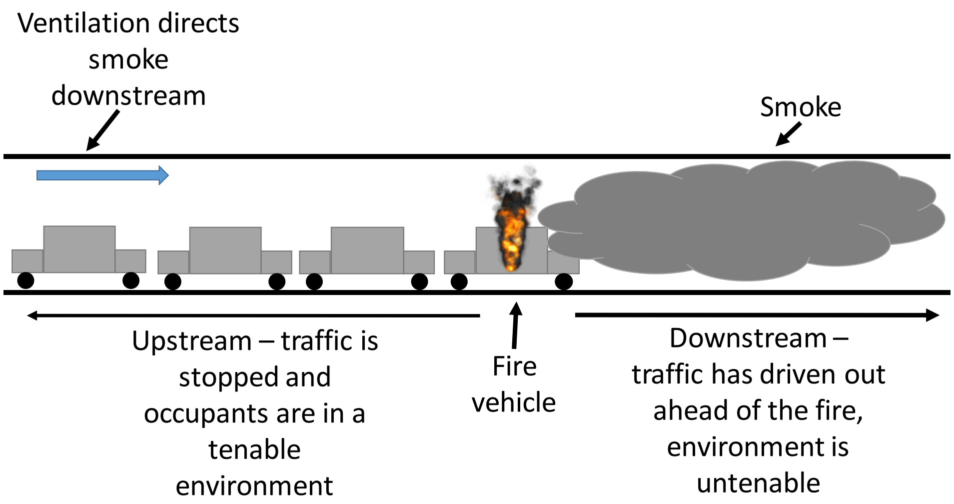
During the detailed design phase, further development and discussion with the AHJ may allow the 2nd independent utility source as a recognized NFPA 502 and 70 emergency power supply source (EPSS), capable of supplying all required life safety loads. Another option may be utilize a generator plant sized for the worst-case demand load for fire emergency service, to qualify as the EPSS, supplying all life safety loads. If neither of these are viable, another design approach may be to close the tunnel in the event of a normal power failure power, if an adequate EPSS of sufficient capacity cannot be provided to support all the life safety loads. This is an approach in force at the SR 99 tunnel, which is powered from two separate utility services and has modest generator capacity to power some emergency systems, but not the complete life safety load needed in a fire event.

4.3.3.7 Life Safety Emergency Ventilation

Ventilation Requirements

Some form of ventilation would be required for both normal operations (management of vehicle emissions) and emergency operations (management of smoke in a fire event). The two primary means are mechanical ventilation (fans) and non-mechanical ventilation (natural). A key requirement in NFPA 502 is the provision of tenable conditions for egress and facilitation of conditions for firefighting. Achieving these goals relies on ventilation, means of egress, and fire control. Ventilation is particularly integral with fire-life safety because it is essential to smoke management. Ventilation systems for modern road tunnels with unidirectional traffic is typically a longitudinal system (Figure 4-8) with airflow achieved using in-tunnel jet fans or a Saccardo nozzle injection system. Natural ventilation relies on the buoyancy of the smoke layer and proximity of openings in the ceiling to vent smoke without the need for fans. This could be an option subject to detailed analysis to confirm performance. Natural ventilation can sometimes be shown to meet FLS requirements for tunnels on the order of 600 feet to 800 feet in length. Large openings in the ceiling are generally required or fully open sidewalls.

Figure 4-9. Longitudinal Ventilation System (nozzle or jet-fan based)



Ventilation Options

The I-5 lid would require ventilation for vehicle emissions and for smoke management. The scheme would depend on the length of the cover, the traffic, and construction schedule. Table 4-6 outlines key parameters and benefits versus drawbacks for a longitudinal ventilation scheme and a natural ventilation scheme.

Table 4-6. Ventilation Option – Longitudinal Ventilation

Ventilation system	Pros	Cons
Jet fans positioned throughout the lid Assume one fan bank with three fans every 350 feet gives 42 fans per bore, or 84 fans for the entire tunnel	• Simple system to operate and maintain • Easy to expand the system as the length of the covered section length is increased • Able to manage a relatively large design fire	• Requires a dividing wall between traffic directions • Noise • Requires vertical clearance • Fans installed in roadway – maintenance requires some traffic disruption • For smoke management, must be able to clear traffic downstream – congested traffic is a concern
Other aspects: May require a ventilation building at each end with exhaust fans and a vertical discharge stack		

Table 4-7. Ventilation Option – Non-Mechanical System (Natural)

Ventilation system	Pros	Cons
Openings in the cover or gaps between covered sections – air exchange occurs via wind effect, vehicle piston effect	• Simple system – no mechanical or electrical elements to maintain • Easy to expand the system as the length of the covered section length is increased	• Maximum covered length of 600 feet to 800 feet • No ability to control levels of carbon monoxide or other vehicle emissions – if exceeded must provide traffic control • Openings/gaps are very large (~100 feet), and cover the full roadway width

Portal Emissions Management

Portal emissions and achieving air quality compliance in surrounding areas would be critical with a longitudinal system. For the cover length alternatives, use of a longitudinal ventilation system could cause emission levels from the portals to be more than allowable levels. An ambient air quality analysis of the emissions from the tunnel portals would be necessary with respect to any sensitive receptors in the surrounding areas near to the exit portals. This ambient air quality analysis would need to incorporate the expected tunnel traffic on an hourly basis, the subsequent vehicle emissions, the expected airflow in the tunnel, and the impact of external meteorological conditions. If acceptable air quality cannot be achieved, then ventilation buildings at each portal could be required to exhaust and disperse vitiated air away from sensitive receptors. This would necessitate provision of ventilation buildings to house equipment at both tunnel portals as well as a large vertical stack to discharge vitiated air. Jet fans would still be required with this option.

4.3.4 Civil – Utilities & Drainage

It is anticipated that utilities in city streets would need to be relocated due to construction impacts. This would require extensive coordination in the design phase with all utility stakeholders. The design team would need accurate locations of all site utilities, which should include an extensive pothole plan to verify utility locations. Utility stakeholders will need to provide input for utility relocations and phase the relocations with the project sequence and schedule.

It is anticipated that the WSDOT ITS system could be impacted during foundation construction. The bridge designer would need accurate locations of all ITS conduit and roadway lighting features. It is desirable to avoid the ITS system with pier locations. However, this may not be possible. If the system cannot be avoided, it would need to be relocated to a new location to allow for pier construction. Cost estimates provided at this stage assume a complete replacement of ITS elements at these locations if impacted.

The existing water, sewer, storm, power and communication systems may need to be upgraded to account for additional demand created by development of the lid. As the project progresses, additional studies would be needed to evaluate the existing utility infrastructure for adequacy of demand.

There are also potential positive utility benefits that the Lid structure could create. For example, the Lid may create an opportunity to link and tie together the water pressure zones on either side of I-5 and provide further reliability and redundancy for the water system. Building a Lid over I-5 could remove 15-acres of pollution generating impervious surface runoff from I-5 by treating stormwater on top of the Lid. Additional stormwater treatment infrastructure could be built on top of the lid providing an opportunity to offload upstream contributing drainage areas from the downstream Swale on Yale. The Lid could also provide a place to re-direct and treat upstream stormwater that currently drains to the combined sewer system. A decentralized wastewater treatment system could be built on the lid to minimize sanitary sewer flows from within the project limits as well as portions of Capitol Hill. The project could utilize the recycled wastewater to meet the project’s non-potable demands such as irrigation, toilet and urinal flush and mechanical process water.

4.3.5 Civil – Roadway & Traffic

Given the steep and rolling terrain within the project site a thorough geometric analysis of the improvements would be considered. The project approach would be to minimize regrading of city streets and I-5. If regrading is necessary, it would be minimized as much as possible to avoid major city street reconstruction that results in additional cost due to right-of-way needs and additional utility relocations. The project would need to remove and replace portions of the existing I-5 to construct pier foundations. Any regrading of I-5 would be minimized or avoided since this would result in additional project duration, more phasing, and additional traffic control considerations. The stormwater system would be evaluated for capacity, but opportunities could exist to minimize rework to the existing system using additional analysis of the projected flows and the capacity of the existing system.

Requirements for roadway illumination under the new lid would need be analyzed for tunnel illumination criteria. The existing light levels on the northbound and southbound I-5 roadways upstream and downstream from the northern and southern limits of the new lid would be evaluated for nighttime illuminance based on WSDOT Design Manual requirements. Lighting under the existing I-5 Seneca Street–University Street and 8th Avenue–Pike Street lids would also need to be evaluated in conjunction with the new tunnel lighting to ensure compliance with the current WSDOT tunnel lighting requirements and uniformity with new illumination under the new lids. This could include installation of new tunnel light fixtures and modification to the existing illumination system.

Impacts to existing WSDOT ITS infrastructure would be reviewed with available as-built information to determine the extent of the potential impacts of the lid structure and associated substructure on existing ITS devices, such as ramp meter signals, variable message signs, and CCTV cameras. The ITS equipment cabinets and associated power and communications infrastructure—including conduits, pull boxes, cable vaults, mainline and distribution fiber-optic communication cable—would also need to be evaluated for conflict with the lid structure to capture the cost of addressing the conflicts.

All existing overhead and ground-mounted signs within the project limits would need to be inventoried and reviewed for conflicts with the lid structure. Affected overhead signs would be considered for replacement with new signs attached to the ceiling of the lid. The size and spacing of new overhead signs would depend on the maximum height of the lid ceiling that can be provided.

Heavy civil and bridge construction in an urban area would create impacts to the traveling public. A detailed traffic analysis would be required based on the project's phasing and future lane configurations. A detailed traffic management plan would be drafted for the project.

4.3.6 Civil - Site

This category includes grading, utilities, and drainage within the lid structure and abutting streets. Given the rolling terrain, a detailed analysis would be conducted to ensure that pedestrian pathways meet Americans with Disabilities Act standards and that bike paths could be designed to conform with bike pathway standards. It is a goal of the project to create and or enhance connectivity for motorists, cyclists, and pedestrians. Adding new building structures on the lid would require that the need for additional capacity to the existing water and sewer systems be analyzed. It is also anticipated that the existing power grid would need to be evaluated based on the level of development.

5. Constructability

A preliminary constructability assessment was conducted to identify the considerations associated with construction of a lid structure through downtown Seattle within the vicinity of the SAB. The work conducted is summarized in each of the following subsections.

5.1 Staging Areas

There is very little room on site for laydown areas or contractor staging. These areas are needed for equipment storage, materials storage, fabrication of formwork, shaft reinforcing cages, water tank storage, work crew staging and other elements that are needed for construction. Currently, there are no identifiable staging areas in the immediate vicinity to the site. If additional right-of-way is needed for the project that area could be useable initially for contractor staging areas. It is assumed that this area may not be useable for the full duration of the project because project infrastructure would eventually occupy the area. A more realistic approach may be to evaluate areas close to the site but in industrial areas, for example, in the area between South Holgate Street and South Spokane Street. There is easy access to and from I–5; however, this would add an inefficiency factor that would increase cost and duration.

Figure 5-1. Potential Off-Site Staging Area

5.2 Constrained Worksite

The project site is constrained by I-5, city streets, and existing buildings. Large equipment would be utilized to construct the project. It would be preferable for equipment to occupy City of Seattle or WSDOT right-of-way if possible, to avoid the high cost of temporary construction easements. However, this would involve temporarily closing city streets and reconfiguring I-5 to provide enough work room for construction equipment. If occupying the right-of-way is not possible, construction scenarios would be evaluated to minimize the size and duration of use for the temporary construction easements.

5.3 Bridge Demolition

It is anticipated that bridge demolition would be performed on this project. Overhang demolition would be required on the northbound I-5 structure in locations of new lid pier construction. Overhang demolition would be required to allow for enough work room to construct lid pier shafts and columns (see Figure 3-5) The Seneca Street off-ramp and Spring Street on-ramp may need to be demolished to be able to construct the Area 1 lid. Removing the ramps would allow the substructure to be constructed because the ramps occupy the same area as the new piers. The south leading edge of the existing Freeway Park structure would need to be demolished to allow work room to construct the north segment of the lid from Spring Street to Seneca Street. Depending on the scope of work within the WSDOT right-of-way, existing overcrossing structures may be demolished and replaced. Bridge demolition would involve specialized equipment, night work, I-5 partial or full closures and detours. As the project progresses, this work would need to be further defined and evaluated.

5.4 Foundation and Pier Construction

It is anticipated that lid piers would utilize drilled shaft foundations of up to 10 feet in diameter and up to over 130 feet in depth. To construct these foundations, large equipment would be required. This would consist of at least two crawler cranes, several sections of steel casing, water storage tanks, dump trucks, forklifts, concrete pump truck, concrete delivery trucks, and other miscellaneous support equipment. It is anticipated the equipment would need to occupy a portion of I-5 during installation, with smaller equipment utilized to construct the remaining structure above the shafts. The equipment setup typically requires a 36-foot-wide construction zone. This would necessitate temporarily reconfiguring I-5 to facilitate construction. During construction of the new foundations, it is recommended that an existing structures monitoring program be deployed to ensure that no damage occurs to existing structures.

5.5 I-5 Roadway Demolition and Reconstruction

It is anticipated that construction of lid piers would require localized demolition of I-5 shoulders or mainline. I-5 traffic would be shifted to create workroom required to construct new lid piers. As the concepts progress, the magnitude of roadway demolition and subsequent reconstruction would be further identified and analyzed.

5.6 Girder Procurement, Delivery, Erection

Depending on build type the girders could range from shallow section prestress concrete girders to deep section steel-plate girders. The precast concrete girders have a relatively short procurement time depending on the backlog at the fabrication plant. Fabricators are also within a short haul time of the project site so delivery to the site should be fairly routine. Deep-section steel girders could add substantial time to the procurement process. If domestic steel is required, there would be a long lead time on plate. Only certain fabricators in the northwest can handle large plate used to fabricate deep section steel girders. It is assumed the steel-plate girders would be fabricated in either of two specialized fabrication shops south of Portland, Oregon. The girders would be shipped once the site is ready to receive them. It is anticipated that large cranes would be needed to lift them in place. The cranes would need to be set fairly close to the final location of the girders to reduce the lifting radius. Steel-plate girders would be delivered to the site with a primer coat of paint. However, an intermediate and top coat would need to be applied at the site after all connections are bolted.

5.7 Traffic

It is anticipated that full closures of city streets and mainline I-5 would be required for demolition and constructed. I-5 closures would be short duration of a night shift or possible weekend closures. City street closures would require longer duration. It is anticipated that interim nightly I-5 lane closures would be required to perform some of the work. For longer duration closures, I-5 would be realigned to facilitate the work. Probable realignments of northbound and southbound I-5 could include mainline shifts to the west, mainline shifts to the east, and splits of the mainline. A detailed traffic analysis will be required (future phase of work) to assess these impacts during and after construction.

5.8 Phasing

The project would consist of four different areas that are generally adjacent to each other. The most efficient delivery of the project would be to construct all four areas concurrently, which would substantially reduce overall project duration and minimize disruptions to I-5 mainline traffic and city streets. It is anticipated that there would be four to six interim roadway realignments of I-5 to construct the project, which would involve removing and applying pavement markings and signing revisions. If the project is phased, sequential construction of the four areas (due to funding or other constraints), the I-5 lane shifts would increase by a factor of four. Due to the disruption of traffic and the amount of striping and restriping of I-5, this would not be desirable. Full closures and lane closures of I-5 would also increase by a factor of four. It is recommended that all four areas of the lid be constructed concurrently to avoid additional costs and duration and to minimize traffic impacts to I-5 and city streets.

5.9 Hazardous Materials

Several excavations would be within the construction limits. It is recommended that any soils, water or other materials that could contain contaminated elements be identified. Building demolitions would need to be surveyed for hazardous materials—existing waterlines could contain asbestos and existing steel to be removed could contain lead paint—and site soils and water should be tested for contaminates. If contaminates of any type are encountered, a budget would need to be included in the project for removal and disposal.

5.10 Construction Noise

A project of this magnitude with known impacts to the traveling public would involve work both day and night. Work would be done at night that creates noise (e.g., bridge demolition, operation of large machinery, trucking noise and other miscellaneous construction noise). This site is near hotels, condominiums, and other residences. Studies would be needed to identify potential noise sources, anticipated noise levels, and applicable mitigation methods.

5.11 Local Businesses

Several businesses are within the project vicinity. There would be impacts to the businesses due to the construction; however, applicable mitigation measures would be included in the contract. On past projects in large urban areas, outreach meetings were conducted to local businesses early in the project. The meetings continued through the design process and into the construction phase. Business access would be evaluated and reviewed to determine if alternate access can be accommodated. There may be peak times for local businesses (such as the Christmas shopping season) where project work would be suspended. Signage options would also be evaluated (e.g., “Businesses Open During Construction”). Additional measures and fine tuning of the listed measures would be evaluated as the project progresses.

6. Summary of Findings

As described in Section 4.3, a maximum potential lid area of 17.4 acres was determined for the SAB. While the maximum potential lid area provides an upper-bound estimate of the new lid area, constructing a lid for all this area may not be practical. Because the approach of the feasibility study is to determine a range of range of ROM costs, lower- and upper-bound lid areas were developed. Figure 6-1 and Figure 6-2 show the bounding lid areas considered.

Figure 6-1. Maximum Potential Developable Lid Area Considered

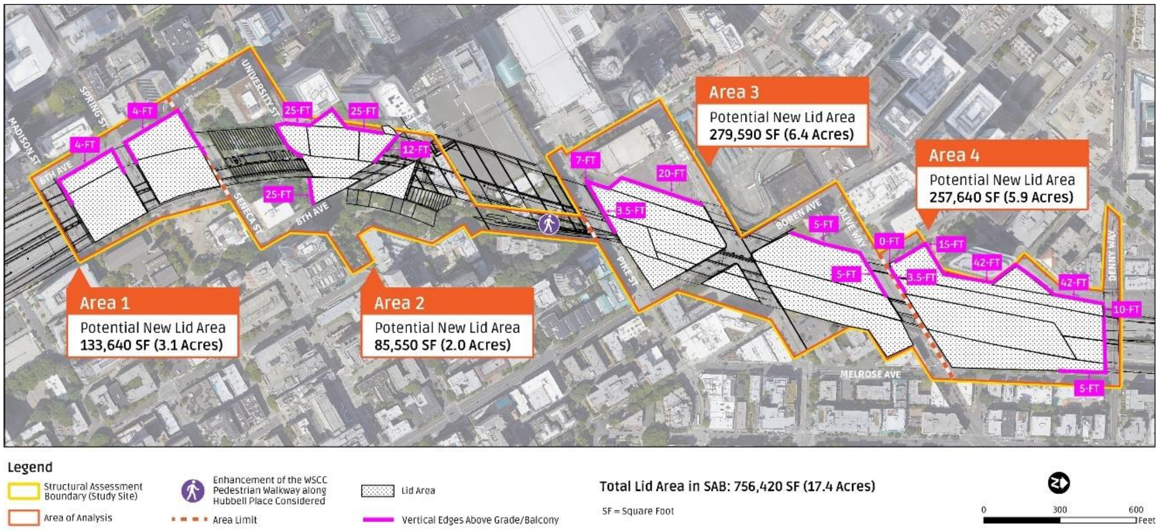
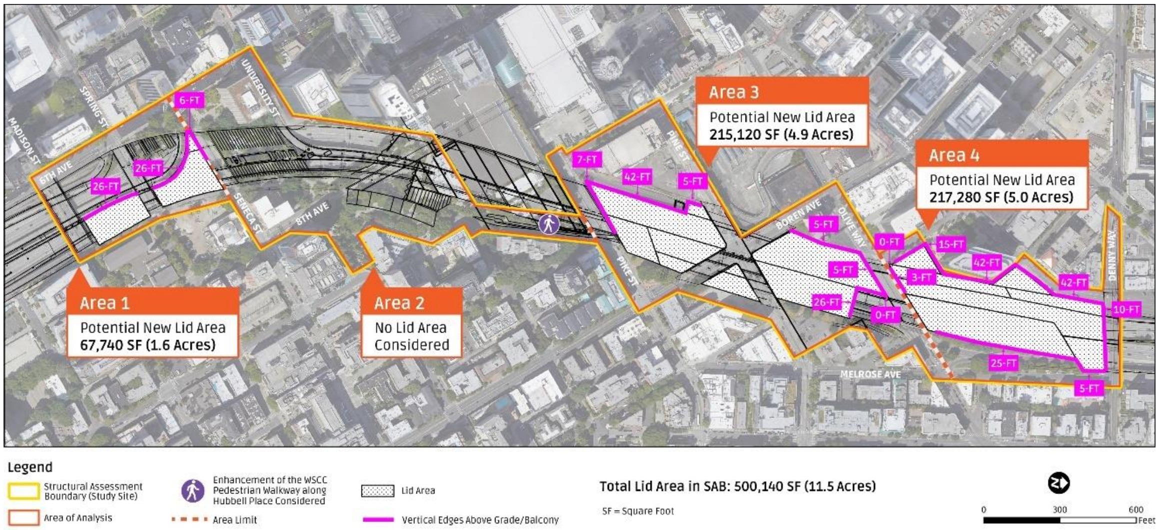


Figure 6-2. Minimum Potential Developable Lid Area Considered



A set of concept cases were defined around the bounding lid areas. The concept cases defined considerations that were used for the analysis. Table 6-1 summarizes the considerations used to define the concept cases:

Table 6-1. Lid Area Concept Cases

Considerations	Concept Cases			
	1	2	3	4
New Lid Area	Minimum		Maximum	
Load Levels	Minimum	Maximum	Minimum	Maximum
Girder Type	Precast Girder	Precast Girder	Steel Plate Girder	Steel Plate Girder
Ramp Removal	No	No	Yes	Yes
Lid Structure Classification	Essential	Critical	Essential	Critical

A description of the considerations are provided below:

- Load Levels
  - Minimum: open space load level assumed
  - Maximum: mix of open space, low-rise, and medium-rise load levels; the maximum load level that the lid structure could support for a given span length.
- **Girder Type:** A sensitivity analysis was conducted comparing the square-foot cost of a steel-plate girder lid to a precast concrete girder lid. The square-foot cost of the steel-plate girder lid was higher than the cost of the precast girder lid. Therefore, the precast girders were used with the minimum new lid area (Cases 1 and 3) and steel-plate girders were used with the maximum new lid area (Cases 2 and 4).
- **Ramp Removal:** The removal of the Seneca Street off-ramp and Spring Street on-ramp was considered with the maximum new lid area concept cases to create space for intermediate piers and to remove the need to provide minimum clearance over the on- and/or off-ramps.
- **Lid Structure Classification:** The lid structure seismic classification was considered per Section 4.3.1.2. Critical structure classification has more stringent demand ductility requirements and would require additional substructure and foundation quantities compared to the essential classification.

Based on the lid area concept table, Cases 1 and 3 are intended to minimize the total ROM costs and Cases 2 and 4 are intended to maximize total ROM costs. The leanest lid project concept and the robust lid project concept were selected to create upper-bound and lower-bound ROM costs. Thus, the following concepts cases were used:

- **Leanest Lid Project Concept (Case 1):** The objective of the leanest lid project concept was to minimize the potential ROM costs. This was achieved by minimizing the new lid area and quantities by making the new lid structure as light as possible.
- **Robust Lid Project Concept (Case 4):** The robust lid project concept was the opposite of the leanest lid project concept whereby the objective was to maximize the ROM cost. This was achieved by maximizing the new lid area and quantities by making the new lid structure as heavy as possible.

The lid superstructures for the robust and leanest lid project concepts were analyzed per the criteria defined in Section 4.3. Linear interpolation was used to find maximum span lengths between the bounding parameters for each load level. If a single-span lid structure or a continuous-span lid structure with equal spans and equal load levels were identified, no special considerations were needed to select the girder size and spacing. However, if the load level or span lengths varied for a continuous span lid structure then the following process was used to select the girder size and spacing:

- If the span lengths were the same but the load levels varied, then the span with the largest load level was used to determine the girder size and spacing.
- If the span lengths varied but the load levels remained the same, then the span with the longest span was used to determine the girder size and spacing.
- If the span lengths and load levels varied, then the girder size and spacing was checked for each span length independently and compared to the adjacent spans. The independent girder size and spacing that resulted in the lowest span capacity-to-demand ratio was selected for all adjacent spans part of the continuous lid structure.

This selection process was conservative and based on the enveloping superstructure analysis defined in Section 4.3. There could be opportunities to reduce the girder size or spacing during design where more complicated structural analysis would be performed.

Figure 6-3 and Figure 6-4 show the maximum allowable load levels for the leanest and robust lid project concepts based on the lid superstructure selection process:

Figure 6-3. Leanest Lid Project Concept Load Levels

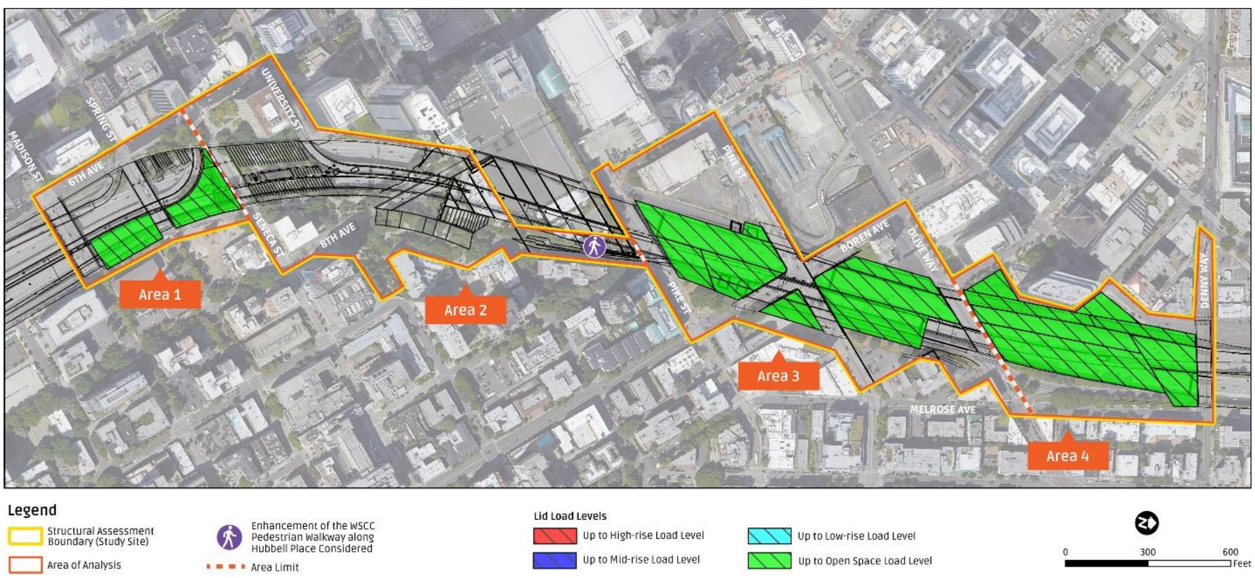
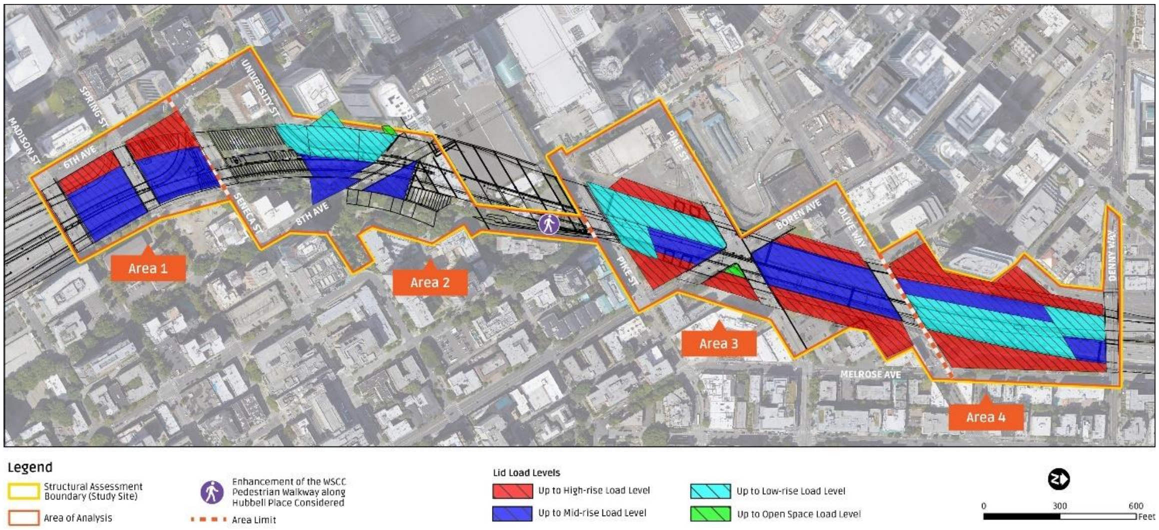


Figure 6-4. Robust Lid Project Concept Load Levels



With the leanest and robust lid project concept girder size and spacing determined, the substructure and foundation components were then sized for the expected vertical and seismic demands. The following assumptions were made:

- The number of columns and shafts can be artificially increased to reduce vertical or seismic demands. This may not produce a solution that is constructible for the assessment systems specified in Section 4.3.1. However, it should capture the ROM costs for the purposes of this feasibility study.
- The average span length for each span length adjacent to a pier line was used to calculate tributary seismic mass for the single degree-of-freedom systems seismic analysis.

The selection process for the substructure column size consisted of the following:

- If the column diameters did not change between the column heights, then linear interpolation was used to find the longitudinal percent reinforcement.
- If the column diameter or percentage reinforcement differed between the column heights, then the largest diameter and percentage reinforcement was used.

The selection process for the drilled shaft consisted of using the smallest shaft diameter and associated percentage reinforcement where a solution exists given a column height and tributary seismic mass.

The superstructure, substructure, and foundation elements sizes were recorded and input to determine capital cost ranges.

7. Potential Cost Ranges

Due to the preliminary nature of the project, ROM cost ranges were estimated in lieu of specific cost estimates on any given test case because this study would not be programming the lid nor does it have the level of detailed information for the consultant team to assume more than is actually known at this stage in the project. Metrics-based methods were used for development of the ROM cost ranges for the project were used in-lieu of a quantity-based estimate in-line with the standard WSDOT approach due to the preliminary nature of the project (i.e. pre 10% design with only limited supporting quantity determinations). Being metric based, quantity-based item specific costs do not exist, only allowances exist for various types of work based on past experience. As the project moves forward, it will be required to develop quantity-based item specific estimates in-line with the WSDOT standard approach.

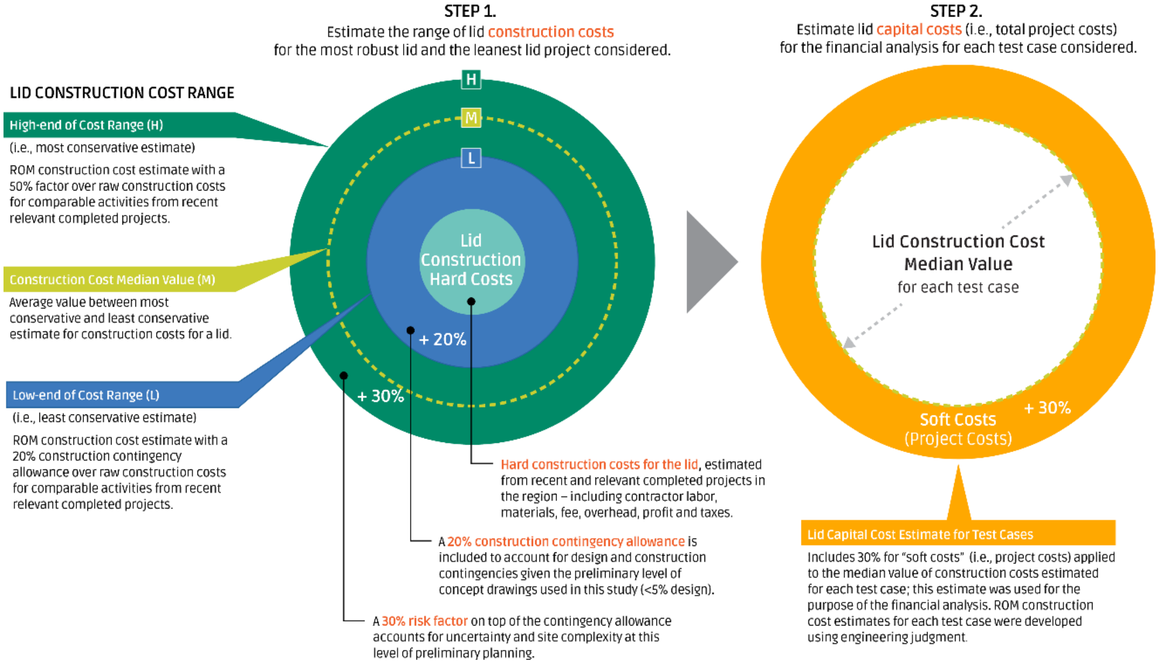
The ROM cost ranges are intended to capture the full spectrum of potential costs for the project based on its intended function (i.e. ability to support various ranges of vertical development). A 20-percent contingency was included in-lieu of broken out contingencies for design and construction as is typically done with quantity-based estimates in-line with the WSDOT standard approach. This was done since costs from real comparable projects were used. Typical quantity-based cost estimates developed from a preliminary design would include contingencies on the order of 40 percent, along with construction contingencies between 5 and 15 percent, resulting in a total contingency, design plus construction, of around 50 to 60 percent. The design contingency would ultimately go to zero when the design of a project is completed. As noted, since the metrics were based on actual constructed projects, it was deemed appropriate to waive the design contingencies in order to not artificially inflate the costs.

The ROM cost ranges developed for the study did not use WSDOT's Cost Estimate Validation Process and it did not perform any formal risk modeling. Future phases of the project will consider more robust analytical tools for developing cost estimates as sufficient detail is developed. The comparable projects used to develop the estimate do not necessarily capture the complexities of working along the I-5 corridor through downtown Seattle. Such complexities include:

- Challenging site topography
- Uncertainty in soil conditions and seismic hazards
- Difficulties with constructing around vertically layered structures
- Neighborhood impacts
- High traffic volumes on I-5
- Constrained right-of-way within a built-out dense urban environment
- Utility and drainage impacts
- Multi-agency coordination
- Forward compatibility
- Contracting methods
- Third-party involvement
- Aging existing infrastructure; replace or safeguard
- Project schedule, phasing, and duration

Figure 7-1 summarizes the approach taken to calculate cost inputs for the economic and financial analyses. First, construction costs (i.e., "hard costs") were estimated through a bookend analysis to answer the question on cost range for lidding I-5 through downtown Seattle. Construction costs were then estimated for each test case considered based on engineering judgement. Second, lid project capital costs to account for total project costs (including right-of-way and variable costs, i.e., "soft costs") were estimated for use in the financial analysis for each test case. Costs included in this study are parametric, or based on unit prices and quantities, and should not be interpreted as anything beyond initial design (<5 percent).

Figure 7-1. Approach to Rough-Order-of-Magnitude Cost Estimates for the Study



To illustrate the potential impacts associated with project complexities, costs were reported with and without a 30-percent risk allowance. It should be understood that this is just an allowance and not an accurate reflection of actual costs. Determining the magnitude of the actual increase in costs associated with the project complexities would be hard to estimate without conducting the next steps identified in the LFS Technical Feasibility Memorandum and conducting a formal risk analysis.

WSDOT has provided input on the cost assumptions at various points during our technical review and determined that they do not have enough information to provide detailed recommendations on project costs. WSDOT recommended consideration of a 50 percent increase to our cost estimate ranges based on the 20 percent contingency allowance and 30 percent risk allowance, consistent with considerations on other planning level studies. As the I-5 lid cost assumptions are based on other completed large capital projects in the region, and not planning estimates, including the SR 99 tunnel, we consider our underlying estimates to already include the impact of realized contingency and risk. We are considering the 50 percent increase to be the high bookend of our range in cost estimates.

Furthermore, ROM costs are based on the capital improvements required to support the construction of the improvements over I-5 and do not assume the rebuilding of I-5, including walls, elevated structures, and overpasses, which total 48 independent structures. The 48 existing I-5 structures evaluated were built in the 1960's with most of the assets operating past their designed life by 2035. We assume that further evaluation will occur as part of I-5 master planning which has yet to commence. The master planning and initial design analysis could conclude that many of these assets will need to be replaced to address deterioration and/or improve operating performance of I-5 through downtown Seattle. There could also be an alternative recommendation that some or all of the assets will not require replacement but may still require significant investments to continue their operation during the 100-year evaluation period modeled in the financial analysis. We refer to the costs of replacing these assets without the lid improvements as our "no-build" alternative, assuming that escalating operating and maintenance and repair and rehabilitation costs will be comparable to full asset replacement. The no-build case is used as the basis for estimating the incremental costs of three test cases. In all likelihood the rebuilding of some or all the I-5 assets would occur as part of the construction of the lid, reducing the overall cost of construction and mitigating construction impacts on I-5 operations. For purposes of our analysis we do assume the replacement of some critical support structures that will be required to construct some of our test case scenarios; however, we do not assume the full reconstruction of all the I-5 assets.

Three different types of costs were considered: capital costs, O&M costs, and repair and rehabilitation (R&R) costs. Annual O&M and R&R costs were taken from databases developed for the State Route 99 Alaskan Way Tunnel (SR99 AWT). The SR99 AWT costs were chosen over other comparable projects since it contained recent knowledge of fire, life, and safety features and is the most representative in scale. The O&M and R&R costs provided input into the life-cycle and economic models being developed outside of the technical team.

From a life-cycle cost perspective, the project was estimated to be constructed in four phases, with each phase being three to four years. Each phase was assumed to overlap by two years, resulting in a total construction duration of twelve years. The anticipated asset life was set to be 75-years to be in compliance with the standard design life of a bridge as defined by the American Association of State Highway Officials (AASHTO). Reference should be made to the final I-5 LFS report for details on the life-cycle and economic assessment.

This study was designed to explore the range in technical feasibility of lidding the freeway, to understand the implications for building both the most robust lid project and the leanest lid project, and still deliver a project that is aligned with the value proposition of this study. These two bookends of analysis in turn become financial bookends to answer the question on cost range for lidding I-5 through downtown Seattle.

The capital costs considered construction costs, right-of-way costs, and other variable costs. All costs are presented in 2019 dollars. As illustrated in Table 7-1, the ranges in cost accounted for the difference in developable lid area; load levels accommodated by the lid structure; consideration of ramp removal; structure classification; and discipline-specific considerations. For the robust lid project, the maximum lid area carried the highest load levels it could carry based on the assuming steel-plate girders spaced reasonably close together, classified the lid structure as seismically critical, assumed that the existing on- and/or off-ramps could be removed as they made sense from a lidding perspective, and considered the high end of the range for estimated costs of off-lid impacts. For the leanest lid project, the minimum lid area carried the lowest load levels (i.e., open space loads) and maximized the spacing of precast prestressed concrete girders, classified the lid structure as seismically essential, assumed that the existing on- and/or off-ramps remained in place, and considered the low end of the range for estimated costs of off-lid impacts.

Table 7-1. Considerations for Capital Cost Parameter Ranges

Consideration	Robust Lid Project	Leanest Lid Project
Lid Area	Maximum	Minimum
Load Levels	Maximum	Open space
Ramp Removal	Yes	No
Lid Structure Seismic Classification	Critical	Essential
Discipline Specific (e.g., Fire, Life Safety, Utilities, Constructability)	High End	Low End
Overpasses Remain in Modified Form	Yes	
Pedestrian Access Improvement at WSCC (Hubble Street)	Yes	

In an attempt to be as realistic as possible when comparing the I-5 lid project to other projects, development of the construction costs was broken down into 11 different categories based on type of construction. The categories, along with a short description of each, are defined in the following bullets. Total costs were extracted from other similar projects by category and normalized based on the area (square footage) of work being conducted. The normalized costs were applied to the square footage of work on this project to develop a cost value.

- **Demolition:** The configuration of the lid structure constructed would have an impact on existing infrastructure. At a minimum, there would be select demolition of bridge overhangs (on- and/or off-ramps, overpasses, and mainline I-5) and wall structures. To maximize developable area, there could be complete demolition of ramps and walls.
- **Structures:** This work includes lid structure, improving the existing overpasses to create Complete Streets with adequate shoulder and sidewalk widths; north/south pedestrian access at the WSCC spanning over Pike Street (when applicable).
- **Streetscapes and Park:** This work includes slab waterproofing, drainage mat, drainage structures and pipe, topsoil, plants, pathways and furniture.
- **Civil/Roadway:** This work includes erosion control, and removing and replacing asphalt roadways, shoulders and concrete roadways.
- **Drainage:** This work includes connecting to existing drainage structures, new drainage structures, new pipe runs, shoring and excavating for drainage structures and pipe, plugging existing pipes, and cleaning existing drainage systems.
- **Traffic:** This work includes illumination systems, traffic signal systems, interconnect systems, ITS, temporary illumination, concrete curb and gutter, concrete sidewalk, curb ramps, concrete driveway entrances, permanent signing and pavement markings.
- **Utilities:** This work includes relocating or protecting all existing wet and dry utilities within or adjacent the project footprint. This cost is based on three recent projects with significant relocation of utilities.

- **Mechanical, Electrical, and Plumbing:** Fire-life safety features would be incorporated into the project and would include an EVS, FFFS, structure fire durability protection, and the associated power and controls, including back-up generators. The existing fire-life safety systems located in the WSCC would need to be replaced in their entirety. It is assumed that a new maintenance facility would be constructed and inclusive of parking, shop, lockers, duty stations, crew space and a loading dock; see overall feasibility document for additional details.
- **Traffic Control:** This work includes providing all resources needed for conduction traffic control operations on and near I-5. This lump sum cost is based on current and recent projects constructed on I-5 and abutting I-5 in the Tacoma area.
- **Federal and State Asset Replacement:** This work refers to assumed costs for replacing I-5 in-kind. The cost ranges are presented without assumed costs for federal and state asset replacement.
- **Vertical Development:** This work refers to the construction of vertical buildings on top or adjacent to the lid structure. The cost ranges were prepared without assumed costs for vertical development.

Right-of-way costs considered potential temporary easement needs, aerial easements, and permanent acquisitions, and were based on values of the assumed affected parcels. The easement and acquisition needs are not yet known, but some were assumed in order to provide an allowance for the range in costs estimated. Input on the values assigned were estimated and referenced as part of the land valuation analysis included in the LFS.

An allowance was also made for other variable costs accounting for construction administration and inspection costs, the cost of construction support services, third-party review costs, and owner (internal agency costs spent on a project) costs. A lump sum value of 30 percent was used.

The resulting range in capital costs in 2019 USD is $855 million (lowest lid project cost range) to $2,863 million (robust lid project cost range), exclusive of vertical development and federal and state asset replacement.

Table 7-2 shows breakdowns per lid area and inclusive of the normalized dollars per square-foot value assumed for both the leanest and robust lid project estimate.

Table 7-2. Capital Cost Breakdown per Lid Area (2019 USD)

	Robust Lid Project (Maximum lid area and load considered)			Leanest Lid Project (Minimum lid area and load considered)			Lid Project Cost Range
Lid Area of Analysis	Area (SF)	Cost including 20% construction contingency ($)	Cost including 20% construction contingency & 30% risk allowance ($)	Area (SF)	Cost including 20% construction contingency ($)	Cost including 20% construction contingency & 30% risk allowance ($)	Cost Range ($)
Area 1	133,640	472 M	614 M	67,740	103 M	134 M	103 M - 614 M
Area 2	85,550	221 M	286 M	N/A	*33 M	*42 M	*33 M - 286 M

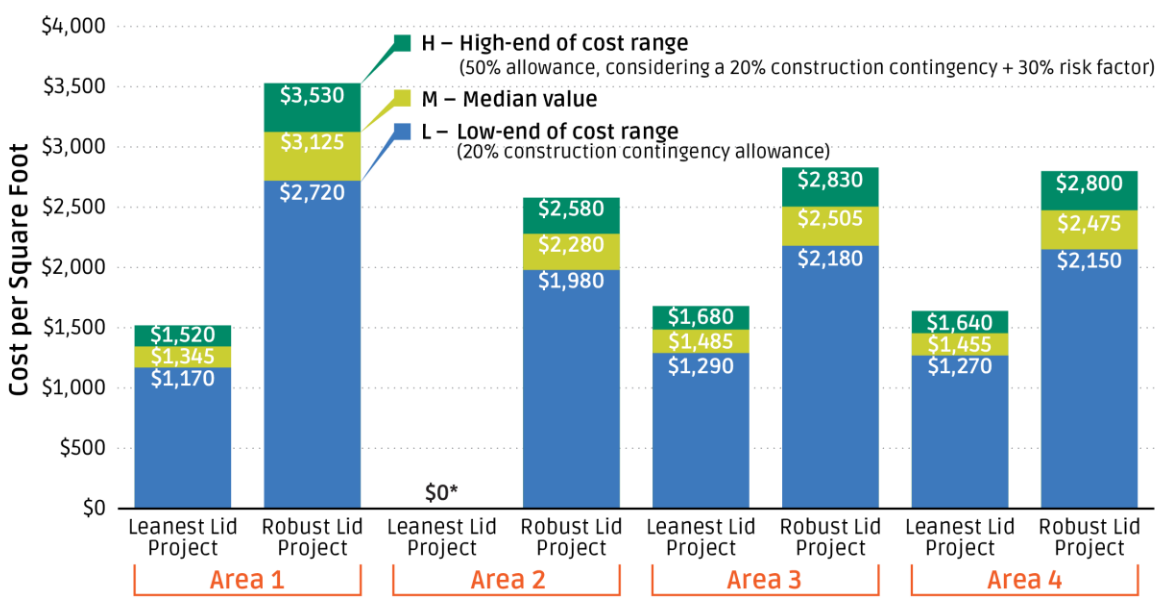
Area 3	279,590	791 M	1,027 M	215,120	361 M	468 M	361 M - 1,027 M
Area 4	257,640	721 M	936 M	217,280	358 M	464 M	358 M - 936 M
Total	**756,420**	**2,205 M**	**2,863 M**	**500,140**	**855 M**	**1,108 M**	**855 M - 2,863 M**

*Cost consideration for enhancement of the WSCC pedestrian walkway along Hubble Place.

Range of financial bookends of analysis, expressed in capital costs per lid area corresponding to the maximum (Figure 6-1) and minimum (Figure 6-2) potential developable lid area considered in the technical feasibility assessment. Cost breakdown is absent of right-of-way costs and federal and state asset replacement but includes other variable costs and are expressed in 2019 USD.

Figure 7-2 shows the construction costs-per-square-foot ranges per area for both the leanest and robust lid project estimates and 20 percent contingency and 20 percent contingency plus 30 percent risk. The construction costs per square foot are largely controlled by the structures costs and the load intensity within an area, as shown in Figure 6-4 for the robust lid project range.

Figure 7-2. Construction Costs per Square-Foot Ranges per Area (2019 USD)

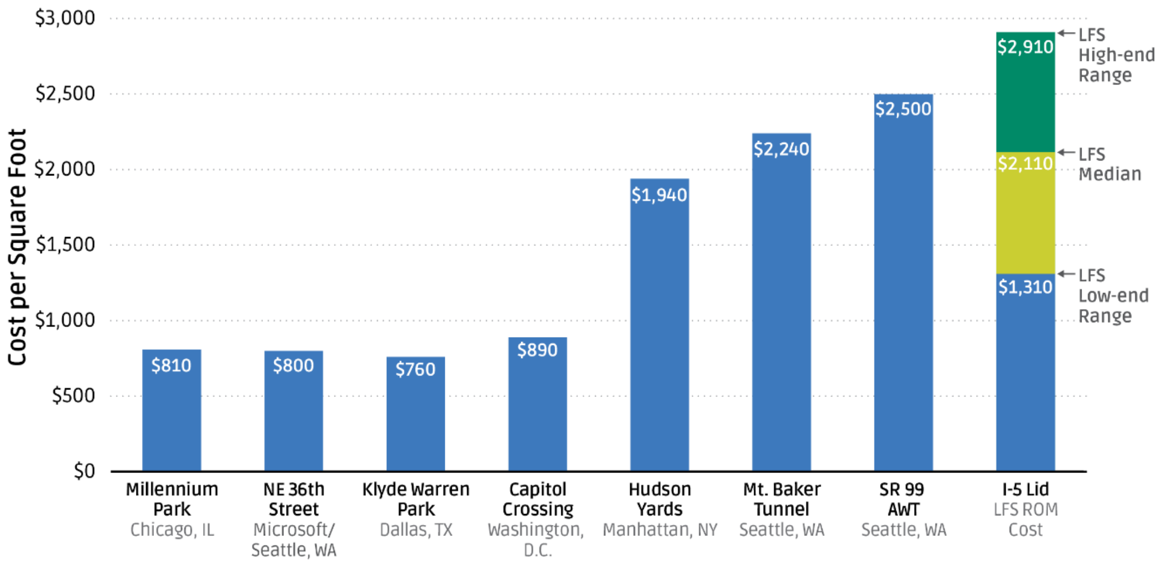


The costs-per-square-foot ranges are construction costs, and thus are not inclusive of right-of-way costs, federal and state asset replacement, and other variable costs.

*Area 2 includes lump-sum construction costs of $25M (at 20-percent) and $32M (at 50-percent compounded contingency allowance and risk factor) for enhancement of the WSCC pedestrian walkway along Hubble Place.

In addition to category-specific cost inputs from other recent and relevant projects, the total resulting costs were compared to local, regional, and national comparable projects on a normalized dollar-per-square-foot basis. Figure 7-3 shows the findings of this comparison. The low end of the range is higher in cost, but in close agreement with other comparable projects supporting open-space loads. The higher cost is likely due to the need to account for project contingency and also the project length and the need for fire, life, and safety components, which are estimated to be between 4 percent and 12 percent of the total construction costs for the leanest and robust lid project estimates, respectively. The high end of the cost range falls between the cost of Hudson Yards, a similar lid structure supporting vertical development, and the SR99 AWT tunnel costs.

Figure 7-3. Normalized Cost-per-Square-Foot Comparison of Representative Projects (2019 USD)



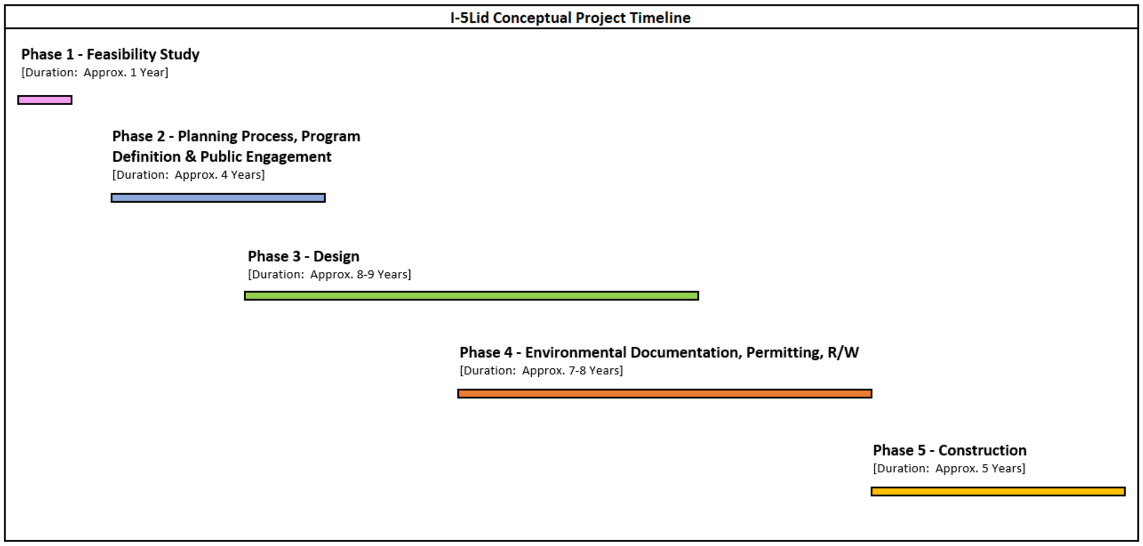
Comparable costs are representative of construction costs, and not capital costs. Other variable and right-of-way costs are not included.

A no-build cost assessment was also conducted to reflect the costs of existing I-5 operations. Details of the no-build cost assessment can be found in the life-cycle and economic assessments located in the overall LFS report.

8. Considerations and Next Steps

The work to-date is preliminary in nature and pre-dates any planning, program definition, public engagement, and design. Figure 8-1 shows a simplistic project timeline to illustrate the preliminary nature of the work conducted. Design, by definition, is the process of change, so this analysis is intended to be the initial step of a longer process that would inform the intricate and multilayered decision-making framework necessary to move this project from ideation to implementation.

Figure 8-1. Conceptual Project Timeline from Feasibility to Implementation



Defining a comprehensive feasibility analysis would require considerable additional in-depth studies, which were beyond the scope of this project. From a technical perspective, these studies would include, but are not limited to, the following:

- Evaluation of Alternative Alignments of I-5: This consists of localized impacts to the current alignment of I-5.
- Alternate Channelization Configurations of Interstate-5
- Transportation and Traffic Network Studies (inclusive of consideration of potential ramp removal): This includes, but not limited to, understanding the impacts to freeway, arterial streets, local transportation, rail service, and evaluation of alternate ramp locations and circulation routes during and after construction.
- Geotechnical Explorations
- Environmental study (inclusive of impacts to cultural resources): A NEPA/SEPA evaluation or planning document would be needed that adheres to Planning and Environmental Linkages guidelines.
- Noise Analysis: A noise analysis will needed to understand noise impacts with the lid concepts. Lidding can reduce noise in locations but concentrate it in others.

- Master Plan and Implementation Considerations: selection of a procurement method; design-build, general contractor/construction management, design-build bid, or an array of public private partnerships, as well as developing a project schedule. Having a master plan would be important in maximizing function of the project through coordinating the interests, responsibilities and investments of tentatively multiple agencies, developers and asset owners.
- Evaluation of Edge Integration: The actual details of the project would be tied to the master plan and implementation considerations utilized to deliver the lid project. The most structurally efficient system would have the lid structure integrated with private development (i.e., buildings) along its edges, if the lid were conceived to support an array of land uses other than open space.
- Evaluation of Unconventional Structural Framing Methods: More unconventional and unique framing options may be suitable for a lid project. Unconventional and unique framing options are most likely more costly than the conventional methods considered as part of this study. As part of a future study, as the urban context analysis, policy goals, and project delivery options are better understood, it would be advisable to explore these alternatives.
- Seismic Hazard: The seismic performance of a lid structure supporting building structures in a high seismic region would need to be defined. Decisions would also be needed regarding magnification of the design seismic hazard as a result of basin effects.
- Freeway Park Modifications and potential considerations around the historic designation process the park is currently exploring.
- Existing Structures Monitoring Program: It would be important to define the baseline conditions of what exists to-date in order to define impacts related to construction. One of the key elements would be the existing cut walls on both the east and west sides of the interstate, which are displacement controlled walls that stabilize the soils.
- Signing, Fire-Life Safety, and MEP Systems: coordinating location of system components to minimize impacts on vertical clearance envelopes and required profile of the potential new lid structure.
- Detailed Structural Assessment and Design: Only a preliminary sensitivity assessment was conducted to determine ranges in potential member sizes for the purpose of developing ROM cost ranges. A detailed structural assessment and design should be conducted in later phases of the project.
- Liquefaction and Lateral Spreading Assessment: Liquefaction and lateral spreading potential are known to exist in the area and could significantly affect the foundation costs and feasibility.
- Tunnel Impacts: how close can new lid foundation elements be constructed relative to the existing U-Link and I-5 Express Lane tunnels.
- Ambient Air Quality Analysis: determines if smoke stacks are needed at the portals of the lid structure.
- Asset Management: constructing a new lid structure over existing aged infrastructure will have an impact on access, maintenance, and cost for repairs, improvements, or replacement.

This document presents only the preliminary technical feasibility analysis that was conducted as part of the I-5 LFS. Other considerations are required to inform the overall feasibility of the project, including an alternatives analysis, governance models, project delivery options, regulatory considerations, funding and financing options, agency alignment, and investment priorities in the region.

8.1 Key Takeaways

From a technical perspective, the following key takeaways from this analysis were identified:

- Based on the work conducted for this study it is technically feasible to construct a lid over I-5 through downtown Seattle, similar to the existing lids of the WSCC and Freeway Park.
  - From an engineering perspective, it is achievable to build a set of lid structures within the study site capable of supporting various load levels of development.
- Existing overpasses and structures along the SAB pre-dated current vertical clearance requirements. Any new lid structure would require meeting the 16-foot 6-inch minimum vertical clearance over existing I-5 structures, representing significant challenges for edge integration with the surrounding urban context, and presenting grade differences ranging from 5 to 15 feet from lid surface to the adjacent street grid and bridge overpasses, and up to 45 feet above the adjacent street grid below, when trying to mimic the existing bridge overpass grades to the extent feasible.
- The potential lid configurations resulting from the present technical assessment are not flat or contiguous surfaces from edge to edge, given the topographical conditions of the site, and the constraints existing structures and ramp access impose. This can significantly affect the connectivity and accessibility potential for active transportation linkages both east-west and north-south.
- Lid edge integration challenges could be addressed by incorporating buildings and/or vertical circulation mechanisms across the SAB. A solution that involved buildings would require significant consideration on planning and project delivery alternatives, to ensure capital cost efficiencies could be achieved integrating the structural elements of both the lid and the buildings.
- Based on the conceptual geometric lid layouts developed, the maximum lid area potential for a robust lid project within the study site (considering the theoretical removal of all ramps) is 17.4 acres and the minimum lid area for the leanest lid project, (with all ramps remaining) is 11.5 acres. The cost per square foot of the lid is not equivalent across the four areas of the SAB given the specific challenges and opportunities each area presents.
- The load capacity of the potential lid configurations is not even across the SAB nor within each lid section. This would present important considerations in terms of the potential development program and capacity.
- The ROM cost estimates do not include potential impacts that would result from removal of ramps to increase lid area development potential. A robust transportation and traffic network study would be necessary to evaluate the operational feasibility because this could have significant costs to replace the function of access to downtown

streets. In addition, this study would be necessary to inform constructability and staging alternatives if this project were to advance to further stages of engineering and design.

- Given that lidding mainline I-5 would change the configuration of the freeway from exposed open-air lanes to a 0.8-mile “tunnel”, building a lid on this site would require installing a Fire and Life Safety (FLS) system.
  - A FLS system requirement represents between 4 percent (leanest lid project estimate) to 12 percent (robust lid project estimate) of total construction costs for the lid project.
- Costs included in this memorandum are parametric and should not be taken as absolute. This analysis also does not consider the economic or societal benefits that could also result from developing this project. This will be discussed in the final LFS report. Further studies will be required to capture these benefits, including those related to a transportation and traffic network study.

The technical feasibility assessment was performed agnostic of urban context, environmental considerations, noise impacts, and user experience implications. Nonetheless, lid sub-area geometric layouts were developed through an iterative approach with the needs identified for urban design best practices, which would be explored in the development program test case framework analysis of the LFS. Future phases of work should consider impacts of technical decisions through a place-based approach. Consideration to the LFS guiding principles established as part of the I-5 Lid Feasibility Study Committee is recommended.

9. References

Appendix A, "Basis of Design for Technical Feasibility Memorandum" includes a detailed list of the engineering standards followed in developing this technical feasibility report. The following referenced documents fall outside the list of engineering standards:

Bonjukian, S., Dunn, L. & Feit, J. M. (2019). Reconnecting the City: LID Case Studies. Seattle, WA: Lid I-5.

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I-5 Lid Feasibility Study

Appendix A

Basis of Design for Technical Feasibility Memorandum

Prepared for:

Seattle
Office of Planning &
Community Development

Prepared by:

wsp

OJB
Magnusson Klemencic Assoc.

EnviroIssues
Framework

HR&A Advisors
Shiels Obletz Johnsen

12/5/19

Basis of Design for Technical Feasibility Memorandum
I-5 Lid Feasibility Study
Contract No. PCD19002

Task 4. Technical Feasibility Assessment

For further information about this report, contact:

David Driskell, Deputy Director, Office of Planning & Community Development

Lyle Bicknell, Principal Urban Designer, Office of Planning & Community Development
(206) 684-0763
Lyle.Bicknell@seattle.gov

Prepared for:

Seattle Office of Planning & Community Development

Prepared by:

WSP

OJB
Magnusson Klemencic Assoc.
EnviroIssues
Framework
HR&A Advisors
Shiels Obletz Johnsen

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Acronyms and Abbreviations

AWS	American Welding Society
CCTV	Closed-Circuit Television
CFR	Code of Federal Regulations
EIS	Environmental Impact Statement
EVS	Emergency Ventilation System
FFFS	Fixed Firefighting System
FHWA	Federal Highway Administration
FLS	Fire and Life Safety
I-5	Interstate 5
ITS	Intelligent Transportation System
LRFD	Load Resistance Factor Design
MEP	Mechanical/Electrical/Plumbing
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
PCF	Pounds per Cubic Foot
PSF	Pounds per Square Foot
ROM	Rough-Order-Of-Magnitude
SCADA	Supervisory Control and Data Acquisition
SEPA	State Environmental Policy Act
WSDOT	Washington State Department of Transportation

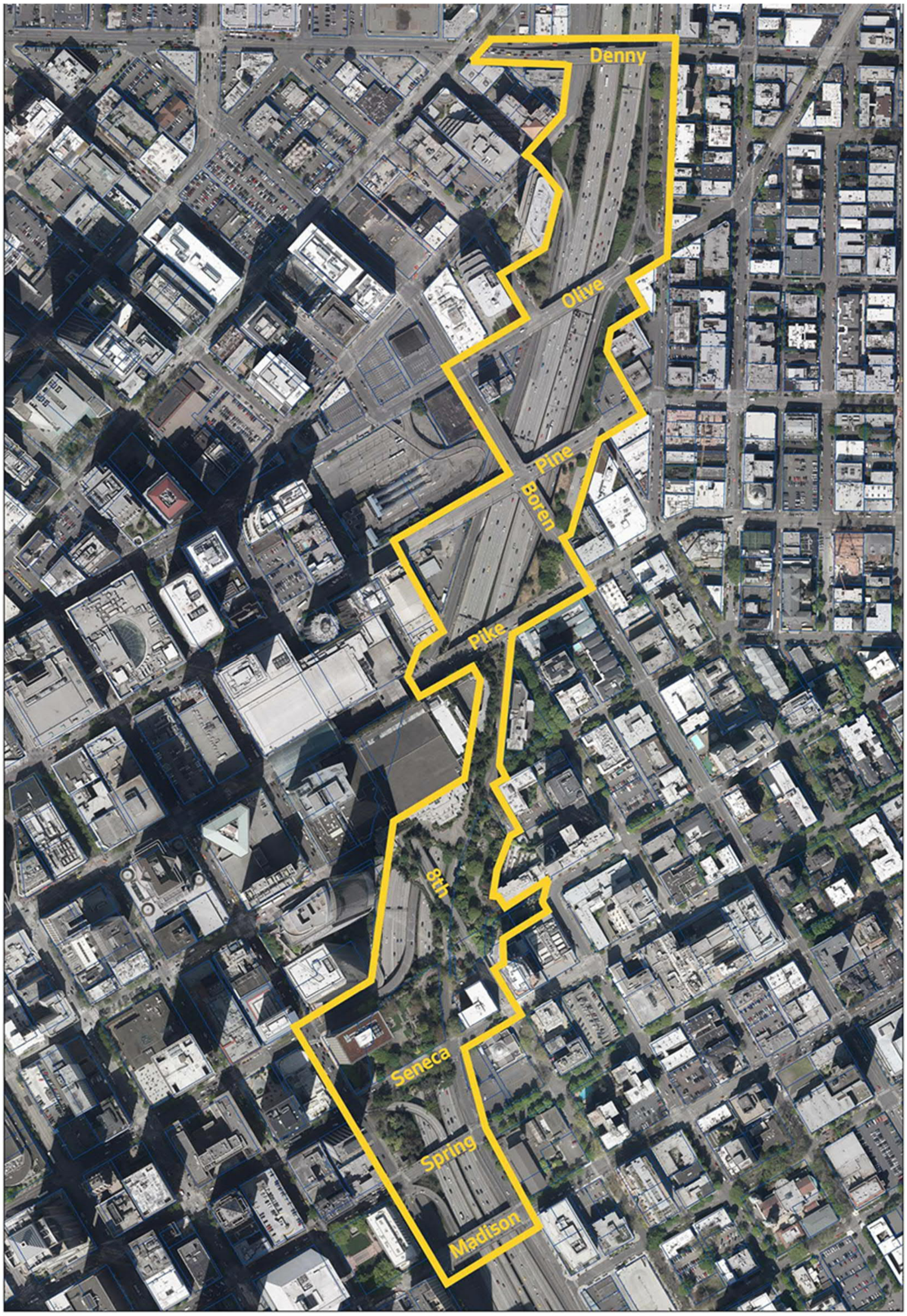
1. Introduction

This Basis of Design for Technical Feasibility Memorandum documents the proposed approach, assumptions, and standards to guide the technical feasibility assessment of the Interstate 5 (I-5) Lid Feasibility Study (LFS) conducted by the consultant team for the City of Seattle, as defined in Task 4 of the scope of work. The purpose of this document is to define criteria for the study and to ensure the services are performed efficiently to achieve the project goals.

This report is intended to be a living document that will be updated as required as the study progresses. The basis of design will ultimately be incorporated into the I-5 LFS Technical Feasibility Memorandum.

The Structural Assessment Boundary for the I-5 LFS generally runs along I-5 from Madison Street to Denny Way and its immediate perimeter (Figure 1-1).

Figure 1-1. Structural Assessment Boundary



Source: I-5 Lid Feasibility Study, Request for Proposals, Office of Planning & Community Development, City of Seattle, 2019

2. General Approach

Determining the feasibility of spanning an interstate within a dense urban environment requires an understanding of the site. I-5 through downtown Seattle features extensive walls supporting city streets on each side of the right-of-way, elevated viaducts, overpasses, on-/off-ramps, and city streets and buildings. In addition, there are subsurface features (e.g., tunnels, utility mains, and laterals). A three-dimensional map of these conditions is required to spatially understand all existing features in relation to each other. This technical feasibility study will consist of data gathering; site reconnaissance; conceptual three-dimensional base mapping; development of conceptual geometric lid layouts, structure types, and framing; and rough-order-of-magnitude (ROM) scoping-level cost estimating. The study is intended to provide the following:

- Potential lid geometric layouts (plan, profile, section)
  - For example, impacts of varying load-carrying levels (e.g., open-space landscaping, medium-level development, and high-level development)
- Potential impacts (temporary and permanent)
  - Temporary closure of roadways (city streets, on-/off-ramps, mainline I-5)
  - Permanent roadway modifications, including realignment of mainline I-5 and/or ramps, is not currently contemplated as part of this study
  - Acquisition of rights-of-way and demolition of existing infrastructure
  - Temporary or permanent utility impacts/modifications
- ROM estimate with conceptual cost allowances/ranges
  - Based primarily on cost metrics, supplemented with some quantities
  - Based on engineering judgment and experience (due to the limited amount of engineering), a limited understanding of the identified impacts, and varying levels of construction risk, cost ranges/contingencies
- The basis for scoping additional studies and engineering that will be needed if additional funding can be secured

This study, being the first of a tentatively multi-phase project, will identify issues needed to be satisfied to establish feasibility, but will not present recommendations to resolve impacts and resulting implications. Instead, the study will identify the potential impacts and potential costs, as described above, from which the City of Seattle and the project stakeholders can assess the economic viability of the project—as well as their wants, needs, and desires—to methodically move the project forward based on credible technical information and resources.

2.1 Coordination

The technical feasibility study will require input from various disciplines. The I-5 LFS technical team, organized as shown in the following bullet list, was set up with this in mind. The technical team will have regularly scheduled bi-weekly coordination meetings and participate in monthly meetings with the City of Seattle, key stakeholders, and partner agencies. The technical team will participate in workshops as requested.

- The Washington State Department of Transportation (WSDOT) Civil Engineering (roadway, geometrics, Intelligent Transportation Systems (ITS), illumination, utilities, and drainage):
  - Requirements for roadway illumination under the new lid will need to be analyzed for tunnel illumination criteria. The existing light levels on the northbound and southbound I-5 roadways upstream and downstream from the northern and southern limits of the new lid will be evaluated for nighttime illuminance based on WSDOT Design Manual requirements. Lighting under the existing I-5 Seneca–University and Eighth Avenue–Pike Street lids will also need to be evaluated in conjunction with the new tunnel lighting to ensure compliance with current WSDOT tunnel lighting requirements and uniformity with new illumination under the new lids. Results from the lighting analyses will support the concept-level cost estimate to install new tunnel light fixtures and modification to the existing illumination system.
  - Impacts to existing WSDOT ITS infrastructure will be reviewed with available as-built information to determine the extent of the potential impacts of the lid structure and associated substructure on existing ITS devices, such as ramp meter signals, variable message signs, and closed-circuit television (CCTV) cameras. The ITS equipment cabinets and associated power and communications infrastructure—including conduits, pull boxes, cable vaults, and mainline and distribution fiber optic communication cable—will also need to be evaluated for conflict with the lid structure as part of the feasibility study to capture the cost of addressing the conflicts.
  - All existing overhead and ground-mounted signs within the project limits will need to be inventoried and reviewed for conflicts with the lid structure. Affected overhead signs will be considered for replacement with new signs attached to the ceiling of the lid. The size and spacing of new overhead signs will depend on the maximum height of the lid ceiling that can be provided.
- Mechanical/Electrical/Plumbing (MEP)/Tunnel (heating, ventilating, and air-conditioning; lighting; Fire and Life Safety (FLS) Assessment: The scope and focus of the tunnel MEP and FLS effort are to provide guidance on system requirements and to identify potential impacts on the project that could affect its feasibility. In this context, "mechanical" refers to an emergency ventilation system (EVS) designed to maintain a tenable environment in the event of fire. The size and complexity of the system can vary greatly depending on tunnel configuration, length, fuel load, and other factors. The term "electrical" generally refers to power and control systems to support tunnel operations. Required electrical systems will vary according to what other systems are being provided and required to be supported. Plumbing systems required for a cover structure will usually be limited to roadway drainage. The major contributor to drainage loading will be the tunnel sprinkler system. FLS systems encompass all the combined systems that ensure safety in the event of an incident. The primary system will be a fixed firefighting system (FFFS), more commonly known as a deluge sprinkler system. The design of this element must be closely coordinated with other systems, including EVS, alarm, system controls, notification, egress, drainage, etc. The way in which these systems interact must be considered and can have a significant impact on the scope and cost of construction. The I-5 LFS will identify the major tunnel systems, assess their requirements, and describe ways they can affect the project.

- Site Civil Engineering (grading, utilities, and drainage): The civil engineering analysis will review the existing conditions with respect to roadway, bicycle, and pedestrian connectivity along with the topographic conditions and the wet utility infrastructure systems (storm drain, sanitary sewer, and domestic water) within and adjacent to the project limits. This analysis will result in a preliminary understanding of the constraints and opportunities presented by the existing conditions. These results will be factored into the Scenario Planning phase where different development options and the required civil engineering improvements to support each development scenario will be studied.
- Building Structural Engineering and Architecture: Depending on the load levels supported by the lid structures, building structures could be constructed and supported by the lid structure. No assessment of the building structures will be conducted; however, cost-per-square-foot metrics will be provided.
- Geotechnical Engineering: The geotechnical engineering evaluation to support the feasibility assessment will review existing subsurface information to develop geotechnical inputs to support the conceptual-level design of the lid structure foundation and side walls. Geotechnical inputs will include seismic ground-motion parameters, axial and lateral capacity for drilled shafts with various diameters, and lateral earth pressure diagrams for retaining wall design.
- Environmental Assessment: I-5 is a federal facility under the stewardship of the Federal Highway Administration (FHWA). As a federal facility, compliance with the National Environmental Policy Act (NEPA) is required when a federal action (such as funding, permits, or policy decisions) is taken. Therefore, prior to FHWA and WSDOT being able to fund, permit, or approve a modification to I-5, the NEPA process will need to be completed. During the NEPA process, compliance with other federal regulations and executive orders (such as those dealing with the National Historic Preservation Act and environmental justice) will occur. In addition, within Washington, state and local agencies are required to comply with the State Environmental Policy Act (SEPA); the NEPA and SEPA processes can be combined.

To better understand which NEPA and SEPA processes or class of action—such as an environmental assessment or an environmental impact statement (EIS)—would be required, an understanding of the potential project impacts and areas of controversy is necessary. Based on the urban context of the project area, early issues to consider include property and access impacts, traffic, environmental justice (disproportionate, adverse impacts to minority and low-income populations), historic and cultural resources, and aesthetics and visual quality.

Agency and stakeholder coordination will occur throughout the NEPA and SEPA processes, and measures to avoid, minimize, or mitigate adverse impacts will be identified, as will any permitting requirements prior to the start of construction. This will include the following:

- Urban design (architecture and landscape architecture)
- Real estate, development, and right-of-way
- Interface coordination

2.2 Basemap Development

A primary objective of this study is to develop conceptual lid structure layouts and gain an understanding of the associated impacts and costs. This is predicated on having a good basemap. Because a survey is not being developed as part of this contract, a preliminary basemap will be developed based on information received from the City of Seattle and other stakeholders. Development of the basemap will include the following:

- A review and inventory of the existing documentation/information received, including existing surveys, geographic information systems, structural as-builts, utility as-builts, geotechnical borings, and explorations within the project footprint.
- The inventory of documents/information used to develop the basemap will include how the information was used, flag the level of confidence in the accuracy of the information received, and denote what information was received but not used in the developing the basemap.

The basemap will contain many features over an appreciable length of I-5 through downtown Seattle. The basemap will consist of multiple files organized by specific features (e.g., channelization, existing structures, storm drainage, and electrical and communication lines). To obtain a compiled basemap, files will need to be referenced.

2.3 Lid Zone Development (Geometric Layout)

The technical team will determine potential layouts (zones) of the lid structure(s), including identifying potential impacts. The layouts will be based on geometrics (maintaining vertical clearances over roadways and tying into adjoining city streets) that consider the findings of the structural assessment for multiple load levels (i.e., open-space landscaping, low-rise, medium-rise, and high-rise developments, and cultural/civic development), which are identified in Table 2-1. Potential impacts will be identified. Impact areas will be labeled as “low risk” or “high risk” along with a list of the impacts. Impacts identified to establish feasibility will not be identified as fatal flaws and that it will be possible to assign a ROM cost to each of the identified impacts.

To generate the potential lid zones, potential work zones associated with the lid structure layouts will be identified. The work zone limits will be approximate based on past experience of similar bridge and lid projects. The number of lane/ramp/street closures will be identified with approximate durations. Similarly, potential impacts to existing structures will be identified. The technical team will identify which structures will be affected, provide a general assessment of extent of the impacts and the reason for the impacts, as well as a ROM estimate of the potential project costs to address the impacts.

2.4 Lid Structural Assessment

A detailed structural computer analysis of each lid zone developed will not be conducted. This would be required in later phases of the project. Instead, a generalized structural assessment will be conducted to support the development of the lid zone layouts and associated impacts. The structural assessment will consider general span configurations (up to three, independent of the specific lid zones) for the various load conditions that have been identified. Table 2-1 summarizes these use types and their corresponding load parameters. A simple beam model will be created to determine the required superstructure type, depth, girder spacing, and other required framing requirements for each load condition. Substructure and foundation sizes will be determined by approximate hand calculations. Unique features of each lid zone, such as specialized framing, will be qualitatively noted along with assumptions made and recommendations for further investigations. These will be prioritized based on the risk and construction costs allotted to the estimate.

Table 2-1. I-5 Lid Land Use Load Matrix

Description	Dead Load (psf)	Live Load (psf)	Supported Uses and Number of Stories			Assumptions
			Residential	Commercial	Civic	
Open Space/ Landscape	1,000	100 or 250	—	—	—	• Assume 5 feet of soil + trees @ 140 pcf. • Includes up to 3-story pavilions.
Low-Rise A	600	430	5	1	0	• Assume 5 stories of wood framing over 1-2 stories of concrete, all above grade. • Timber roof and floors w/1.5 inches lightweight concrete topping. • 12- to-15-inch concrete slab at transfer level and 4-inch concrete slab on grade.
Low-Rise B	850	575	0	5		• Assume steel framed with concrete slab-on-metal deck. • Assume accessible roof.
Medium-Rise	2,650	1,150	14	17	—	• Assume steel framed with concrete slab-on-metal deck. • Assume accessible roof.
High-Rise	6,815	2,100	45	30	—	• Assume steel framed with concrete slab-on-metal deck. • Assume accessible roof.
Cultural/Civic	700	650	—		3	• Assume steel framed with concrete slab-on-metal deck. • Assume accessible roof. • Assume gallery floor live load @ 150 psf.

2.5 Technical Feasibility Memorandum

The consultant team will prepare and submit a draft Comprehensive Technical Feasibility Memorandum, providing a conceptual description of the lid area and section layout, structural framing, and load-carrying capabilities. Potential impacts—permanent and temporary—will be identified for each lid zone along with the associated risks and ROM costs from which the City of Seattle and the project stakeholders can evaluate their wants, needs, and desires, and methodically move the project forward based on credible technical information and resources. Anticipated items to be addressed in the memorandum include the following:

- Structural assessment findings
- Lid-zone structural layouts and identified impacts:
  - Load level

  - Open-space/landscape loads
  - Medium-rise development loads
  - High-rise development loads
- Risk assessment
- ROM costs
- Constructability matrix: Based on the identified temporary construction zone limits, the consultant team will determine the number of lane closures and associated durations, and identify specialty, schedule critical, and/or high-risk work activities. These will be logged in a matrix with reference to the lid zone development figures.
- Traffic impacts: Traffic modeling to assess impacts to I-5 and/or Seattle traffic operations resulting from temporary lane and street closures will not be performed as part of the I-5 LFS. The urban analysis phase of the larger feasibility study will look at localized traffic impacts, but the results of these impacts will likely not be addressed.
- Risk assessment: A list that qualitatively assesses the risk potential associated with the identified impacts will be included. The risks identified will be included, or mitigated for, in the design and construction efforts in later phases of the project (currently not scoped). Risks could be associated with the following:
  - Traffic control (during and after construction)
  - Environmental permitting
  - Civil design
  - Geotechnical design
  - Structural design (new and existing structures)
  - Constructability, site access, and staging
  - Utility impacts
  - Public outreach/involvement
  - Real estate, development, and right-of-way
- Maintenance: The goal of the risk assessment is to characterize aspects of the project that have not been fully vetted and that require further analysis beyond the scoping level of this contract for successful implementation in later phases of work.
- Cost estimating: A scoping-level ROM construction cost estimate will be developed based on the sketches and identified impacts. The cost estimate will be partially quantity-based using conceptual-level unit pricing referenced from the City of Seattle, WSDOT, or other sources, as necessary; however, it will be heavily weighted toward metrics and contingencies based on risk for the identified potential impacts. Where material quantities are provided, they will be assumed based on past experience and engineering judgment, and not on actual engineering calculations. It is assumed more detailed quantity-based estimates will be developed as part of future phases of work. The cost estimate will include appropriate values for escalation and an estimation of right-of-way costs (as applicable).

3. Assumptions

The following list of assumptions will be used to guide the I-5 LFS's technical and structural assessment:

- The work products developed as part of this study are preliminary and should be used for scoping-level purposes only. Future technical studies are recommended to gain a better understanding of the impacts, risks, and costs associated with the project.
- The technical feasibility study assumes that it will be possible to assign a ROM cost to each of the identified impacts without performing any construction engineering and/or studying potential modifications to I-5.
- The City of Seattle and its stakeholders will provide existing documentation/information necessary to create a conceptual basemap and gain an understanding of the existing site conditions.
- The basemap developed as part of this study will be based on compiling the existing documentation/information. The basemap should be considered "for informational purposes only" and not used for anything beyond this study. A formal survey and mapping effort is recommended for future phases of work. The City of Seattle will retain ownership of the basemap and all associated files upon completion of this study.
- Feasibility will be based on current/existing conditions and not on potential projects that may or may not occur within the project extents.
- Essential bridge criteria will not be imposed beyond the criteria outlined in Section 4.
- The geometric lid layouts will consider that the existing bridges carrying city streets over I-5 can be demolished, with traffic being temporarily detoured and/or disrupted for a significant length of time while the lid structure is built, allowing the city street connections to be re-established (potentially on a new alignment). The ability to maintain traffic during this time will not be explored as part of this study. Roadways on overpasses identified to be demolished to accommodate lid construction will be assumed to be replaced in kind. These replacement structures will not be analyzed at this phase, with the framing and superstructure dimensions to match the existing structures. These structures will need to be analyzed in future phases.
- The basemap will be developed in AutoCAD Civil 3D 2017.
- Existing structures will not be assessed for deficiencies based on current code standards.
- For purposes of technical feasibility, it will be assumed that the existing road network has adequate capacity to support the proposed development on top of the lid. A detailed traffic analysis is recommended for future phases of work to confirm this assumption and to remediate any deficiencies noted for these roadways.
- For purposes of technical feasibility, it will be assumed that the existing storm drain system has adequate capacity to support the proposed development on top of the lid. A downstream analysis is recommended in future phases of work to confirm this assumption.
- For purposes of technical feasibility, it will be assumed that the existing sanitary sewer system has adequate capacity to support the proposed development on top of the lid. A

sewer shed and capacity analysis is recommended in future phases of work to confirm this assumption.

- There is adequate water pressure and supply to support the proposed development on top of the lid. A water network analysis is recommended in future phases of work to confirm this assumption.
- The existing electrical system has adequate capacity to support the proposed development on top of the lid. An electrical analysis to confirm this assumption is outside the scope of this study.
- No new subsurface exploration will be performed for this feasibility study. Further explorations and evaluations will need to be performed in future phases of work to validate the geotechnical parameters.
- A full-scale photometric model of I-5 under the lid will not be developed for the feasibility study.
- Due to the complexity of the project and the dense urban context, the potential exists for significant environmental impacts and/or a high level of controversy. Therefore, an EIS will be required to complete the NEPA and SEPA processes. Per the Fixing America's Surface Transportation Act and Executive Order 13807, "Establishing Discipline and Accountability in the Environmental Review and Permitting Process for Infrastructure Projects," the project's NEPA document would be used for all required federal actions ("one federal decision") and would be completed within two years. Federal permits would then be required to be completed within 90 days of the issuance of the EIS's Record of Decision unless requested otherwise. State and local agency permits are not subject to this 90-day requirement.
- The following lists systems that are likely to be required to conform with applicable codes and standards:
  - Emergency Ventilation System: A fire ventilation system could be required, depending on tunnel length and environmental conditions. At the least, a ventilation system analysis will be required. If a system is to be provided, it will likely be a longitudinal type with jet fans located at roadway entry portals. For a longer tunnel, in excess of 1,000 feet, additional banks of fans could be required along the roadway. Installing an EVS might be avoided if the tunnel structure can be divided into separate sections, each less than approximately 400 to 800 feet in length and having a wide gap in between. The interaction of tunnel EVS and sprinkler systems could reduce the required capacity and complexity of the EVS system.
  - Fire Fighting Systems: Per National Fire Protection Association (NFPA) 502, a fire standpipe system must be provided in tunnels with lengths exceeding 300 feet. Seattle fire code requires an FFFS (an automatic deluge sprinkler system) to be provided in roadway tunnels. The type and capacity of the FFFS will depend on the fuel load types allowed to pass through the tunnel. The Seattle I-5 corridor allows passage of hazard materials cargoes, which includes combustible liquid tankers. These represent the largest fuel loads described in NFPA 502. Mitigation of liquid fuels fires is challenging. A consensus would need to be reached with the authority having jurisdiction as to what constitutes a plausible level of protection achievable with an FFFS and what capacity the system will have in order to reach that goal. Ventilation system capacity and response time, as well as egress timeline, will play a

role in the overall achievement of life-safety in a fire event and must be considered when sizing the FFFS. In any case, an FFFS designed to address a liquid fuels fire will be robust. The addition of an Automatic Film Forming Foam system could be required.

- Structural Fire Durability: NFPA 502 requires that road tunnels be protected from fire damage that can lead to progressive structural collapse. A structural durability analysis must be performed regardless of tunnel length. The analysis will determine the degree of temperature mitigation required to protect the structure. For worst-case conditions, a thermal protection system—either board or spray—will be required on the tunnel ceiling and the upper parts of walls. FFFSs have a cooling effect on temperature generated in a fire and could eliminate the need for a thermal board. This depends highly on fuel load and ceiling configuration. When liquid fuel tankers are allowed, some form of thermal protection is generally required beyond the provision of an FFFS.
- Power and Controls: Local transformers and associated space provisions will usually be required to provide power for lighting and EVSs. EVS fans are required to be provided with a motor control center, including required switchgear, switchboards, and related appurtenances. These must be housed in a dedicated room that is climate controlled. They may be co-located with main electrical equipment and transformers. Controls infrastructure for EVS, FFFS, fire alarm, CCTV, notification systems, etc. will be required. A SCADA-based monitoring and controls data link to the WSDOT Operations and Controls Center must be provided. Based on tunnel length, emergency power and emergency lighting could be required. Backup power could be provided by an emergency generator or by an additional utility supply from a second substation.

4. Design and Engineering Standards

This section provides a complete list of the standards the project will need to comply with or address. New publications or revisions to the list of standards made after April 1, 2019, will not be considered in the study.

- WSDOT
  - AGi32 Basics for Highway Lighting
  - Local Agency Guidelines (M36-63)
  - Bridge Design Manual (M 23-50)
  - Bridge Inspection Manual (M 36-64)
  - Bridge and Structures Office Design Memoranda
  - Communications Manual (M 3030)
  - Construction Manual (M 41-01)
  - Design Manual (M 22-01)
  - Environmental Manual (M 31-11) (provides guidance for compliance with federal environmental laws and regulations, including FHWA's environmental regulations in 23 Code of Federal Regulations (CFR) § 771)
  - Geotechnical Design Manual (M 46-03)
  - Highway Runoff Manual (M 31-16)
  - Hydraulics Manual (M 23-03)
  - Illumination Design Supplement
  - Intelligent Design for Transportation
  - Maintenance Manual (M 51-01)
  - Materials Manual (M 46-01)
  - Northwest Region Current Practices in Electrical Design
  - Northwest Region Electrical Special Provisions
  - Northwest Region Illumination and Signal Details
  - Northwest Region ITS Design Requirements
  - Northwest Region ITS Special Provisions
  - Northwest Region ITS Details
  - Pavement Policy
  - Pavement Surface Condition Field Rating Manual for Asphalt Pavements
  - Plans Preparation Manual (M 22-31)
  - Power System Design
  - Roadside Manual (M 25-30)
  - Standard Plans (M 21-01)
  - Standard Specifications (M41-10) – and Amendments

  - Traffic Manual (M 51-02)
  - Temporary Erosion and Sediment Control Manual (M 3109)
  - Utilities Accommodation Policy (M 22-86)
  - Utilities Manual (M 22-87)
- American Association of State Highway Transportation Officials
  - A Policy on Design Standards – Interstate System
  - A Policy on Geometric Design of Highway and Streets
  - Guide Design Specifications for Bridge Temporary Works
  - Guide for Development of Pedestrian Facilities
  - Guide for High-Occupancy Vehicle (HOV) Facilities
  - Guide for Planning, Design, and Operation of Pedestrian Facilities
  - Guide Specifications for Load and Resistance Factor Design (LRFD) Seismic Bridge Design
  - Guide Specifications for the Design of Pedestrian Bridges
  - Guide Specifications for Structural Design of Sound Barriers
  - LRFD Bridge Construction Specifications
  - LRFD Bridge Design Specifications
  - LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, First Edition
  - Manual of Bridge Evaluation
  - Manual of Subsurface Investigations
  - Policy on Geometric Design of Highways and Streets
  - Roadside Design Guide
  - Standard Specifications for Transportation Materials and Methods of Sampling and Testing
- FHWA
  - Drilled Shafts: Construction Procedures and LRFD Design Methods (FHWA-NHI-10-016), May 2010
  - Flexibility in Highway Design
  - Manual on Uniform Traffic Control Devices (MUTCD)
  - Seismic Retrofit Manual for Highway Structures: Part 1 – Bridges, (FHWA-HRT-06-032), January 2006
  - Separated Bike Lane Planning and Design Guide
  - Technical Manual for Design and Construction of Road Tunnels – Civil Elements (publication FHWA-NHI-10-034)
  - Washington State Modifications to the Manual on Uniform Traffic Control Devices (WAC 468-95)

- National Fire Protection Association (NFPA)
  - NFPA 14, Standard for the Installation of Standpipe and Hose Systems, 2019 Edition
  - NFPA 13, Standard for the Installation of Sprinkler Systems, 2019 Edition
  - NFPA 70, National Electrical Code
  - NFPA 72, National Fire Alarm and Signaling Code
  - NFPA 502, Standard for Road Tunnels, Bridges, and Other Limited Access Highways, 2017 Edition
- City of Seattle
  - Building Code
  - Contract Surveying Standards
  - Drafting Standards/City of Seattle Inter-Departmental CADD Standards
  - Electrical Code
  - Right-of-Way Lighting Level Design Guidelines
  - Standard Plans
  - Standard Specifications for Road Bridge and Municipal Construction
  - Storm Water Manual
  - Traffic Control Manual for in Street Work (Traffic Control Manual)
- Seattle City Light
  - Construction Standards and Work Practices
  - Material Standards
- Seattle Public Utilities
  - Client Assistance Memo 1180
  - Design Standards and Guidelines (DSG)
- Seattle Department of Transportation
  - Adaptive VISSIM Modeling – SCOOT Deployment Cost Estimation Memo
  - Contract Quality Control/Quality Assurance Standards for Consultant Design
  - Right-of-Way Opening and Restoration Rules
  - Streets Illustrated, Seattle's Right-of-Way Improvements Manual
- Seattle Department of Parks and Recreation
  - Design Standard Section 26 56 00 Design of Outdoor Lighting
  - Standard Details and Plans
  - Technical Specifications

- Additional Standards:
  - American Concrete Institute Code Requirements for Environmental Engineering Concrete Structures (ACI 350)
  - American Society of Civil Engineers (ASCE) 7 Minimum Design Loads for Buildings and Other Structures
  - American Welding Society (AWS) Structural Welding Code - Bridge (AWS D1.5M/D1.5)
  - AWS Structural Welding Code - Reinforcing Steel (AWS D1.4/D1.4M)
  - AWS Structural Welding Code - Steel (AWS D1.1/D1.1M)
  - International Code Council, International Building Code
  - NFPA 205 Standard for Road Tunnels, Bridges and Other Limited Access Highways
  - Overview of King County Metro Transit's ITS Infrastructure Requirements for Transit Signal Priority and Real Time Signs
  - State of Washington, Washington State Building Code
  - United States Code of Federal Regulations, 33 CFR Part 118, Bridge Lighting and Other Signals

I-5 Lid Feasibility Study

Appendix B
Basemap Development Methodology

Prepared for:

Seattle Office of Planning & Community Development

Prepared by:

WSP

OJB
Magnusson Klemencic Assoc.

EnviroIssues
Framework

HR&A Advisors
Shiels Obletz Johnsen

December 5, 2019

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Appendices

Acronyms and Abbreviations

I-5	Interstate 5
OPCD	Office of Planning and Community Development
SAB	Structural Assessment Boundary
SCL	Seattle City Light
SPU	Seattle Public Utilities
ST	Sound Transit
WSCC	Washington State Convention Center
WSDOT	Washington State Department of Transportation

1. Introduction

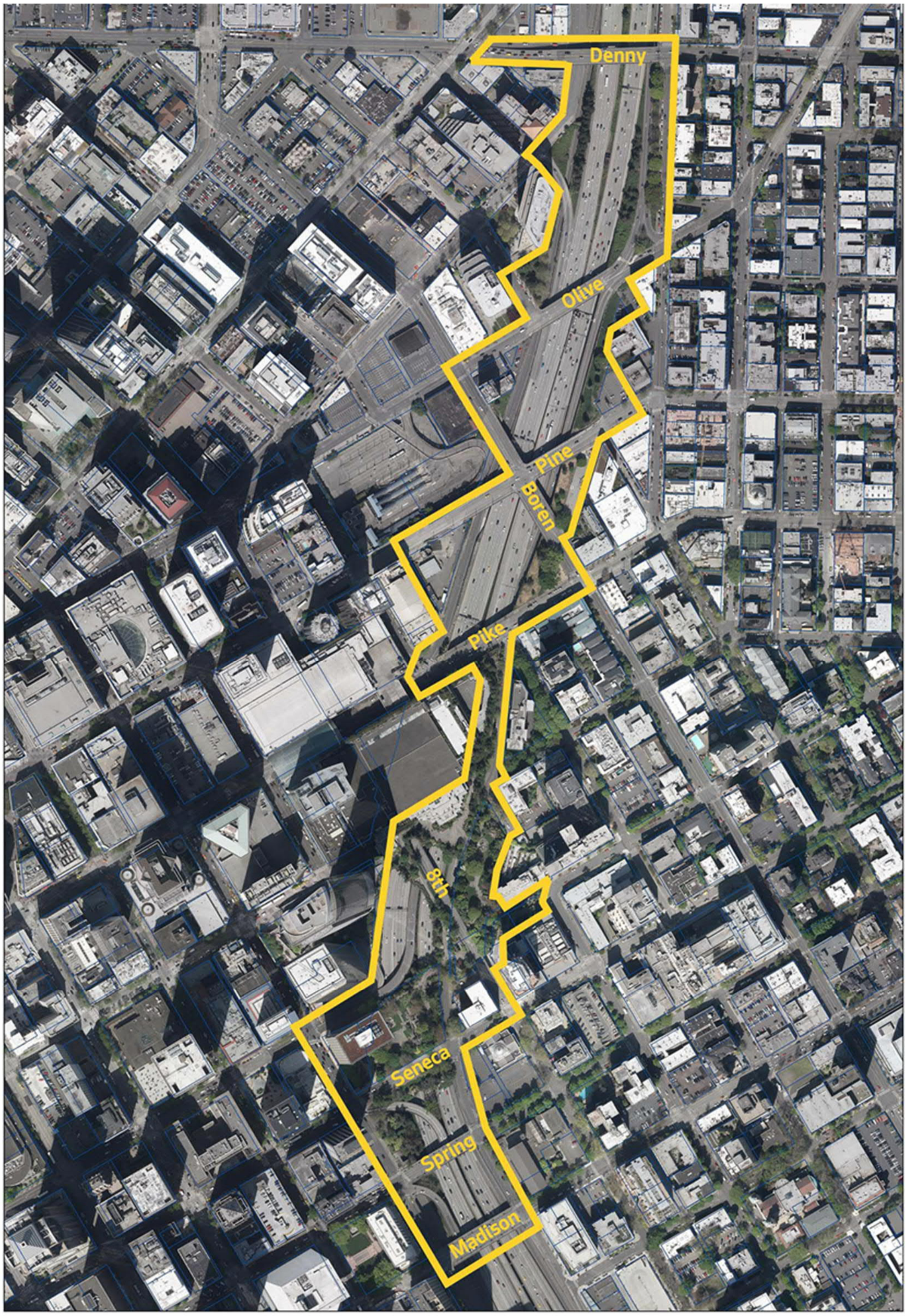
This Basemap Development Methodology describes the sources, approach, and assumptions used to develop the basemap for the technical feasibility assessment of the I-5 Lid Feasibility Study conducted by the consultant team for the City of Seattle, as defined in Task 4 of the scope of work.

The Structural Assessment Boundary (SAB) for the I-5 Lid Feasibility Study generally runs along Interstate 5 (I-5) from Madison Street to Denny Way and its immediate perimeter (Figure 1-1). A primary objective of this study is to develop conceptual lid structural layouts on the SAB and gain an understanding of the associated constraints, impacts, and costs. This is predicated on having a representative basemap to work from. A survey is not being developed as part of this contract; thus, a preliminary basemap was developed based on information received from the City and other agencies and stakeholders.

The basemap refers to a collection of geographic and engineering CAD data that form the foundation for the lid concepts. The function of the basemap is to provide the background detail necessary to develop engineering assumptions for the technical feasibility component of the Study. The layers for the basemap include streets, parcels, structural as-builts, utility as-builts, right-of-way limits, contours, and aerial imagery.

It is intended that this basemap development documentation and its appendices be a living document, which will be updated as required as the study progresses.

Figure 1-1. Structural Assessment Boundary



Source: I-5 Lid Feasibility Study, Request for Proposals, OPCD, City of Seattle, 2019

1.1 Summary of Data Collected

A formal information request was sent to relevant agencies and stakeholders, channeled through the Office of Planning and Community Development (OPCD) of the City of Seattle in March 2019, and the requested documents and information were provided to the project team via email or SharePoint file delivery. Information for basemap development was received from the Washington State Department of Transportation (WSDOT), Seattle Public Utilities (SPU), Seattle City Light (SCL), Sound Transit (ST), and Washington State Convention Center (WSCC)/Pine Street Group. The data transfers have been documented via an Information Request Matrix spreadsheet. The development of the basemap includes the appendix documents that summarize the data collected and outline how the files were compiled and consolidated into distinct xref files. The basemap and information provided in the attachments are living documents that will be updated as new or updated information is received.

1.2 Basemap Development Assumptions

The following list of assumptions were made in development of the basemap:

- The City and its stakeholders have provided existing documentation/information necessary to create a conceptual basemap and gain an understanding of the existing site conditions.
- The basemap developed as part of this study was based on compiling and merging these existing documents and does not include any additional survey work. The basemap should be considered "for informational purposes only" and not used for any purpose beyond this preliminary study phase. A formal survey and mapping effort is recommended for future phases of work.
- Feasibility will be based on existing conditions and not on potential projects that may or may not occur within the project extents.
- The basemap was developed in AutoCAD Civil 3D 2017, with all associated xref files in the ".dwg" format. All files that were provided in a different format were converted to ".dwg".
- A full-scale photometric model of I-5 under the lid will not be developed for the feasibility study.
- Inventory of existing signs on I-5 or adjacent city streets will not be conducted.

1.3 Appendix B-1: Basemap xref File List

The basemap contains many features over the project limits along I-5 through downtown Seattle. For utilities, the basemap has considered one- to two-block information from the limits of I-5. The basemap consists of multiple files compiled by specific features (e.g., channelization, existing structures, storm drainage, utilities, etc.) and sorted by the associated agency (WSDOT, SCL, SPU, ST). A.A.1.1.1.1Appendix B-1 contains a list of the multiple files that will need to be referenced to obtain a compiled basemap. The naming convention for these xref files is as follows:

- SCL xref – "E_SCL_ELEC.dwg". This xref includes SCL's electrical network within the project area.

- SPU xref – “E_SPU_UTIL.dwg”. This xref includes SPU’s utility network within the project area.
- WSDOT xrefs – “E_WSDOT_[feature description].dwg”, where “feature description” refers to the specific features included within the particular xref file (right-of-way, contours, alignment, etc.)
- ST xrefs – “E_ST_[feature description].dwg”, where “feature description” refers to the specific features included within the particular xref file (parcels, structures, alignment, etc.)
- WSCC xrefs – “E_WSCCA_[feature description].dwg”, where “feature description” refers to the specific features included within the particular xref file (utilities, right-of-way, structures, etc.)

1.4 Appendix B-2: Information Tracking and Use Form

This form provides a review and inventory of the existing documentation/information received with a description of how the information was used and the level of confidence in the accuracy of the information. The received information includes, but is not limited to, existing survey, roadway and right-of-way limits, geographic information systems, structural as-builts, and utility as-builts.

1.5 Appendix B-3: WSDOT and ST As-Builts: Processed Structures Components to xref

The limits of the WSDOT and Sound Transit structures located within the project limits were largely left out of CAD files provided by these agencies. Therefore, the as-built drawings that were provided by these agencies were used to sketch the limits of the structural foundation elements for each of these structures within the basemap. The A.A.1.1.1.1Appendix B-3 documentation outlines the process off cataloging the structures and incorporating these structures into the basemap.

Appendix B-1 Basemap xref File List

xref Name	Agency Supplying Information	Elements Compiled within xref	Notes:
ApproximateLimits.dwg	---	Limits of Structural Assessment Boundary (SAB)	
E_PHOTO.dwg	WSP Team	Aerial Photos of project area	Source: 2019 Bing Maps Aerial Images
E_SCL_ELEC.dwg	SCL	SCL's Electrical Network	
E_SPU_UTIL.dwg	SPU	SPU's Utility Network	
E_ST_Struct_(Pine St Area)	Sound Transit (ST)	ST's ULink tunnel and related structures in the Pine Street Area	
E_ST_Align	Sound Transit (ST)	ST's ULink Track alignment	
E_ST_Parcels_(X334-X344-X346)	Sound Transit (ST)	Roadway/Right of Way Boundaries	
E_ST_X344SF-SurfaceFeatures	Sound Transit (ST)	Surface Features in the Pine Street Area	
E_ST_X344TM-Telecomm	Sound Transit (ST)	Stub tunnel and ULink tunnel systems	
E_ST_X344UT-Utilties	Sound Transit (ST)	Stub tunnel and ULink tunnel utilities	
E_WSDOT_AL-Alignment.dwg	WSDOT	I-5 NB alignment	
E_WSDOT_BL-Breakline_Grnd.dwg	WSDOT	Ground level breaklines	
E_WSDOT_CONTOURS.dwg	WSDOT	Contours	
E_WSDOT_DR-Drainage.dwg	WSDOT	WSDOT's Drainage inlets	
E_WSDOT_PM-Photo-Monument.dwg	WSDOT	Photo Monument Locations	
E_WSDOT_RD_BCD-Barrier-Curb-Driveways.dwg	WSDOT	Limits of curb/barrier lines along I-5 and City of Seattle surface streets within 1-2 blocks from the limits of I-5	
E_WSDOT_RD_MK-Markings.dwg	WSDOT	Channelization/pavement markings along I-5 and City of Seattle surface streets within 1-2 blocks from the limits of I-5	
E_WSDOT_RD_Names.dwg	WSDOT	Road/street names for City of Seattle surface streets within 1-2 blocks from the limits of I-5	
E_WSDOT_RW-RightofWay.dwg	WSDOT	I-5 right of way limits along the project area.	

xref Name	Agency Supplying Information	Elements Compiled within xref	Notes:
E_WSDOT_ST_BG&WA-Bridge&Walls.dwg	WSDOT	Plan view of WSDOT bridge locations as provided in WSDOT basefiles; provides linework for face of wall, but does not include bridge substructure locations nor retaining wall limits or wall identification numbers.	
E_WSDOT_STRC.dwg	WSDOT - provided as-built dwgs Project Team - developed xref	Limits of WSDOT bridges (superstructure and substructre) and foundations of WSDOT retaining walls; information extracted from WSDOT as-built drawings and manually drawn into xref.	See "WSDOT & ST As-Builts: Processed Structures Components to Xref" summary tables for exhaustive list of bridge as-built files utilized to develop this xref.
E_WSDOT_TP_MM-ManMade.dwg	WSDOT	Provides outline of man-made structures not owned by WSDOT that cross I-5 or are located in the City of Seattle within 1-2 blocks from the limits of I-5.	
E_WSDOT_TP_NT-Trees.dwg	WSDOT	Trees and vegetation within WSDOT ROW and in the City of Seattle within 1-2 blocks from the limits of I-5.	
E_WSDOT_TR_IL-Lights.dwg	WSDOT	Luminaire and light pole locations within 1-2 blocks from the limits of I-5.	
E_WSDOT_TR_SG&SN-Signal&Signs.dwg	WSDOT	Traffic signal and freeway signage locations within 1-2 blocks from the limits of I-5.	
E_WSDOT_UT-Utilities.dwg	WSDOT	WSDOT's Utility Network	
E_WSDOT_Z-TXT-Labels.dwg	WSDOT	Text labels for all elements identified in the files supplied by WSDOT.	
E_WSCCA_UTIL.dwg	Washington State Convention Center (WSCC)	Storm and sewer lines for the WSCC Addition	
E_WSCCA_RW-RightofWay.dwg	Washington State Convention Center (WSCC)	Limits of existing roadway, sidewalks, and parcel limits (prior to Addition Construction)	
E_WSCCA_STRC.dwg	Washington State Convention Center (WSCC)	Existing and proposed structures within WSCCA area	

Appendix B-2 Information Tracking and Use Form

Basemap Development: Information Tracking Form

NOTE: Files highlighted in ORANGE were not used in the development of the project basemap.

Received File Name	Agency	File Description	Date Received	Received File Format	Converted File Format	File Notes	Created xref Name
WSDOT xref files, "E_WSDOT_[...].dwg"							
208005_A_InRoads3D.dgn	WSDOT	I-5 Roadway; 2011 Survey	04/05/19	dgn	dwg	Not within the project limits.	N/A; not used
208005_B_InRoads3D.dgn	WSDOT	I-5 Roadway; 2011 Survey	04/05/19	dgn	dwg	InRoads from Denny Way on Northern limit to S. Weller St on Southern limit.	E_WSDOT_AL-Alignment.dwg
208005_C_InRoads3D.dgn	WSDOT	I-5 Roadway; 2011 Survey	04/05/19	dgn	dwg	Not within the project limits.	N/A; not used
208005_D_InRoads3D.dgn	WSDOT	I-5 Roadway; 2011 Survey	04/05/19	dgn	dwg	Not within the project limits.	N/A; not used
208005_E_InRoads3D.dgn	WSDOT	I-5 Roadway; 2011 Survey	04/05/19	dgn	dwg	Not within the project limits.	N/A; not used
208005_F_InRoads3D.dgn	WSDOT	I-5 Roadway; 2011 Survey	04/05/19	dgn	dwg	InRoads from Denny Way on Southern limit to E. Galer St on the Northern limit.	E_WSDOT_AL-Alignment.dwg
208005_G_InRoads3D.dgn	WSDOT	I-5 Roadway; 2011 Survey	04/05/19	dgn	dwg	Not within the project limits.	N/A; not used
208005_H_InRoads3D.dgn	WSDOT	I-5 Roadway; 2011 Survey	04/05/19	dgn	dwg	Not within the project limits.	N/A; not used
BASEMAP.dgn	WSDOT	Master Basefile of I-5, including xrefs of 208005_A, B, C, D, etc.	04/05/19	dgn	dwg	Includes xrefs of 208005_A, B, C, D, etc.	E_WSDOT_AL-Alignment.dwg
P9017_BP_ST.dgn	WSDOT	Base map of Structures with Structure ID #'s	04/05/19	dgn	dwg	Provides limits of WSDOT Structures, identified by their Structure ID #'s	E_WSDOT_ST_BG&WA-Bridge&Walls.dwg
P9017_BP_StreetNames.dgn	WSDOT	Street Names	04/05/19	dgn	dwg	reference file that displays the adjacent street names	E_WSDOT_RD_Names.dwg
survey_dec08.dgn	WSDOT	Base map from Dec 2008 survey	04/05/19	dgn	dwg	Used to fill in the gaps within "208005_B" and "208005_F"	E_WSDOT_AL-Alignment.dwg
XL4422_BP_EX_EXP.dgn	WSDOT	Future Seneca St Widening Basemap	04/05/19	dgn	dwg	Seneca Street Widening Base Map; Express Lanes	N/A; not used
XL4422_BP_EX_Flyover.dgn	WSDOT	Future Seneca St Widening Basemap	04/05/19	dgn	dwg	Seneca Street Widening Base Map; Not within project limits	N/A; not used
XL4422_BP_EX_NB.dgn	WSDOT	Future Seneca St Widening Basemap	04/05/19	dgn	dwg	Seneca Street Widening Base Map; I-5 NB	N/A; not used
XL4422_BP_EX_SB.dgn	WSDOT	Future Seneca St Widening Basemap	04/05/19	dgn	dwg	Seneca Street Widening Base Map; I-5 SB	N/A; not used
XL4422_BP_EX_PR.dgn	WSDOT	Future Seneca St Widening Basemap	04/05/19	dgn	dwg	Seneca Street Widening Base Map; Channelization	N/A; not used
160032-R6.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Alternative R6 with expressway volumes; not within project limits	N/A; not used
N3 Chan.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Channelization Alternative N3; not within project limits	N/A; not used
N5 Chan.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Channelization Alternative N5; overlaps	N/A; not used
N5B Align.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Alignment Alternative N5B; overlaps & shifted	N/A; not used
N5B Chan.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Channelization Alternative N5B; overlaps	N/A; not used
N12B Chan.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Channelization Alternative N12B; overlaps	N/A; not used
N17 Align.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Alignment Alternative N17; overlaps & shifted	N/A; not used

Received File Name	Agency	File Description	Date Received	Received File Format	Converted File Format	File Notes	Created xref Name
N17 Chan.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Channelization Alternative N17; overlaps	N/A; not used
P9017_BP_N5B-N12B.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Sheet set up, I5 Line Diagram	N/A; not used
P9017_BP_S2.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Sheet set up, Profiles, Not within project limits (North of Denny)	N/A; not used
P9017_BP_S3.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Sheet set up, Profiles, Not within project limits (North of Denny)	N/A; not used
S1_AddLane_85th_to_SR522_option2.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Channelization, Bridge & Wall Plan, Not within project limits (North of Denny)	N/A; not used
S4 Align.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Alignment Alternative S4	N/A; not used (duplicate information)
S4 Chan.dgn	WSDOT	Seneca to SR520 Mobility Improvements	04/05/19	dgn	dwg	Channelization Alternative S4	N/A; not used (duplicate information)
208006_I5_MP164-MP167.dgn	WSDOT	I-5 Roadway; Seneca St. Widening	04/18/19	dgn	dwg	Illumination elements over I5 width extents	E_WSDOT_TR_IL-Lights.dwg
214012_I5_SenecaSt_NBonly.dgn	WSDOT	I-5 Roadway; Seneca St. Widening	04/18/19	dgn	dwg	provides NB roadway, adjacent buildings, contours, no utilities	mutiple "E_WSDOT_" files based on feature: E_WSDOT_TP_MM-ManMade.dwg E_WSDOT_CONTOURS.dwg
214012_I5_SenecaSt_NBonly_Con2ft.dgn	WSDOT	I-5 Roadway; Seneca St. Widening	04/18/19	dgn	dwg	provides NB contours only	E_WSDOT_CONTOURS.dwg
214012_I5_SenecaSt_NBSB.dgn	WSDOT	I-5 Roadway; Seneca St. Widening	04/18/19	dgn	dwg	provides NB & SB roadway, adjacent buildings, contours, no utilities	mutiple "E_WSDOT_" files based on feature: E_WSDOT_TP_MM-ManMade.dwg E_WSDOT_CONTOURS.dwg
214012_I5_SenecaSt_NBSB_Con2ft.dgn	WSDOT	I-5 Roadway; Seneca St. Widening	04/18/19	dgn	dwg	provides NB & SB contours only	E_WSDOT_CONTOURS.dwg
Existing3DTLConventionCenterWSDOT.dgn	WSDOT	I-5 Roadway; Seneca St. Widening	04/18/19	dgn	dwg	I5 channelization and structures (incl. framing for WSCC and Freeway Park)	E_WSDOT_TP_MM-ManMade.dwg
I5_SenecaSt_NBonly.dtm	WSDOT	I-5 Roadway; Seneca St. Widening In-roads surface file for NB	04/18/19	dtm	dwg	NB Channelization	N/A; not used (duplicate information)
I5_SenecaSt_SBonly.dtm	WSDOT	I-5 Roadway; Seneca St. Widening In-roads surface file for SB	04/18/19	dtm	dwg	SB Channelization	N/A; not used (duplicate information)
SCL xref: "E_SCL_ELEC.dwg"							
0163n.dwg	SCL	Electric network in block 0163N	04/17/19	dwg	---	---	E_SCL_ELEC.dwg
0163s.dwg	SCL	Electric network in block 0163S	04/17/19	dwg	---	---	"
0164n.dwg	SCL	Electric network in block 0164N	04/17/19	dwg	---	---	"
0172n.dwg	SCL	Electric network in block 0172N	04/17/19	dwg	---	---	"
0172s.dwg	SCL	Electric network in block 0172S	04/17/19	dwg	---	---	"
0173n.dwg	SCL	Electric network in block 0173N	04/17/19	dwg	---	---	"
0173s.dwg	SCL	Electric network in block 0173S	04/17/19	dwg	---	---	"
0181n.dwg	SCL	Electric network in block 0181N	04/17/19	dwg	---	---	"
0181s.dwg	SCL	Electric network in block 0181S	04/17/19	dwg	---	---	"
0191n.dwg	SCL	Electric network in block 0191N	04/17/19	dwg	---	---	"
0191s.dwg	SCL	Electric network in block 0191S	04/17/19	dwg	---	---	"
0329p.dwg	SCL	Electric network in block 0329P	04/17/19	dwg	---	---	"
0338s.dwg	SCL	Electric network in block 0338S	04/17/19	dwg	---	---	"
0339p.dwg	SCL	Electric network in block 0339P	04/17/19	dwg	---	---	"
0348s.dwg	SCL	Electric network in block 0348S	04/17/19	dwg	---	---	"

Received File Name	Agency	File Description	Date Received	Received File Format	Converted File Format	File Notes	Created xref Name
0358n.dwg	SCL	Electric network in block 0358N	04/17/19	dwg	---	---	"
0401p.dwg	SCL	Electric network in block 0401P	04/17/19	dwg	---	---	"
0689s.dwg	SCL	Electric network in block 0689S	04/17/19	dwg	---	---	"
0699s.dwg	SCL	Electric network in block 0699S	04/17/19	dwg	---	---	"
0702s.dwg	SCL	Electric network in block 0702S	04/17/19	dwg	---	---	"
0703n.dwg	SCL	Electric network in block 0703N	04/17/19	dwg	---	---	"
0703s.dwg	SCL	Electric network in block 0703S	04/17/19	dwg	---	---	"
0704n.dwg	SCL	Electric network in block 0704N	04/17/19	dwg	---	---	"
0712n.dwg	SCL	Electric network in block 0712N	04/17/19	dwg	---	---	"
0712s.dwg	SCL	Electric network in block 0712S	04/17/19	dwg	---	---	"
0721s.dwg	SCL	Electric network in block 0721S	04/17/19	dwg	---	---	"
0722n.dwg	SCL	Electric network in block 0722N	04/17/19	dwg	---	---	"
0731s.dwg	SCL	Electric network in block 0731S	04/17/19	dwg	---	---	"
SPU xref: "E_SPU_UTIL.dwg"							
DWW_Infrastructure_Catch_Basin.dwg	SPU	Catch Basin locations	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-STRM-CB
DWW_Infrastructure_CCTV_Observations.dwg	SPU	CCTV Observations	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-CCTV-OBSV
DWW_Infrastructure_CSO_Basins.dwg	SPU	CSO Basin Locations	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-CSO_-BASN
DWW_Infrastructure_Drainage_Basins.dwg	SPU	Drainage Basins	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-DRAN-BASN
DWW_Infrastructure_DWW_Aba_Rem_Mainlines.dwg	SPU	DWW Mainlines	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-SEWR-ABA_-MAIN
DWW_Infrastructure_DWW_Aba_Rem_Mainline_End_Points.dwg	SPU	DWW Mainline end points	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-SEWR-ABA_-MAIN-ENDP
DWW_Infrastructure_DWW_Aba_Rem_Non_Mainlines.dwg	SPU	DWW Non-mainlines	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-SEWR-ABA_-LINE
DWW_Infrastructure_DWW_Aba_Rem_Side_Sewer_Latera_Points.dwg	SPU	Sewer lateral points	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-SEWR-ABA_-LATR-PNTS
DWW_Infrastructure_DWW_Inlets.dwg	SPU	Inlets	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-SEWR-INLT
DWW_Infrastructure_DWW_Mainlines_Permitted_Use.dwg	SPU	Mainlines, permitted use	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-SEWR-MAIN-PRMT
DWW_Infrastructure_DWW_Mainline_Connection_Points_Wyes.dwg	SPU	Mainlines, connection points	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-SEWR-MAIN-WYE
DWW_Infrastructure_DWW_Mainline_End_Points.dwg	SPU	Mainline, end points	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwglayer: E-SCL-SEWR-MAIN-ENDP
DWW_Infrastructure_DWW_Repairs.dwg	SPU	DWW repairs	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-SEWR-MAIN-REPR
DWW_Infrastructure_DWW_Side_Sewers_and_Laterals.dwg	SPU	Side Sewers	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-SEWR-MAIN-LATR
DWW_Infrastructure_DWW_Side_Sewer_and_Lateral_Points.dwg	SPU	Side Sewer Lateral Points	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-SEWR-MAIN-LATR-PNTS

Received File Name	Agency	File Description	Date Received	Received File Format	Converted File Format	File Notes	Created xref Name
DWW_Infrastructure_Parcels.dwg	SPU	Parcels	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-PRCL
Project_Area.dwg	SPU		04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-PROJ
Water_Appurtenances_Abandoned_Appurtenances.dwg	SPU	Abadoned	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-APRT-ABND
Water_Appurtenances_Appurtenances.dwg	SPU	Appurtenances	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-APRT
Water_Hydrants.dwg	SPU	Hydrants	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-WATR-HYDT
Water_Line_Features_Abandoned_Water_Lines.dwg	SPU	Abandoned Water Lines	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-WATR-ABND
Water_Line_Features_Water_Line_Features.dwg	SPU	Water Lines	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-WATR-FEAT
Water_Services_Citywide_Use.dwg	SPU	Water Services Citywide	04/18/19	dwg	---	---	xref: E_SPU_UTIL.dwg layer: E-SCL-SRVC-USE
Contours_2016_DWG.dwg	SPU	Topo/contours within project area	04/26/19	dwg	---	---	n/a; WSDOT Contours utilized
Sound Transit xref files, "E_ST_[…].dwg"							
U11_N14_RP.dwg	Sound Transit (via King County Metro)	Basefiles/dwgs for the ULink Tunnel under I-5 to Capitol Hill and DSTT Stub Tunnel	04/25/19	.dwg	n/a	Tunnel wall alignment from I5 SB and to the east to Cap Hill Station	N/A; not used (Outside Limits)
n086gs.dwg	Sound Transit		04/25/19	.dwg	n/a	Roadway/RoW boundaries	N/A; not used (Outside Limits)
N088GS.dwg	Sound Transit		04/25/19	.dwg	n/a	Roadway/RoW boundaries	N/A; not used (Outside Limits)
N089GS.dwg	Sound Transit		04/25/19	.dwg	n/a	Roadway/RoW boundaries	N/A; not used (Outside Limits)
N090gs.dwg	Sound Transit		04/25/19	.dwg	n/a	Roadway/RoW boundaries	N/A; not used (Outside Limits)
N092GS.dwg	Sound Transit		04/25/19	.dwg	n/a	Roadway/RoW boundaries	N/A; not used (Outside Limits)
n100gs.dwg	Sound Transit		04/25/19	.dwg	n/a	Roadway/RoW boundaries	N/A; not used (Outside Limits)
n105gs.dwg	Sound Transit		04/25/19	.dwg	n/a	Roadway/RoW boundaries	N/A; not used (Outside Limits)
U15_R03_CC.dwg	Sound Transit		04/25/19	.dwg	n/a	I-5 NB (and some SB) channelization	xref - E_ST_Chan_(Olive-Cherry)
U15_R05_RP.dwg	Sound Transit		04/25/19	.dwg	n/a	Builds on U11_N14_RP with some add'l info	xref - E_ST_Chan_(Olive-Cherry)
U15_R05_SP.dwg	Sound Transit		04/25/19	.dwg	n/a	Tunnel launch pit limits with pile locations (coord shift req'd)	N/A; not used (Outside Limits)
U20_L10_MP.dwg	Sound Transit		04/25/19	.dwg	n/a	Track alignment from Cap Hill Station to UW Station	N/A; not used (Outside Limits)
U20_L10_SP.dwg	Sound Transit		04/25/19	.dwg	n/a	Tunnel Wall alignment from Cap Hill Station to UW Station	N/A; not used (Outside Limits)
U30_V05_SP.dwg	Sound Transit		04/25/19	.dwg	n/a	Tunnel launch pit at end of Stub tunnel and track alignment under I5 SB;	Combined into one Xref - Named E_ST_Struct_(Pine St Area)
U30_V05_ST_101_1.dwg	Sound Transit		04/25/19	.dwg	n/a	Tunnel launch pit at end of Stub tunnel	Combined into one Xref - Named E_ST_Struct_(Pine St Area)
U30_V05_ST_101_2.dwg	Sound Transit		04/25/19	.dwg	n/a	Pile locations for tunnel launch pit	Combined into one Xref - Named E_ST_Struct_(Pine St Area)
U60_L10_KA.dwg	Sound Transit		04/25/19	.dwg	n/a	Track alignment for entire Ulink	Xref - Named E_ST_Align
x297rx.dwg	Sound Transit		04/25/19	.dwg	n/a	Property/parcel boundaries	N/A; not used (Outside Limits)

Received File Name	Agency	File Description	Date Received	Received File Format	Converted File Format	File Notes	Created xref Name
X299rx.dwg	Sound Transit		04/25/19	.dwg	n/a	Property/parcel boundaries	N/A; not used (Outside Limits)
X300rx.dwg	Sound Transit		04/25/19	.dwg	n/a	Property/parcel boundaries	N/A; not used (Outside Limits)
X331rx.dwg	Sound Transit		04/25/19	.dwg	n/a	Property/parcel boundaries	N/A; not used (Outside Limits)
X333bg.dwg	Sound Transit		04/25/19	.dwg	n/a	building outlines	N/A; not used (Outside Limits)
X333cn.dwg	Sound Transit		04/25/19	.dwg	n/a	Contours	N/A; not used (Outside Limits)
X333GR.dwg	Sound Transit		04/25/19	.dwg	n/a	not sure what these points are for?	N/A; not used (Outside Limits)
x333gs.dwg	Sound Transit		04/25/19	.dwg	n/a	Roadway/RoW boundaries	N/A; not used (Outside Limits)
X333rx.dwg	Sound Transit		04/25/19	.dwg	n/a	Property/parcel boundaries	N/A; not used (Outside Limits)
X333sf.dwg	Sound Transit		04/25/19	.dwg	n/a	surface features	N/A; not used (Outside Limits)
X333ut.dwg	Sound Transit		04/25/19	.dwg	n/a	utilities	N/A; not used (Outside Limits)
X333vg.dwg	Sound Transit		04/25/19	.dwg	n/a	vegetation	N/A; not used (Outside Limits)
x334gs.dwg	Sound Transit		04/25/19	.dwg	n/a	Roadway/RoW boundaries	Combined into one Xref - Named E_ST_Parcels_(X334-X344-X346)
X334rx.dwg	Sound Transit		04/25/19	.dwg	n/a	Property/parcel boundaries	Combined into one Xref - Named E_ST_Parcels_(X334-X344-X346)
x339gs.dwg	Sound Transit		04/25/19	.dwg	n/a	Roadway/RoW boundaries	N/A; not used (Outside Limits)
X341rx.dwg	Sound Transit		04/25/19	.dwg	n/a	Property/parcel boundaries	N/A; not used (Outside Limits)
X343cn.dwg	Sound Transit		04/25/19	.dwg	n/a	Contours	N/A; not used (Outside Limits)
X343GR.dwg	Sound Transit		04/25/19	.dwg	n/a	not sure what these points are for?	N/A; not used (Outside Limits)
x343gs.dwg	Sound Transit		04/25/19	.dwg	n/a	Roadway/RoW boundaries	N/A; not used (Outside Limits)
X343RX.dwg	Sound Transit		04/25/19	.dwg	n/a	Property/parcel boundaries	N/A; not used (Outside Limits)
X343sf.dwg	Sound Transit		04/25/19	.dwg	n/a	surface features	N/A; not used (Outside Limits)
X343UT.dwg	Sound Transit		04/25/19	.dwg	n/a	utilities	N/A; not used (Outside Limits)
X344GR.dwg	Sound Transit		04/25/19	.dwg	n/a	not sure what these points are for?	Combined into one Xref - Named E_ST_Parcels_(X334-X344-X346)
x344gs.dwg	Sound Transit		04/25/19	.dwg	n/a	Roadway/RoW boundaries	Combined into one Xref - Named E_ST_Parcels_(X334-X344-X346)
X344RX.dwg	Sound Transit		04/25/19	.dwg	n/a	Property/parcel boundaries	Combined into one Xref - Named E_ST_Parcels_(X334-X344-X346)
x344sf.dwg	Sound Transit		04/25/19	.dwg	n/a	surface features	Xref - Named E_ST_X344SF-SurfaceFeatures
X344tm.dwg	Sound Transit		04/25/19	.dwg	n/a	stub tunnel outline	Xref - Named E_ST_X344TM-Telecomm
X344tt.dwg	Sound Transit		04/25/19	.dwg	n/a	stub tunnel systems	Xref - (Over lap area inE_ST_X344TM-Telecomm (needed keep separate to hard to combineE_ST_X344TT-Telecomm
x344ut.dwg	Sound Transit		04/25/19	.dwg	n/a	utilities	Xref - Named E_ST_X344UT-Utilties
x345gs.dwg	Sound Transit		04/25/19	.dwg	n/a	Roadway/RoW boundaries	N/A; not used (Outside Limits)
X345rx.dwg	Sound Transit		04/25/19	.dwg	n/a	Property/parcel boundaries	N/A; not used (Outside Limits)
X346RX.dwg	Sound Transit		04/25/19	.dwg	n/a	Property/parcel boundaries	Combined into one Xref - Named E_ST_Parcels_(X334-X344-X346)
X346SF.dwg	Sound Transit		04/25/19	.dwg	n/a	surface features	N/A; not used (Outside Limits)

Received File Name	Agency	File Description	Date Received	Received File Format	Converted File Format	File Notes	Created xref Name
WSCC/Pine Street Group xref files, "E_WSCCA_[...].dwg"							
XDES_Sewer.dwg	WSCC/ Pine Street Group	Future Addition basefile - Facility Sewer lines	05/23/19	.dwg	n/a	Sewer lines for the WSCC Addition	E_WSCCA_UTIL.dwg layer: WSCCA_Sewer
XDES_Storm.dwg	WSCC/ Pine Street Group	Future Addition basefile - Facility Storm lines	05/23/19	.dwg	n/a	Storm lines for the WSCC Addition	E_WSCCA_UTIL.dwg layer: WSCCA_Storm
XDES_Site.dwg	WSCC/ Pine Street Group	Future Addition basefile - existing site limits	05/23/19	.dwg	n/a	Limits of existing roadway, sidewalks, and parcel limits (prior to Addition Construction)	E_WSCCA_RW-RightofWay.dwg
XDES_SURV-ADD-2.dwg	WSCC/ Pine Street Group	Future Addition basefile - existing bus station shoring, Boren and Pine Street Foundations	05/23/19	.dwg	n/a	Existing and proposed structures within WSCCA area	E_WSCCA_STRC.dwg Block: "Convention Center Station Retaining Walls".
XDES_WSDOT_HOV.dwg	WSCC/ Pine Street Group	Future Addition basefile - survey of WSDOT HOV elements	05/23/19	.dwg	n/a	Survey of WSDOT HOV lane adjacent to WSCCA. Copy over WSDOT Air Lease Limits (with text) over to xref.	E_WSCCA_RW-RightofWay.dwg
XFBO_Survey I-5.dwg	WSCC/ Pine Street Group	Express Land On-ramp Survey	05/23/19	.dwg	n/a	Contours and limits of the WSDOT HOV lane adjacent to the WSCCA. NOTE: this dwg file indicates the following: "INTERSTATE-5 RAMP (CONDEMNED BY THE STATE OF WASHINGTON)".	n/a
XFBO_Survey KC Loop.dwg	WSCC/ Pine Street Group	Survey of Pike Street and Convention Place	05/23/19	.dwg	n/a	Survey/contours of Pike, 7th, 8th, and 9th roadways	n/a
XFBO_Survey WSCC.dwg	WSCC/ Pine Street Group	Add'l survey by WSCC	05/23/19	.dwg	n/a	Survey of WSCCA site; not used for master basemap since these existing site features will be replaced with the WSCCA construction.	n/a
XFBO_Survey_Pine-Olive Boren-Melrose.dwg	WSCC/ Pine Street Group	Future Addition basefile - survey of adjacent roadways	05/23/19	.dwg	n/a	Survey/contours of Melrose, Olive, Pine, and Boren roadways	n/a
XS-BASE-17.dwg	WSCC/ Pine Street Group	Future Addition basefile - roadway and parcel limits	05/23/19	.dwg	n/a	Limits of roadways and parcels; base for Surface files (below)	n/a
XS-SUR-02-2.dwg	WSCC/ Pine Street Group	Future Addition basefile - roadway surface file	05/23/19	.dwg	n/a	Roadway surface file	n/a
XS-SUR-09.dwg	WSCC/ Pine Street Group	Future Addition basefile - roadway surface file	05/23/19	.dwg	n/a	Roadway surface file	n/a
XS-SUR-11.dwg	WSCC/ Pine Street Group	Future Addition basefile - roadway surface file	05/23/19	.dwg	n/a	Roadway surface file	n/a
XS-SUR-17.dwg	WSCC/ Pine Street Group	Future Addition basefile - roadway surface file	05/23/19	.dwg	n/a	Roadway surface file	n/a
XS-SUR-17-2.dwg	WSCC/ Pine Street Group	Future Addition basefile - roadway surface file	05/23/19	.dwg	n/a	Roadway surface file	n/a
XS-SUR-24.dwg	WSCC/ Pine Street Group	Future Addition basefile - roadway surface file	05/23/19	.dwg	n/a	Roadway surface file	n/a
XS-SUR-3D.dwg	WSCC/ Pine Street Group	Future Addition basefile - 3D surface	05/23/19	.dwg	n/a	Survey outside of project limits - not used	n/a

Agency Data Requests – Information Request Matrix

Priority	Agency	Agency Point of Contact	Discipline (T - technical; U - Urban; S - Social Equity; E - Economics & Finance)	Required Response By	Document/Information Required	Information Requested (Description)	Notes (requested format of documents, limits of information req'd, etc.)	Additional Questions	Date Information Obtained	Description of Data Obtained
3	OPCD	Lyle Bicknell	T	Week of 4/1/2019	Aerial Information	Existing aerial maps can be used for identifying the major surface structures that will need to be avoided and for determining where the foundation construction acitivites can be carried out within City of Seattle right-of-way, with, or without, street closures.	Aerial Map		05/09/19	Obtained from OPCD via Flashdrive. Aerial Map stored here: https://seattle.pbid.com/I5LFStudy/WIP/Graphics%20Resources/Forms/AllItems.aspx
NA	WSCC (Original)	Ron Yorita	T	Week of 5/6/2019	As-built/Construction Plans for Existing Washington State Convention Center	Structural, Civil and Exterior Architectural Information on the Original Washington State Convention Center	pdf scans	NA	05/10/19	pdfs of the construction drawings (Volumes I, II, IV, V) and Geotechnical Report
NA	PSRC	NA	T/U/E/P	NA	NA	NA	NA		05/22/19	I-5 Corridor Partnership Call-To-Action Report (April 2019)
1	SDOT		T	Week of 4/1/2019	Subsurface Geotechnical Information	Existing borings and foundation design information from major private developments that have occurred immediately adjacent to I-5.	pdfs/reports		---	Comment from SDOT on 4/23/19: This is a question for WSDOT, not SDOT
1	SPU		T	Week of 4/22/2019	Wet Utilities	SPU to provide existing wet utility network (domestic water/fire suppression, anitary sewer, storm drainage and combined sewer)	GIS database/shapefile with metadata/ pdfs/reports		4/18/19 (emailed docs)	GIS feature classes and shapefiles; pipe length totals for DWU
2	SPU		T	Week of 4/22/2019	Private Utilities	If this information is not present on the City of Seattle GIS database/shapefile with metadatabase, we will assume that any conflicts can be identified later in the study, or in the future. These utilities may need to be located if conflicts cannot be avoided in a later phase of the design development of the project.	CAD basefiles		4/18/19 (emailed docs)	GIS feature classes and shapefiles; pipe length totals for DWU
3	SPU	Catherine Wendland - GIS Analyst (via Lyle)	T	Week of 4/22/2019	Surface Topography	Surface topography basefiles in the project area.	CAD basefiles		4/18/19 (emailed docs) 4/25/19 (contour dwg file emailed)	GIS feature classes and shapefiles; pipe length totals for DWU 2016 Contour dwg file of the project site. SPU indicated they could extend the limits of the info provided if necessary.
1	WSDOT	Rob Fellows	T	Week of 4/1/2019	I-5 Survey and Existing Utility Information	Actual survey information, tied to a datum, for at least the surface of I-5. Accurate information about the elevation of the I-5 roadway is important to verify vertical clearance requirements for the new lid strucuture. We'd also like information on existing utilities within the I-5 corridor.	CAD basefiles	4/17 - add'l request to receive alignment (*.alg), surface (*.dtm), and survey point files	4/2, 4/9, 4/18 - Rob F posted relevant files to PS site	

Priority	Agency	Agency Point of Contact	Discipline (T - technical; U - Urban; S - Social Equity; E - Economics & Finance)	Required Response By	Document/Information Required	Information Requested (Description)	Notes (requested format of documents, limits of information req'd, etc.)	Additional Questions	Date Information Obtained	Description of Data Obtained
1	Sound Transit	Alex Kreig (ST Planning)	T	Week of 4/1/2019	Basefiles/dwgs and geotechnical data for the ULink Tunnel under I-5 to Capitol Hill and DSTT Stub Tunnel	CAD basefiles (including utility information), contract drawings, and geotechnical information/reports requested for Contract U230 for the ULink LRT tunnel under I-5 and the Downtown Seattle Transit Tunnel stub tunnel. U230 - twin bore tunnels from Capitol hill to C510 Wall C510 - DSTT rail upgrade, including stub tunnel from DSTT to the area near the Paramount Theater U215 - contract which modified the I-5 wall to allow the U230 TBM to tunnel through the area without grinding into the walls.	CAD basefiles geotechnical information/reports		4/25/19 - emailed ftp link from KCM.	U230 basefiles/xrefs provided by Jeff Suter from King County Metro.
1	SCL		T	Week of 4/22/2019	Electric network in study area	SCL to provide existing electrical network in the vicinity of the project	CAD basefiles/pdfs		4/8/19 (emailed docs) 4/12/19 (emailed docs) 5/3/19 (emailed docs) 5/9/19 (emailed docs)	pdfs and basefiles of SCL networks in project area. 5/9 - pdf of a future 3rd transmission line to add redundancy and reliability (installed 2022); request to consider this during the evaluation
3	WSDOT	Rob Fellows	T	Week of 4/1/2019	As-built/Construction Plans for Existing I-5 along Downtown Seattle	Of particular interest are the walls that were constructed in order construct I-5. Confirm whether the uphill wall (east side of I-5) is secant pile construction and that tiebacks were not used. Information about the foundations for the bridges crossing I-5 will be instructive.	pdfs/reports	pdfs of as-builts; did not include the WSCC lid as-builts.	4/9/19 - WSP staff collected at WSDOT offices	pdfs of the as-builts of the bridges within the project area.
2	Sound Transit	Alex Kreig (ST Planning)	T	Week of 4/1/2019	Subsurface Geotechnical Information	Existing borings and foundation design information from ST for the I-5 Lid study area	pdfs/reports		5/13/19 - posted to Sharepoint	Geotechnical data reports for C510, C215, and U230

Priority	Agency	Agency Point of Contact	Discipline (T - technical; U - Urban; S - Social Equity; E - Economics & Finance)	Required Response By	Document/Information Required	Information Requested (Description)	Notes (requested format of documents, limits of information req'd, etc.)	Additional Questions	Date Information Obtained	Description of Data Obtained
6	WSDOT	Rob Fellows/Susan Everett	T	Week of 4/1/2019	WSDOT Design Criteria	Critical design criteria for WSDOT facility, including the following topics: • minimum clearances that the lid will need to adhere to (clear height in I-5, horizontal clearances from existing piers, foundations, walls, etc) • Can we touch or load on existing WSDOT improvements if we deem that we are negatively impacting the performance of that improvement (footings, secant pile walls, etc)? • With respect to constructability, what are we allowed to do and what are we restricted from doing (e.g. temporarily lane closures and closure windows)? • What is working well within this corridor that we need to make sure to maintain? • What are issues within the corridor that you are hoping this project might address?	pdfs/reports/agency input		5/31/19 - email from Rob F containing comments from Susan E	Comments from Susan: • Assumption for landscaping loads of 5 feet of soil and trees at 140 pcf is low. Landscape architects want 6' of soil at about 200 pcf. • Tunnels (lids) need back up power sources. Connections to separate substations with a transfer switch between the two substations is one concept. Generators are another concept. Need a small structure for the generator or switching equipment in either case. • Mechanical ventilation will be required with the new NFPA standard. • AHJ is WSDOT for I_5 and the structure over I-5 . SFD is AHJ for housing and parks on the structure • Assume there will be a separate SCADA system for the tunnel on the SICE platform. IT will be tied into the Shoreline SICE consoles. That is the primary control center. The secondary control center could be at the SR 99 NOB or I-90 tunnel. • Structural survivability – assume 1 " layer of promat on all interior concrete surfaces. • Assume there is mechanical ventilation any time there is FFSF .
4	WSDOT	Rob Fellows	T	Week of 4/22/2019	Future Construction Plans for Reconstructing I-5	Design information/documentation on WSDOT plans for reconstructing, or rehabilitating, I-5 in the future.	pdfs/reports/agency input		5/7/19 - WSDOT posted spreadsheet	Spreadsheet contains all projects in the study area assumed funded in WSDOTs' 10 year plan. Doesn't list projectr costs, and timelines may change if funding assumptions or bid prices change.

Priority	Agency	Agency Point of Contact	Discipline (T - technical; U - Urban; S - Social Equity; E - Economics & Finance)	Required Response By	Document/Information Required	Information Requested (Description)	Notes (requested format of documents, limits of information req'd, etc.)	Additional Questions	Date Information Obtained	Description of Data Obtained
2	WSDOT	Rob Fellows	T	Week of 4/1/2019	Subsurface Geotechnical Information	Existing borings and foundation design information from WSDOT for the I-5 Lid Study area	pdfs/reports		6/24/2019 - WSDOT Posted numerous geotechnical pdf documents	WSDOT provided 140 geotechnical files that cover soil information within the project area. Geotechnical documents provided by WSDOT include the following types of files that cover the project area: • boring logs • consultant reports • pile data
2	OPCD		T	Week of 4/1/2019	GIS Dataset	• Boundary information: Rights of Way, parcel information, easements	CAD basefiles geotechnical information/reports			
1	Seattle Fire Department		T	Week of 5/27/2019	Fire department design criteria	Fire truck loading criteria, current fire truck turning templates, and fire hydrant spacing requirements for residential, commercial, institutional zones	Excel (CSV or XLS)/email for loading criteria and hydrant spacing; PDF/CAD figures or detailed list for turning template criteria			
3	OPCD	Lyle Bicknell	T	Week of 4/1/2019	Aerial Information	Existing aerial maps can be used for identifying the major surface structures that will need to be avoided and for determining where the foundation construction acitivites can be carried out within City of Seattle right-of-way, with, or without, street closures.	Aerial Map		05/09/19	Obtained from OPCD via Flashdrive. Aerial Map stored here: https://seattle.pbid.com/I5LFStudy/WIP/Graphics%20Resources/Forms/AllItems.aspx
NA	WSCC (Original)	Ron Yorita	T	Week of 5/6/2019	As-built/Construction Plans for Existing Washington State Convention Center	Structural, Civil and Exterior Architectural Information on the Original Washington State Convention Center	pdf scans	NA	05/10/19	pdfs of the construction drawings (Volumes I, II, IV, V) and Geotechnical Report
NA	PSRC	NA	T/U/E/P	NA	NA	NA	NA		05/22/19	I-5 Corridor Partnership Call-To-Action Report (April 2019)

Appendix B-3 WSDOT and ST As-Builts: Processed Structures Components to xref

WSDOT Structures/Bridges within Project Area

Bridge Number	Structure Identification Number (for Bridges) Contract Number (for Walls)	Location	Year Contructed	Map on Page in WSDOT Bridge List (M23-09.09, Aug 2018)	Description on Page in WSDOT Bridge List (M23-09.09, Aug 2018)
I-5 Mainline					
5/544	0007504E	I-5 overpass; Yesler Way		46	114
5/545E	0007110A	I-5 NB mainline viaduct from James St to Olive Way		46-49	114
5/545W	0007110B	I-5 SB mainline viaduct from Jefferson St to Columbia St		46	114
5/546	0007110C	I-5 overpass at Madison St		46, 47	114
5/547	0007110D	I-5 overpass at Spring St		47	114
5/545N-W	0007110H	I-5 NB Exit ramp (Exit 165) for Seneca St		46, 47	114
5/548PS	0009839A	I-5 under N. Park Plaza/S-Col Ramp N under plaza		47	114
5/548	0007110E	I-5 overpass at Seneca St		47	114
5/548PN	0009668A	I-5 under S. Park Plaza/Cherry N Ramp S under plaza/S-Col Ramp S under plaza		47	114
5/549E-N	0007409B	I-5 NB on-ramp at University St		47	114
5/549CNC	000000PJ	Convention Center Lid		47	114
5/549	0007409A	I-5 overpass at 8th Ave - Trade Center		47, 48	114

Bridge Number	Structure Identification Number (for Bridges) Contract Number (for Walls)	Location	Year Contructed	Map on Page in WSDOT Bridge List (M23-09.09, Aug 2018)	Description on Page in WSDOT Bridge List (M23-09.09, Aug 2018)
Northbound Collector-Distributor					
5/545NCD	0007110F	I-5 NB (NBCD) viaduct from James St to Marion St		46	114
Southbound Collector-Distributor					
5/545SCD	0007110G	I-5 SB (SBCD) viaduct; James Exit Ramp		46	114
Northbound Collector-Distributor to 7th Ave/Madison St					
5/545N-E	0007110I	I-5 NB (NBCD) Madison Exit Ramp		46	114
Additional Ramps and Structures					
5/545R	0007110K	I-5 Reversible lanes ramp from James St to Columbia St		46	129
5/546REN Tunnel	0007110L	5th Ave Exp Tunnel; Express Lanes on-ramp from Cherry/Columbia St		46	129
5/547E-S	0007110J	I-5 SB on-ramp at Spring St over SBCD		47	115
5/548PW	0009839B	S-Col Ramp under W Park Plaza		47	115
5/550	0007409C	I-5 overpass at Pike St		48	115
5/551	0007409D	I-5 overpass at Boren St and Pine St		48	115
5/552	0006635A	I-5 overpass at Olive Way		48	115
5/553R Tunnel	0006635D	Express Lanes tunnel transition from under I-5 NB and to 5/566W viaduct (at Denny Way)		49	115
5/553	0006635B	I-5 overpass at Denny Way		48	115
5/553 E-S	0006635C	Yale St Ramp over Rev Ramp		49	116

Bridge Number	Structure Identification Number (for Bridges) Contract Number (for Walls)	Location	Year Contructed	Map on Page in WSDOT Bridge List (M23-09.09, Aug 2018)	Description on Page in WSDOT Bridge List (M23-09.09, Aug 2018)
5/553REN	0006635E	Reversible Lanes under utility bridge		49	130
5/566W	0006800A	Express Lanes viaduct starting at Denny Way on the south end		49	116
Retaining Walls					
Multiple, see "WSDOT & ST As-Builts: Processed Structures Components to Xref" for more information on retaining walls		Retaining Walls on East and West edges of I-5 along Downtown from Madison to Denny		---	---

Tracking Sheet

Missing Structures Identification									CAD Input Record		QC Record	
Item Num	PDF Region	Bridge	PDF Link	PDF Page #	Component	Time	Name	Notes:	Time	Name	Time	Name
1	1 & 2	5_545E	Click	37,96, 101	Buried Foundation	4/25/2019	TMP	Pier 16-27	4/26/2019	JL	5/10/2019	TMP
2	1 & 2	5_545E	Click	112	Rev_Wall W-14	4/26/2019	TMP	Use Region PDF for location	4/26/2019	JL	5/14/2019	TMP
3	1 & 2	5_545E	Click	134	Rev_Wall W-16	4/26/2019	TMP	Use Region PDF for location	4/29/2019	JL	5/14/2019	TMP
4	2 & 3	5_545E	Click	115	Wall W-18	4/26/2019	TMP	Use Region PDF for location	4/29/2019	JL	5/14/2019	TMP
5	1	5_545E	Click	103, 104	Wall W-11	4/29/2019	TMP	Use Region PDF for location	4/29/2019	JL	5/14/2019	TMP
6	1	5_545E	Click	132	Wall W-15	4/29/2019	TMP	Use Region PDF for location	4/29/2019	JL	5/14/2019	TMP
7	1	5_546	Click	11	Buried Foundation	4/29/2019	TMP	Piers 1-4 foundations	4/30/2019	JL	5/10/2019	TMP
8	4	5_549	Click	18	Columns and Buried Foundation	5/3/2019	JWC	Piers 1-10 foundations	5/6/2019	LC	5/20/2019	JWC
9	4	5_549 E-N	Click	20 (pier 1), 21 (Piers 2&3), 22 (4, 5, 6, 7)	Columns and Buried Foundation	5/3/2019	JWC	Piers 1-7 foundations	5/7/2019	LC	5/20/2019	JWC
10	5	5_550	Click	15, 17	Columns and Buried Foundation	5/3/2019	JWC	Piers 1, 2, 3 foundations	5/7/2019	LC	5/17/2019	JWC
11	6 (1)	5_551	Click	25	Columns and Buried Foundation	5/3/2019	JWC	Piers 1-5 of two bridge structures	5/7/2019	LC	5/20/2019	JWC
12	6	5_552	Click	1, 5, 8	Buried Foundation	4/29/2019	JWC	Piers 1-4	5/3/2019	LC	5/17/2019	JWC
13	7	5_553	Click	9-13	Buried Foundation	4/29/2019	JWC	Piers 1-4	5/6/2019	LC	5/17/2019	JWC
14	7	5_553REN	Click	14	Abutment/Retaining Wall Footing	4/29/2019	JWC	Piers 1-2 Walls	5/7/2019	LC	5/17/2019	JWC
15	7	5_553ES	Click	16-18	Abutment/Retaining Wall Footing	4/29/2019	JWC	Piers 1-2 Walls	5/7/2019	LC	5/17/2019	JWC
16	2	5_547ES	Click	9	Buried Foundation	4/29/2019	TMP	Pier 1-4	4/30/2019	JL	5/10/2019	TMP
17	2	5_547	Click	9, 14	Buried Foundation	4/29/2019	TMP	Pier 1-4	4/30/2019	JL	5/10/2019	TMP
18	1,2,3	5_545NW	Click	18	Buried Foundation	4/29/2019	TMP	Pier 17-abt	4/30/2019	JL	5/13/2019	TMP
19	6, 7	6635	Click	79	Wall W-1 Footing	4/29/2019	JWC	See page 25 & Region PDF for location	5/10/2019	LC	5/17/2019	JWC
20	7	6635	Click	83	Wall W-2 Footing	4/29/2019	JWC	See Page 26 & Region PDF for location	5/10/2019	LC	5/17/2019	JWC
21	7	6635	Click	Zone 1 - 98, Zone 2 - 91, Zone 3 - 89	Wall W-3 Footing	4/29/2019	JWC	See Page 23-24 & Region PDF for location	5/10/2019	LC	5/17/2019	JWC
22	7	6635	Click	103-104	Wall W-4 Footing	4/29/2019	JWC	See page 25 & Region PDF for location	5/10/2019	LC	5/17/2019	JWC
23	7	6635	Click	106, 107	Wall W-5 Footing	4/29/2019	JWC	See page 25 & Region PDF for location	5/10/2019	LC	5/17/2019	JWC
24	7	6635	Click	108	Wall W-6 Footing	4/29/2019	JWC	See Page 23-24 & Region PDF for location NOTE - no footing plan view provided, see notes on pdf page to create the footing outlines along the wall limits	5/10/2019	LC	5/17/2019	JWC
26	7	6635	Click	126	Cylinder Piles Wall in front of W-6, ~~W-7~~	4/29/2019	JWC	See Page 23-24 & Region PDF for location	5/11/2019	LC	5/17/2019	JWC
30	7	6635	Click	135	Wall W-11 Footing	5/3/2019	JWC	See Page 25 for location; 34' long wall; Sheet D-4 for type 2 retaining wall details	5/10/2019	LC	5/20/2019	JWC
32	2	5_548PW	Click	4, 5	Buried Foundation	5/3/2019	TMP	Piles punched through W-17 and W-18 for new footings	5/7/2019	JL	5/13/2019	TMP
33	3	5_548	Click	10, 17	Buried Foundation	5/3/2019	TMP		5/8/2019	LC	5/13/2019	TMP

Missing Structures Identification									CAD Input Record		QC Record	
Item Num	PDF Region	Bridge	PDF Link	PDF Page #	Component	Time	Name	Notes:	Time	Name	Time	Name
34	2, 3	5_545E	Click	129	Wall W-17	5/3/2019	TMP	5_548PW punches piles through footing.	5/8/2019	LC	5/14/2019	TMP
35	3	5_548PS	Click	3, 4	Footings & North Lid	5/3/2019	TMP		5/8/2019	JL	5/13/2019	TMP
36	1	5_545E	Click	106	Wall W-12	5/6/2019	TMP		5/8/2019	LC	5/14/2019	TMP
37	1	5_545E	Click	107	Wall W-13	5/6/2019	TMP		5/8/2019	LC	5/14/2019	TMP
38	3	5_545E	Click	112	Wall W-19	5/6/2019	TMP	Retaining Wall	5/9/2019	LC	5/14/2019	TMP
39	3	5_545E	Click	131	Wall W-19	5/6/2019	TMP	Cylinder walls	5/9/2019	LC	5/14/2019	TMP
40	3	5_545E	Click	136	Wall W-20	5/6/2019	TMP		5/9/2019	LC	5/14/2019	TMP
41	3	5_545E	Click	137	Wall W-21	5/6/2019	TMP		5/9/2019	LC	5/14/2019	TMP
42	1, 2, 3	5_545E	Click	123-126	Wall W-26	5/6/2019	TMP		5/9/2019	LC	5/14/2019	TMP
43	4	5_545E	Click	153	Wall W-27	5/6/2019	TMP		5/7/2019	JL	5/14/2019	TMP
44	4, 5	5_545E	Click	156, 157	Wall W-29	5/8/2019	TMP		5/13/2019	JL	5/14/2019	TMP
45	4	7409	Click	95	Wall W-28 Footing	5/8/2019	JWC	See Page 30 & Region PDF for location	5/17/2019	LC	5/17/2019	JWC
46	4	7409	Click	use xref "S344sf" (see notes) & 98, 100-109	Wall W-30 (1) Pile Wall	5/8/2019	JWC	Sound Transit xref "x344sf" provides pile/wall outlines of this wall from NB Pier 47 to 49, only. Use this file as a reference for these piles and to help lay the rest of the wall out. See Page 17 (with respect to W-30, W-37, W-38, W-47 and Bridge 5_550) & Region PDF for location	5/14/2019	LC	5/17/2019	JWC
47	4	7409	Click	112-113	Wall W-31 (1) Battered Pile Footing	5/8/2019		See Page 30-31 & Region PDF for location	5/14/2019	JL	5/20/2019	JWC
48	4	7409	Click	114	Wall W-32 (1) Footing	5/8/2019	JWC	See Page 30 & Region PDF for location	5/15/2019	JL	5/17/2019	JWC
49	5	7409	Click	115-116	Wall W-33 Battered Pile Footing/Spread Footing	5/8/2019	JWC	See Page 34 See Page 17 (with respect to W-33, W-36 and Bridge 5_550) & Region PDF for location	5/15/2019	JL	5/17/2019	JWC
50	5, 6(1)	7409	Click	117	Wall W-34 Footing	5/8/2019	JWC	See Region PDF for location	5/15/2019	JL	5/17/2019	JWC
51	5, 6(1)	7409	Click	118	Wall W-35 (1) Footing	5/8/2019	JWC	See Region PDF for location	5/15/2019	JL	5/20/2019	JWC
52	5, 6(1)	7409	Click	use xref "S344sf" (see notes) & '119-120	Wall W-36 Battered Pile Footing	5/8/2019	JWC	Sound Transit xref "x344sf" provides pile/wall outlines of this wall near Bridge 5_551. Use this file as a reference. A portion of the battered pile footing Wall W-36 was replaced by a drilled shaft wall. This is shown in the xref. See Page 34. See Page 17 (with respect to W-33, W-36 and Bridge 5_550) & Region PDF for location Conflict of Information Noted for WSDOT Wall W-36 – conflicting information on wall type and limits of wall type transitions. • Contract 7409 As-builts – wall structural sheets (Sheets 115-116) and the relevant cross-section details within the plan set show a battered pile supported concrete cantilever wall. However, the “Roadway Plan & Slope Indicator Locations” sheets (Sheets 34-35), show Wall W-36 as a tangent pile shaft wall in plan view. • ST’s U230 basefiles show the end of the wall (last 125’ of wall) as a battered pile supported wall, while the rest is shown as a tangent pile shaft wall. • Conclusion: Assumption for feasibility study: It is assumed that the structural sheets are correct and that the roadway plan sheets show an old iteration of wall type. The assumption is that ST’s review of these as-builts incorrectly utilized the tangent pile wall shown in the roadway plan	5/15/2019	JL	5/31/2019	JWC

Missing Structures Identification									CAD Input Record		QC Record	
Item Num	PDF Region	Bridge	PDF Link	PDF Page #	Component	Time	Name	Notes:	Time	Name	Time	Name
								sheets. Therefore, the feasibility study team will assume that this wall is a battered pile supported concrete cantilever wall along the entire wall limits. This assumption will need to be verified in future phases.				
53	5	7409	Click	121	Wall W-37 Pile Wall	5/8/2019	JWC	See Page 34. See Page 17 (with respect to W-30, W-37, W-38, W-47 and Bridge 5_550) & Region PDF for location	5/15/2019	LC	5/17/2019	JWC
54	5, 6(1)	7409	Click	use xref "S344sf" (see notes) & 123-126	Wall W-38 Pile Wall/Spread Footing	5/8/2019	JWC	Sound Transit xref "x344sf" provides pile/wall outlines of this wall near Bridge 5_551 (Piles 13 to 26, only). Use this file as a reference for these piles and to help lay the rest of the wall out. See Page 34-36 See Page 17 (with respect to W-30, W-37, W-38, W-47 and Bridge 5_550) & Region PDF for location	5/16/2019	JL	5/17/2019	JWC
55	5, 6(1)	7409	Click	128-130	Wall W-39 Footing	5/8/2019	JWC	See Page 35-38 for location with respect to I-5 SB piers; and Region PDF for location	5/15/2019	LC	5/17/2019	JWC
56	5, 6(1)	7409	Click	131	Wall W-40 Footing	5/8/2019	JWC	See Page 36 & Region PDF for location.	5/15/2019	LC	5/17/2019	JWC
57	5, 6(1)	7409	Click	132-133	Wall W-41 Footing	5/8/2019	JWC	See Page 36-37 & Region PDF for location.	5/15/2019	LC	5/17/2019	JWC
58	5, 6(1)	7409	Click	134	Wall W-42 Pile Wall	5/8/2019	JWC	See Page 36-37 & Region PDF for location. Conflict of Information Noted for WSDOT Wall W-42: • Contract 7409 As-builts – the wall structural sheet (Sheet 130) shows a smooth curve along the front face of the entire wall length. However, a review of Google Street View shows that at the end of the wall as it abuts with Pier No. 1 of Olive Way Undercrossing, there is a bend and a corner that was constructed in the wall that is not aligned with the as-built drawings. Reviewing Google Earth from 1990 reveals that this condition was present at that time as well. • Conclusion: It is assumed that the contractor placed the shafts and face of wall to a different alignment than the as-built drawings suggest. The face of wall survey line provided by WSDOT will be utilized for existing face of wall and the pile locations will be assumed based on consistent offsets and spacings provided on the as-built drawings.	5/17/2019	JL	5/31/2019	JWC
59	5, 6(1)	7409	Click	131	Wall W-43 Footing	5/8/2019	JWC	See Page 36 & Region PDF for location.	5/16/2019	LC	5/17/2019	JWC
60	5, 6(1)	7409	Click	135-136	Wall W-44 Pile Wall	5/8/2019	JWC	See Page 36 & Region PDF for location.	5/16/2019	LC	5/17/2019	JWC
61	5, 6(1)	7409	Click	39, 137	Wall W-45 Pile Wall and W-45 Bracing Frame	5/8/2019	JWC	See Page 37&38 & Region PDF for location.	5/16/2019	LC	5/17/2019	JWC
62	5, 6(1)	7409	Click	17 (pile outlines only)	Wall W-47 Pile Wall	5/8/2019	JWC	See Page 17 (with respect to W-30, W-37, W-38, W-47 and Bridge 5_550) & Region PDF for location	5/16/2019	LC	5/17/2019	JWC
63	6	6635	Click	138, 148-151	Wall W-30 (2) Footing	5/8/2019	JWC	See Page 22 & Region PDF for location	5/13/2019	LC	5/17/2019	JWC
64	7	6635	Click	139, 148-151	Wall W-31 (2) Footing	5/8/2019	JWC	See Page 23 & Region PDF for location	5/10/2019	LC	5/17/2019	JWC
65	7	6635	Click	141, 148-151	Wall W-32 (2) Footing	5/8/2019	JWC	See Page 23 & Region PDF for location	5/10/2019	LC	5/17/2019	JWC
66	7	6635	Click	146 & 165, 148-151	Wall W-35 (2) Footing	5/8/2019	JWC	See Page 22-23 & Region PDF for location	5/10/2019	LC	5/17/2019	JWC
67	All	5_545E	Click	272	Buried Foundation	5/9/2019	TMP	Pier 28-38. The bottom of columns are "pins" at the following piers (28,31,32,35). Construction problem if traditional demo methods are used. Assumed 30' pile length	5/10/2019	JL	5/13/2019	TMP
68	All	5_545E	Click	273	Buried Foundation	5/9/2019	TMP	Pier 39-58. The bottom of columns are "pins" at the following piers (39,42,43,46,47,50,51,54,55). Construction problem if traditional demo methods are used. Assumed 30' pile length	5/13/2019	JL	5/13/2019	TMP
69	1	5_545E	Click	99, 100	Wall W-9	5/10/2019	TMP		5/12/2019	LC	5/14/2019	TMP

Missing Structures Identification									CAD Input Record		QC Record	
Item Num	PDF Region	Bridge	PDF Link	PDF Page #	Component	Time	Name	Notes:	Time	Name	Time	Name
70	5	WSCC Lid	Click	14	WSCC Foundation	5/13/2019	JWC	see image snapshot on Page 14; New structure limits in blue	5/16/2019	JL	5/17/2019	JWC
71	5, 6(1)	ST Walls, tunnels and other structures	n/a	use xref "S344sf" for outlines of these walls	ST walls/structures	5/13/2019	JWC	Sound Transit xref "x344sf" provides pile/wall and tunnel outlines of various structures that are west of I-5 in the Pine/Pike area.	5/17/2019	JL	5/20/2019	JWC
72	7	5_545E	Click	312, 313	Buried Foundation	5/14/2019	TMP	Pier 59, Pier 60 (Pier 61 has missing info)	5/15/2019	LC		
73	6, 7	5_553R Tunnel	Click	1	Tunnel Extents	5/14/2019	TMP		5/16/2019	LC		
74	3	5_545E	Click	116	Wall W-22	5/15/2019	TMP		5/15/2019	JL		
75	6(1)	ST - SBE Pit	Click	1, 4	SBE Pit and Permanent Tiebacks	5/24/2019	JWC	Sound Transit xref "U15_R05_SP" provides pit wall and pile outlines; Page 1 shows location/labels for all ST tunnel pits; Page 4 of pdf shows limits of tie backs. Tiebacks are 57' long from outside face of pit wall.	5/28/2019	JL	5/31/2019	JWC
76	6(1)	ST - NBE Pit	Click	1, 8	NBE Pit and Permanent Tiebacks	5/24/2019	JWC	Sound Transit xref "U15_R05_SP" provides pit wall and pile outlines; Page 1 shows location/labels for all ST tunnel pits; Page 8 of pdf shows limits of tie backs. Tiebacks are 57' long from outside face of pit wall.	5/28/2019	JL	5/31/2019	JWC
77	6(1)	ST - SBW Pit	Click	1, 11	SBW (no perm tiebacks)	5/24/2019	JWC	Sound Transit xref "U15_R05_SP" provides pit wall and pile outlines; Page 1 shows location/labels for all ST tunnel pits.	5/28/2019	JL	5/31/2019	JWC
78	6(1)	ST - NBW Pit	Click	1, 14	NBW (no perm tiebacks)	5/24/2019	JWC	Sound Transit xref "U15_R05_SP" provides pit wall and pile outlines; Page 1 shows location/labels for all ST tunnel pits.	5/28/2019	JL	5/31/2019	JWC
79	6(1)	ST - Wall D	Click	1, 11	Wall D Piles and wall facing limits	5/24/2019	JWC	Sound Transit xref "x344sf" provides outline of Wall D; Page 1, 11 of pdf shows location of Wall D with respect to SBW Pit. Rename the block this wall is onto be "ST U215 - Exist Wall D".	5/28/2019	JL	5/31/2019	JWC
80	6(1)	ST U230 Bored Tunnel Walls	Click	1	Exterior Walls of Bored Tunnel	5/24/2019	JWC	Sound Transit xref "U30_V05_SP" provides the tunnel wall outline for only a portion of the tunnel under I-5. Please complete the rest of the tunnel walls within the project limits.	5/28/2019	JL	5/31/2019	JWC

Summary of Bridge and Structure Documents provided by WSDOT

Bridge #	Agency	File Name	File	Used?	Rationale	Lid Limits?	Constr. Limits?	Access Impacts?
5/544	WSDOT	_	_		_	No	No	No
		Inspection Reports	Folder/PDF	No	Not in Vicinity			
		0007504E_SIA.pdf	PDF	No	Not in Vicinity			
		ZA7504_Snapshot_Plans.pdf	PDF	No	Not in Vicinity			
		ZA7504-166002_Full_Set.pdf	PDF	Yes	Not in Vicinity			
5/545SCD						No	No	Yes
5/545W						No	No	Yes
5/545R						No	No	Yes
5/545E	WSDOT					Yes	Yes	Yes
		Inspection Reports	Folder/PDF	No	N/A for XREF			
		5_545E_SIA.pdf	PDF	No	N/A for XREF			
		000711A_Electrical_System_Upgrade.pdf	PDF	No	Not Structural			
		000711A_Expansion_Joint_Repair.pdf	PDF	No	N/A for use in XREF			
		000711A_Northbound_Downtown_Channelization.pdf	PDF	No	Not Structural			
		000711A_Seismic_Retrofit.pdf	PDF	No	N/A for use in XREF			
		AsBuilt_007110.pdf	PDF	Yes	Retaining Walls			
		AsBuilt_007110_part.pdf	PDF	No	Repeat Info			
		BridgePlans0007110A__2019_04_09.pdf	PDF	Yes	Retaining Walls & Buried Foundations			
5/545NCD						No	No	Yes
5/545N-E						No	No	No
5/546REN Tunnel						No	No	Yes

Bridge #	Agency	File Name	File	Used?	Rationale	Lid Limits?	Constr. Limits?	Access Impacts?
5/545N-W						Yes	Yes	Yes
		Inspection Reports	Folder/PDF	No	N/A for XREF			
		0007110H_SIA.pdf	PDF	No	N/A for XREF			
		0007110H_Snapshot.pdf	PDF	Yes	Foundations			
		AsBuilt_007110.pdf	PDF	No	No foundations			
		AsBuilt_007110_part.pdf	PDF	No	Repeat Info			
		Downtown Seattle Bridges Seismic Retrofit.pdf	PDF	No	N/A for use in XREF			
		SR5 Holgate to 8th Ave Vicinity Seismic Retrofit.pdf	PDF	No	N/A for use in XREF			
5/546						Yes	Yes	Yes
		Inspection Reports	Folder/PDF	No	N/A for XREF			
		0007110C_SIA.pdf	PDF	No	N/A for XREF			
		0007110C_Snapshot.pdf	PDF	Yes	Foundations			
		AsBuilt_007110.pdf	PDF	No	No foundations			
		AsBuilt_007110_part.pdf	PDF	No	Repeat Info			
5/547E-S						Yes	Yes	Yes
		InspectionReports0007110J__2019_04_09	Folder/PDF	No	N/A for XREF			
		0007110J_SIA.pdf	PDF	No	N/A for XREF			
		0007110J_Snapshot.pdf	PDF	Yes	Foundations			
		AsBuilt_007110.pdf	PDF	No	No foundations			
		AsBuilt_007110_part.pdf	PDF	No	Repeat Info			
		Interstate Ramp Resurvacing Dearborn to Ship Canal.pdf	PDF	No	Repeat Info			
		SR5 Holgate to 8th Ave Vicinity Seismic Retrofit.pdf	PDF	No	N/A for use in XREF			

Bridge #	Agency	File Name	File	Used?	Rationale	Lid Limits?	Constr. Limits?	Access Impacts?
5/547						Yes	Yes	Yes
		Inspection Reports	Folder/PDF	No	N/A for XREF			
		0007110D_SIA.pdf	PDF	No	N/A for XREF			
		0007110D_Snapshot.pdf	PDF	Yes	Foundations			
		AsBuilt_007110.pdf	PDF	No	No foundations			
		AsBuilt_007110_part.pdf	PDF	No	Repeat Info			
5/548PW						Yes	Yes	Yes
		InspectionReports0009839B__2019_04_09	Folder/PDF	No	N/A for XREF			
		0009839B_SIA.pdf	PDF	No	N/A for XREF			
		9839B_Snapshot.pdf	PDF	Yes	Foundations			
		Pedestrian Plaza Stage 2.pdf	PDF	Yes	Foundations check			
5/548PS						Yes	Yes	Yes
		Inspection Reports	Folder/PDF	No	N/A for XREF			
		0009839A_SIA.pdf	PDF	No	N/A for XREF			
		0009839A_Snapshot.pdf	PDF	No	Same info as 5/548PW			
		Pedestrian Plaza Stage 2.pdf	PDF	No	Same info as 5/548PW			
5/548						Yes	Yes	Yes
		InspectionReports0007110E__2019_04_09	Folder/PDF	No	N/A for XREF			
		0007110E_SIA.pdf	PDF	No	N/A for XREF			
		0007110E_Snapshot.pdf	PDF	Yes	Foundations			
		AsBuilt_007110.pdf	PDF	Yes	Foundations			
		AsBuilt_007110_part.pdf	PDF	No	Repeat Info			

Bridge #	Agency	File Name	File	Used?	Rationale	Lid Limits?	Constr. Limits?	Access Impacts?
5/548PN						Yes	Yes	Yes
		InspectionReports0009668A__2019_04_09	Folder/PDF	No	N/A for XREF			
		0009668A_SIA.pdf	PDF	No	N/A for XREF			
		0009668A_Snapshot.pdf	PDF	Yes	Fooings & North Lid Extents			
		Pedestrian Plaza Stage1.pdf	PDF	Yes	Fooings & North Lid Extents			
5/549						Yes	Yes	Yes
5/549E-N						Yes	Yes	Yes
5/549CNC						Yes	Yes	Yes
		InspectionReports000000PJ__2019_04_09	Folder/PDF	No	N/A for XREF			
		000000PJ_SIA.pdf	PDF	No	N/A for XREF			
		PJ_Snapshot.pdf	PDF	No	Illumination info only			
5/550						Yes	Yes	Yes
5/551						Yes	Yes	Yes
5/552						Yes	Yes	Yes
5/553R Tunnel						Yes	Yes	Yes
		InspectionReports0006635D__2019_04_09	Folder/PDF	No	N/A for XREF			
		0006635D_SIA.pdf	PDF	No	N/A for XREF			
		6635D_Snapshot.pdf	PDF	No	Panels, maintenance building foundations, but not used			
		AsBuilt_006635.pdf	PDF	No	Panels, maintenance building foundations, but not used			

Bridge #	Agency	File Name	File	Used?	Rationale	Lid Limits?	Constr. Limits?	Access Impacts?
		AsBuilt_006635_part.pdf	PDF	No	Repeat Info			
5/553 E-S						Yes	Yes	Yes
5/553REN						Yes	Yes	Yes
5/553						Yes	Yes	Yes
5/566W						No	No	Yes

I-5 Lid Feasibility Study

Appendix C

Diagrams of Lid Area Concepts

Prepared for:

Seattle
Office of Planning & Community Development

Prepared by:

WSP

OJB
Magnusson Klemencic Assoc.
EnviroIssues
Framework
HR&A Advisors
Shiels Obletz Johnsen

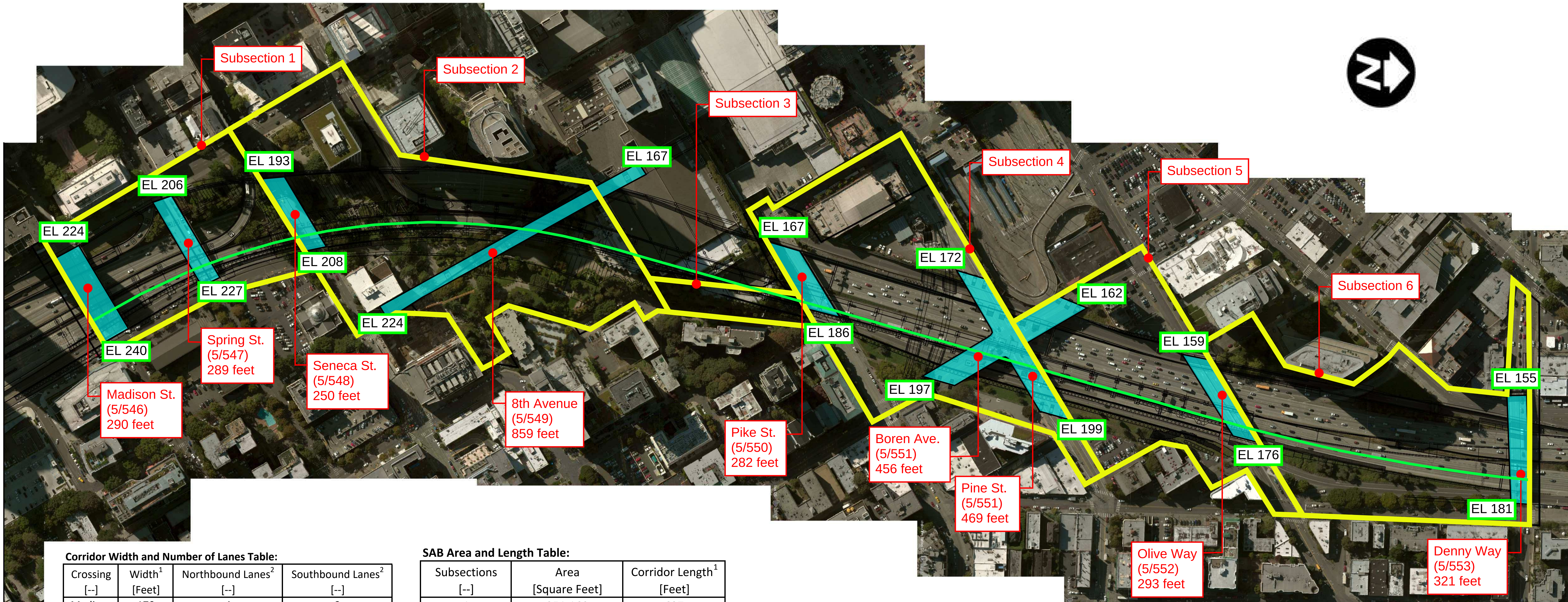
December 5, 2019

SAB Existing Features & Characterizations

Delimitation of Structural Assessment Boundary Sub-Areas

SAB Sub-Area [--]	Delimitation [--]
1	Madison Street to Seneca Street
2	Seneca Street, Freeway Park, and the Washington State Convention Center, to Pike Street
3	Pike Street to Olive Way
4	Olive Way to Denny Way

LEGEND:
- SAB Limits & Subsections
- I-5 Corridor Length



Corridor Width and Number of Lanes Table:

Crossing [--]	Width[1] [Feet]	Northbound Lanes[2] [--]	Southbound Lanes[2] [--]
Madison	170	4	3
Spring	160	3	3
Seneca	218	4	3
8th	184	4	4
Pike	178	3	5
Pine	161	4	5
Olive	167	4	5
Denny	168	4	5

Note:
1.) Width is measured perpendicular to the corridor at bridge crossing centerline from curb-to-curb
2.) Number of lanes does not include on-ramps, off-ramps, or reversible lanes.

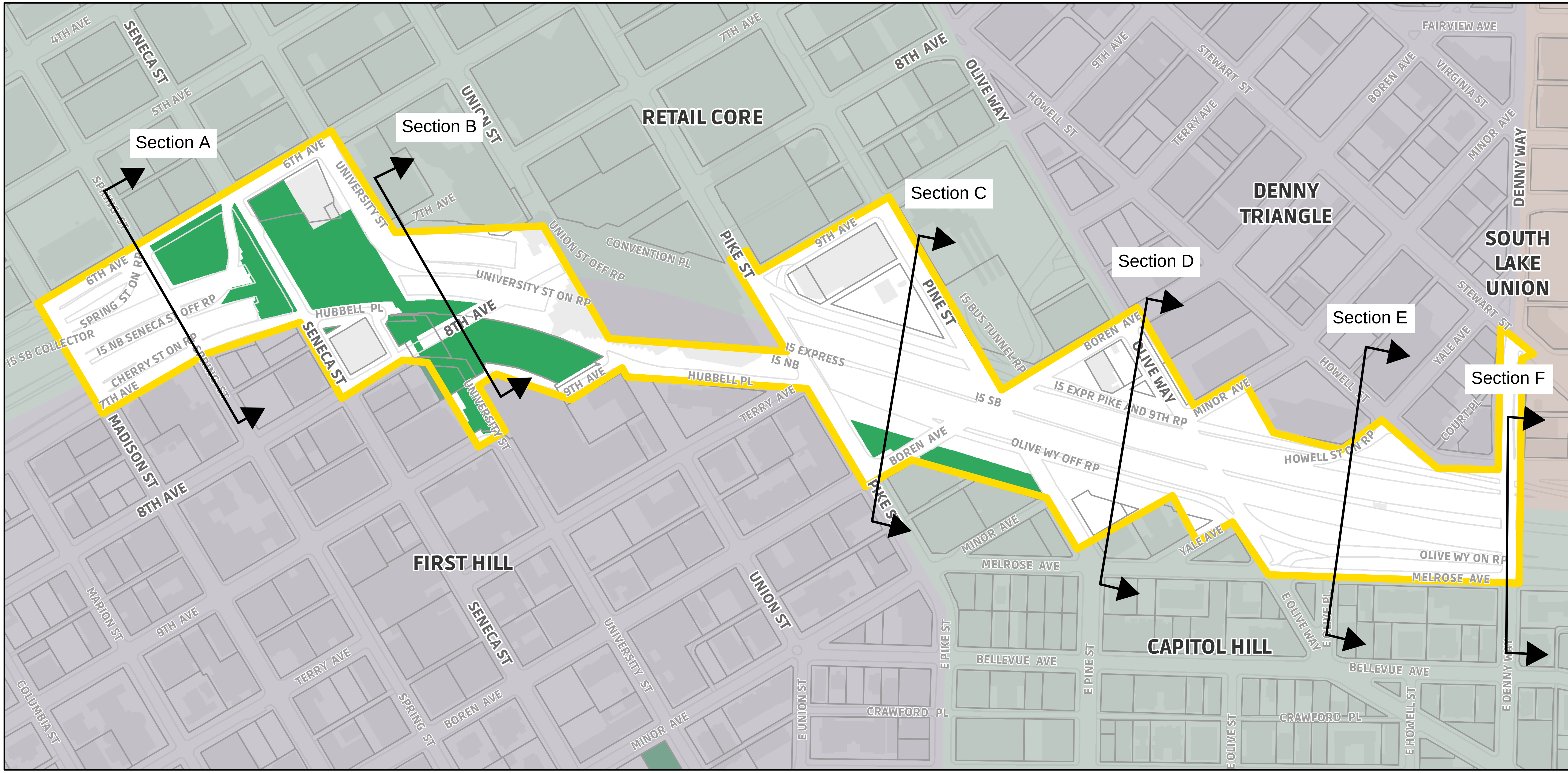
SAB Area and Length Table:

Subsections [--]	Area [Square Feet]	Corridor Length[1] [Feet]
1	251,160	637
2	503,140	985
3	38,830	494
4	397,970	710
5	267,310	628
6	356,590	806
∑	1,815,000	4,260

Note:
1.) Corridor length is measured along the center of I-5 Northbound lanes within the SAB defined limits.

NOTES:
1.) All bridge lengths shown in plan are measured from back to back of pavement seat
2.) All elevations shown in plan are at back of pavement seat

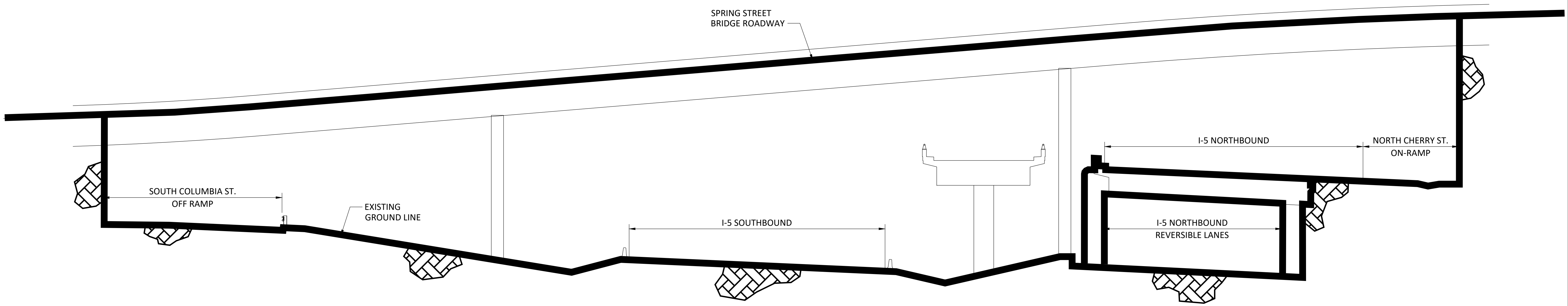
Structural Assessment Boundary (SAB)



Legend

Structural Assessment Boundary
Parcel Line
Roadway Pavement Edge
Parks and Open Space
Building Outlines

0 300 600 Feet



SECTION A

1" = 20' scale 10 0 10 20 feet

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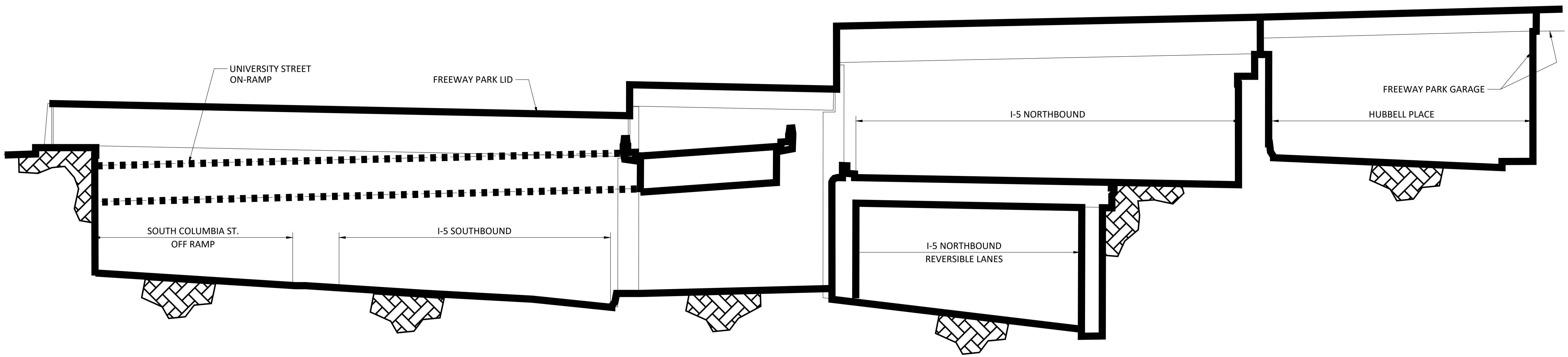

SECTION B

1" = 20' — scale: 10 0 10 20 feet

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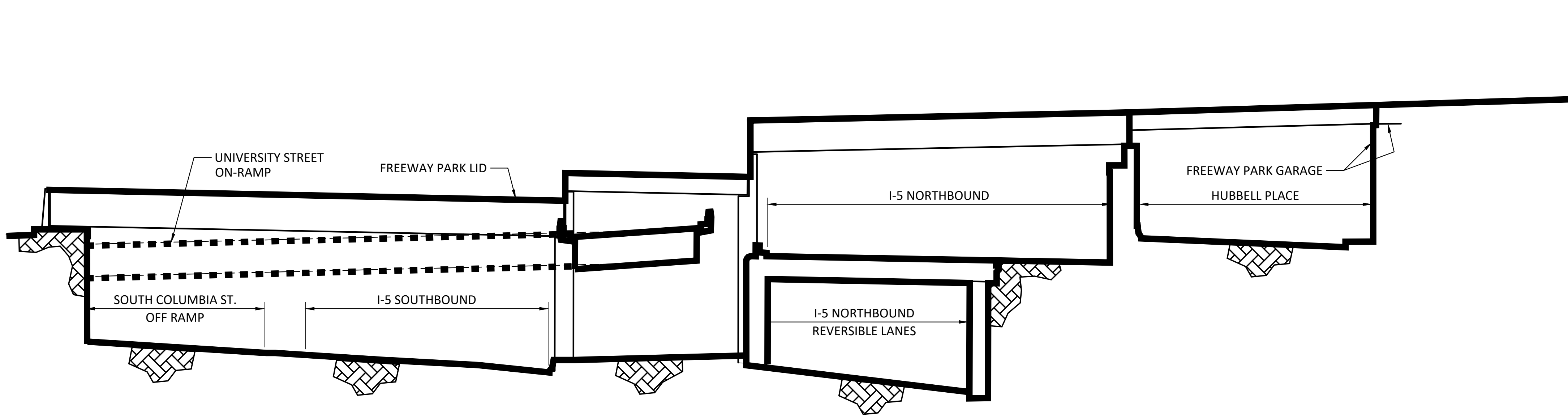

SECTION B

1" = 30' 30 0 30 60
scale feet

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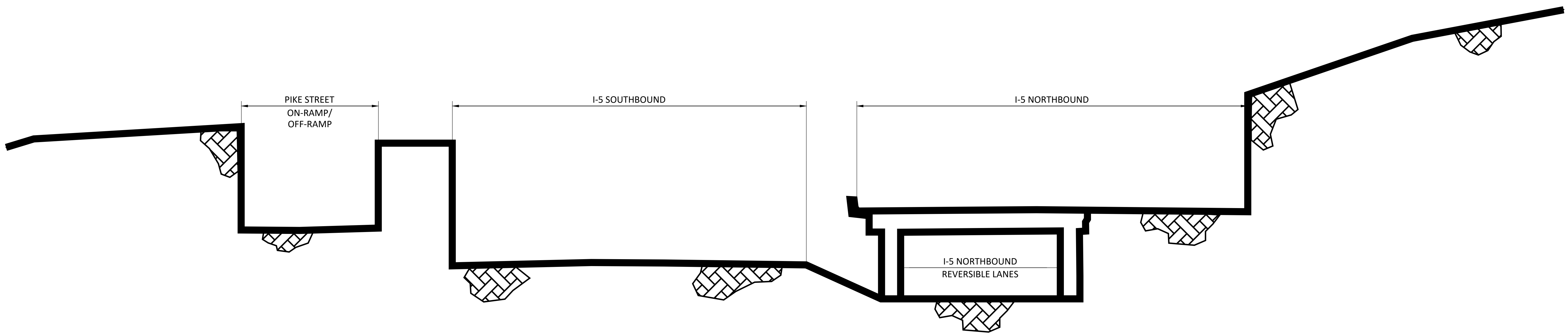

SECTION C

1" = 24'
12 0 12 24
scale feet

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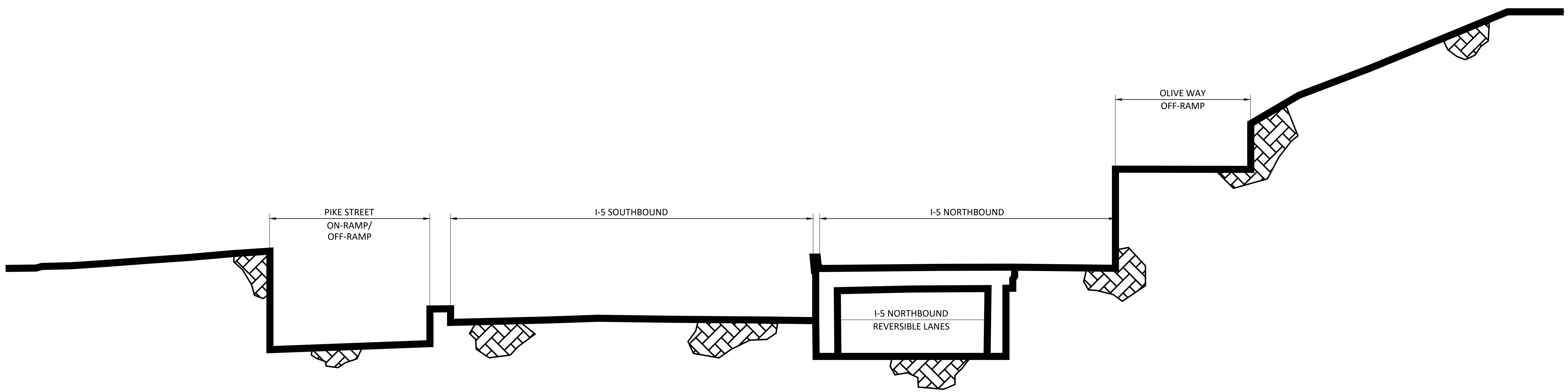
DESIGN BY ______
CHECK BY ______
PROJ MGR ______

DRAWING NO. ______
PROJECT NO. ______
DATE: ______
SHEET NO. ______



SECTION D

1" = 24' scale 12 0 12 24 feet

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DESIGN BY ______
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PROJ MGR ______

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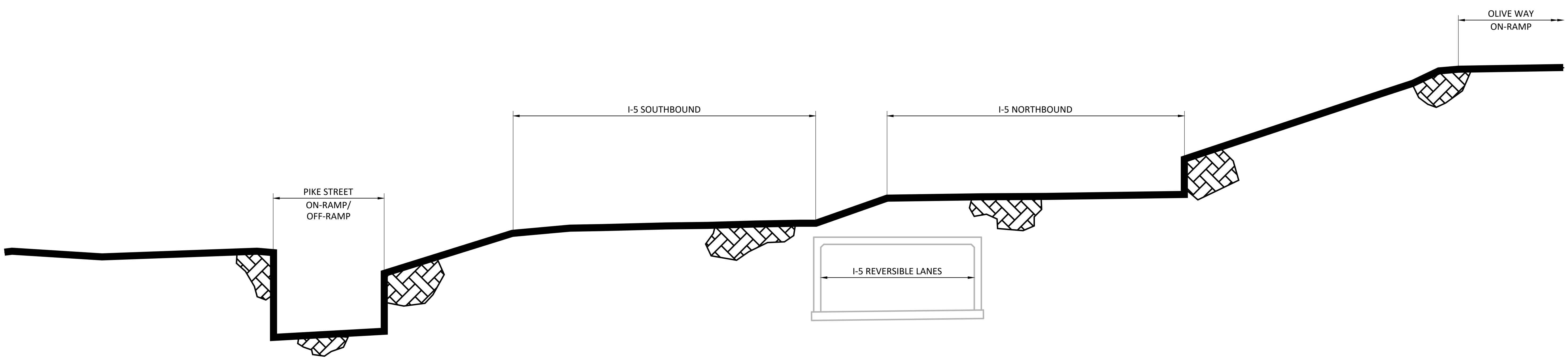
PROJECT NO. ______
DATE: ______
SHEET NO. ______



SECTION E

1" = 24' — scale: 12, 0, 12, 24 feet

Last Saved by: Childress on: Sep 25, 2019 10:15 AM File: Q:\FederalWay\2019\A19.0175\00\CADD\Working\LWC\2019-09-25_Sections.dwg

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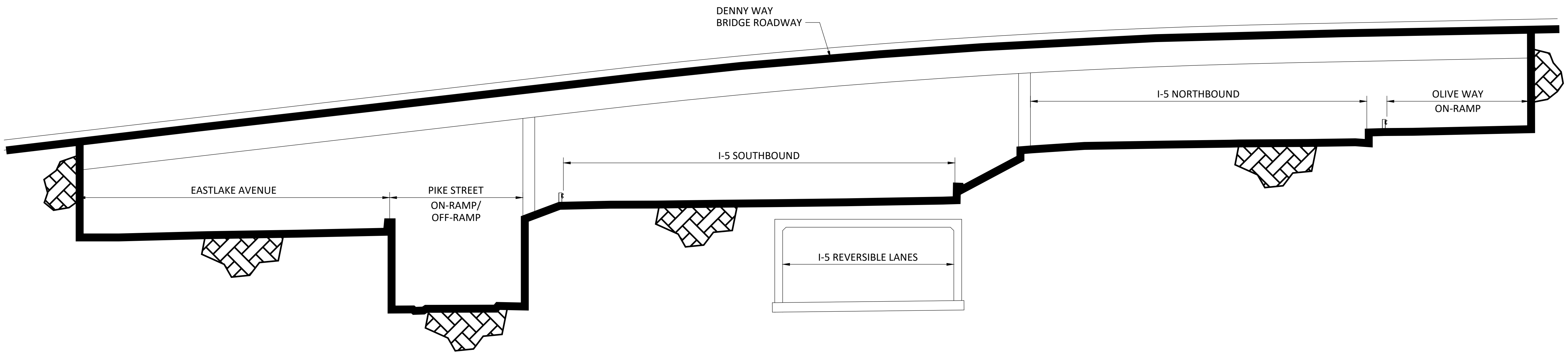
PROJECT NO. ______
DATE: ______
SHEET NO. ______



SECTION F

1" = 24'
12 0 12 24
scale feet

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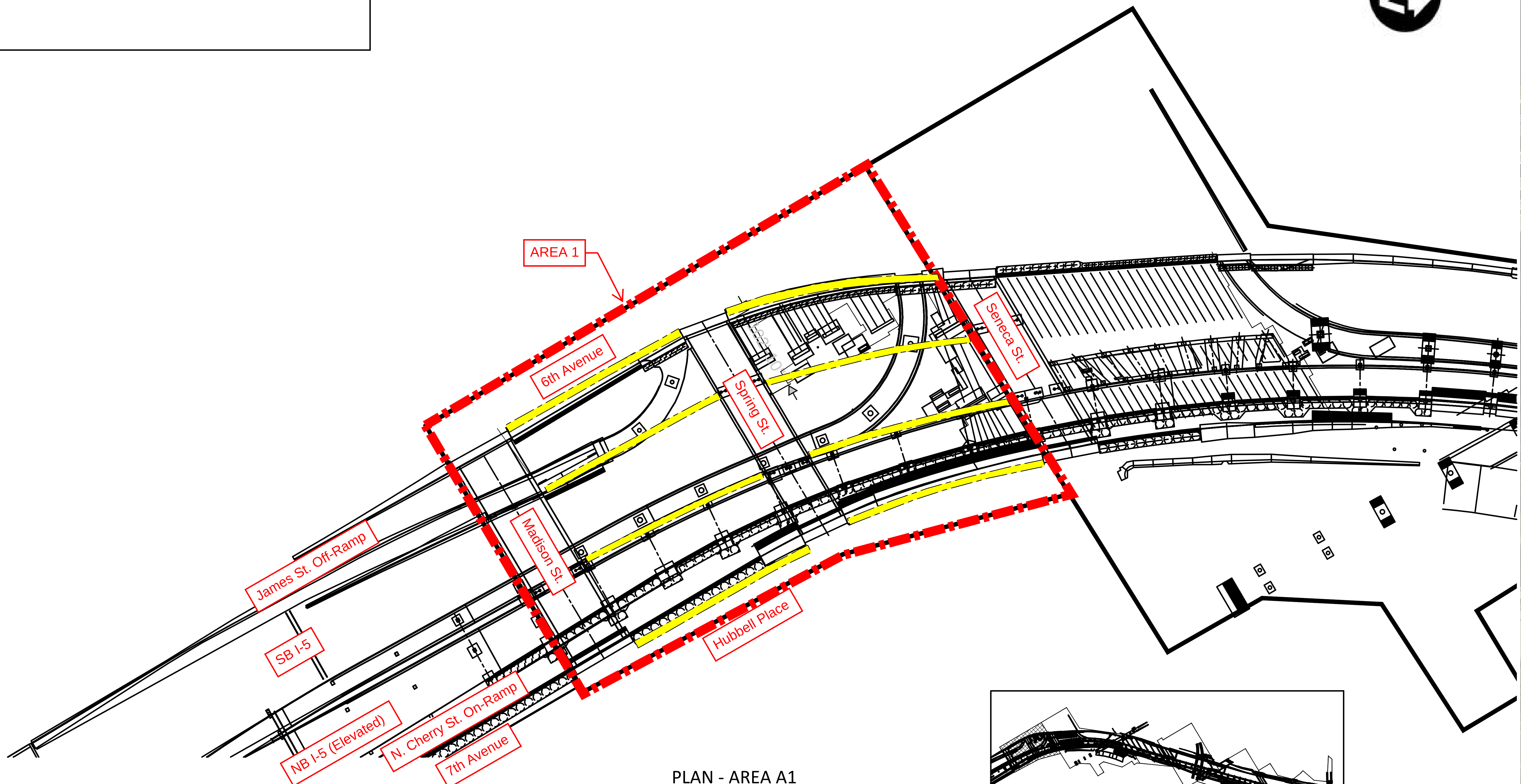
PROJ MGR

DRAWING NO.
PROJECT NO.
DATE:
SHEET NO.

LEGEND:

Potential Pier Locations



PLAN - AREA A1

1" = 120' 60 0 60 120 scale feet

KEYPLAN

PRELIMINARY

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CITY OF SEATTLE
I-5 LID FEASIBILITY STUDY

AREA 1 PLAN

DRAWING NO.
PROJECT NO.
DATE:
SHEET NO.

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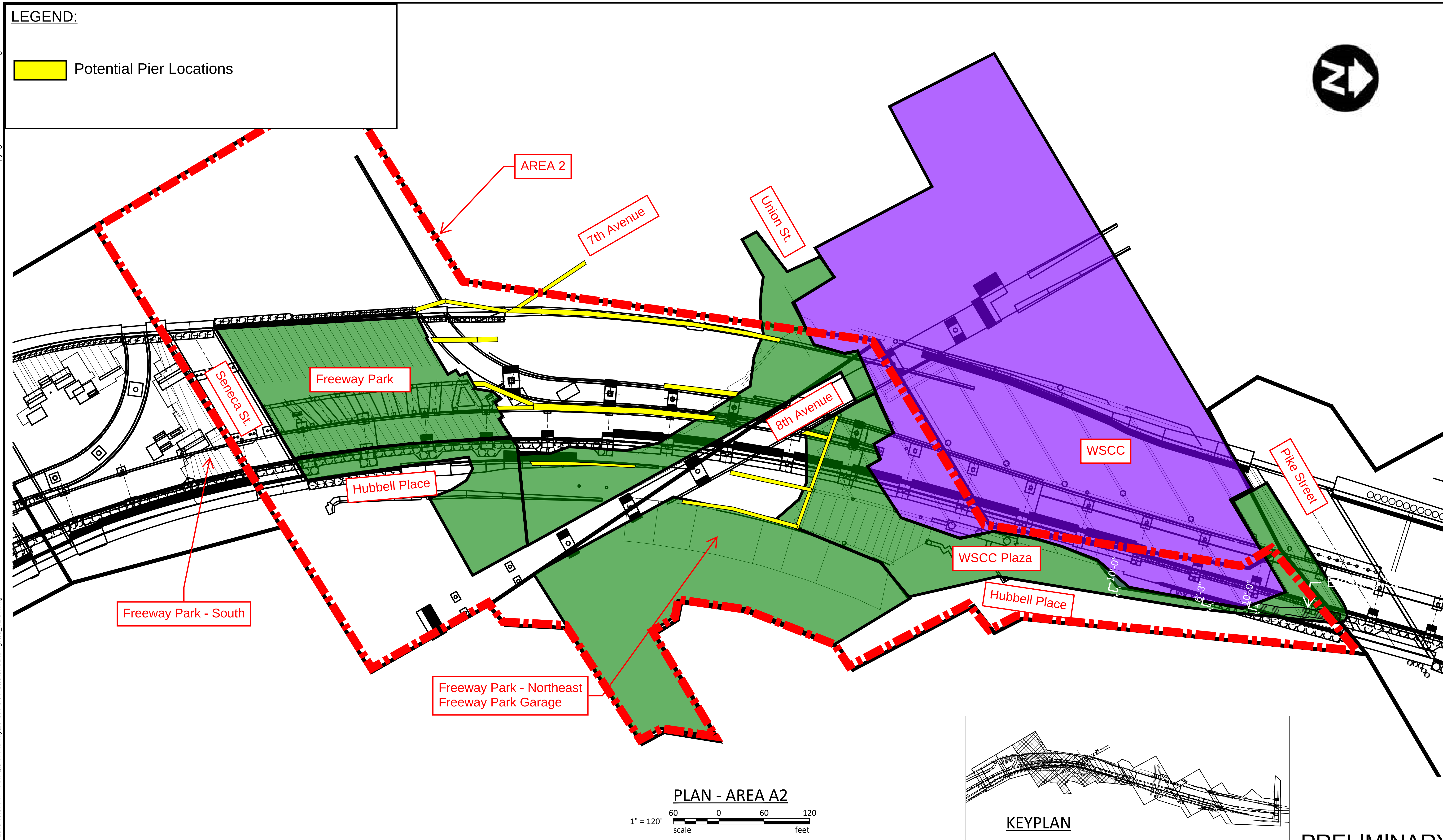

PRELIMINARY

MARK	REVISION DESCRIPTION	BY	APP.	DATE

wsp
WSP USA Inc.
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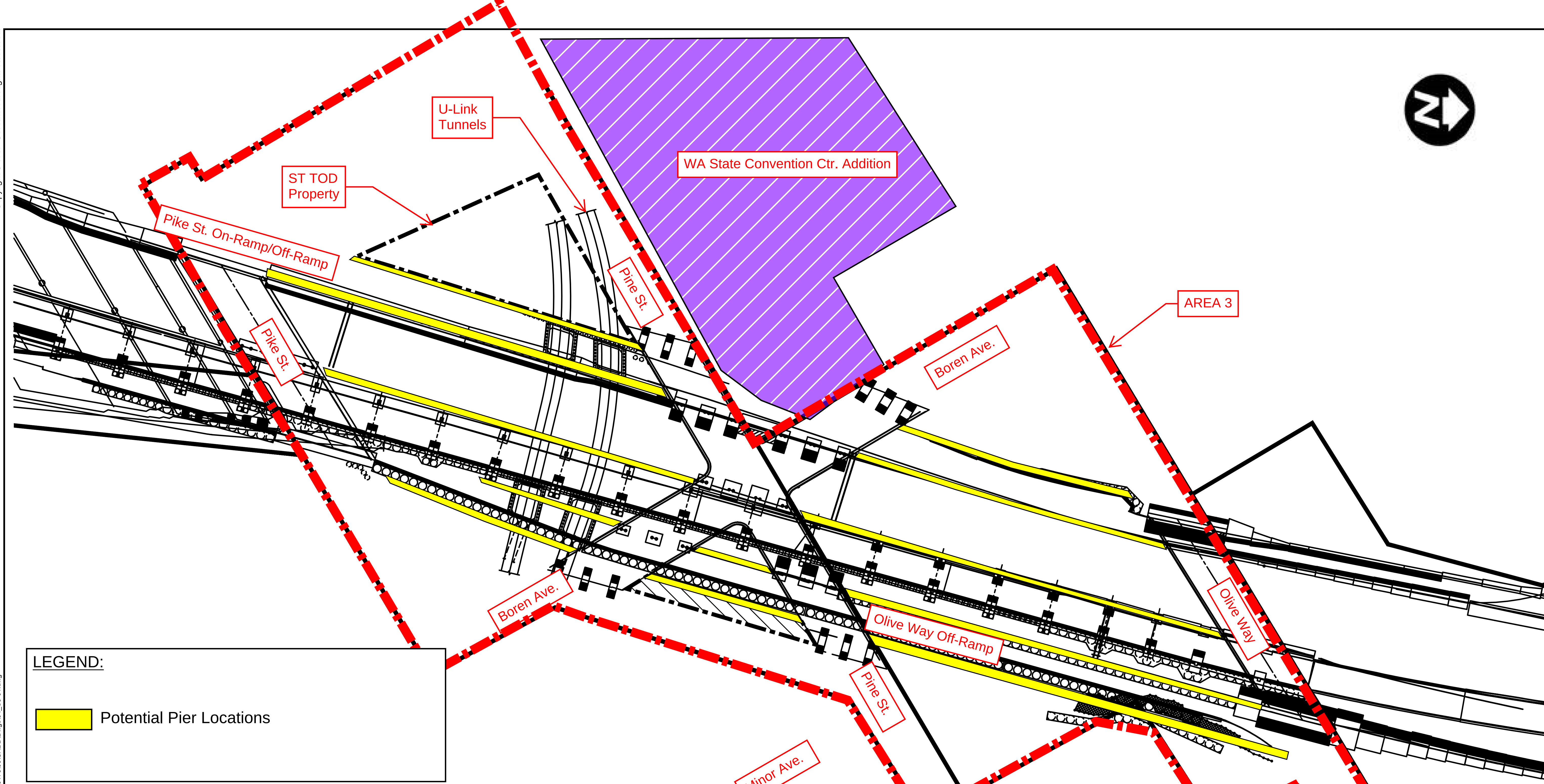
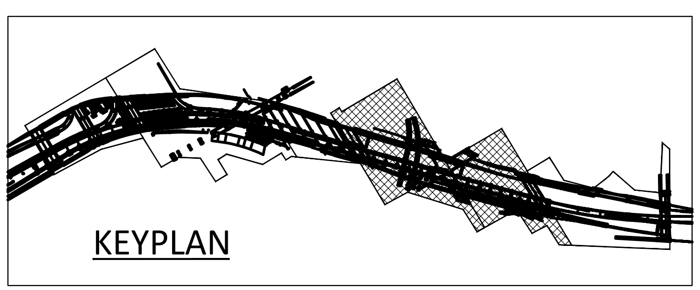
CITY OF SEATTLE
I-5 LID FEASIBILITY STUDY
AREA 2 PLAN

DRAWING NO.
PROJECT NO.
DATE:
SHEET NO.



LEGEND:

Potential Pier Locations



KEYPLAN

PLAN - AREA A3

1" = 120'   60   0   60   120
scale   feet

PRELIMINARY

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PROJ MGR PRJ

CITY OF SEATTLE
I-5 LID FEASIBILITY STUDY

AREA 3 PLAN

DRAWING NO.
PROJECT NO.
DATE:
SHEET NO.

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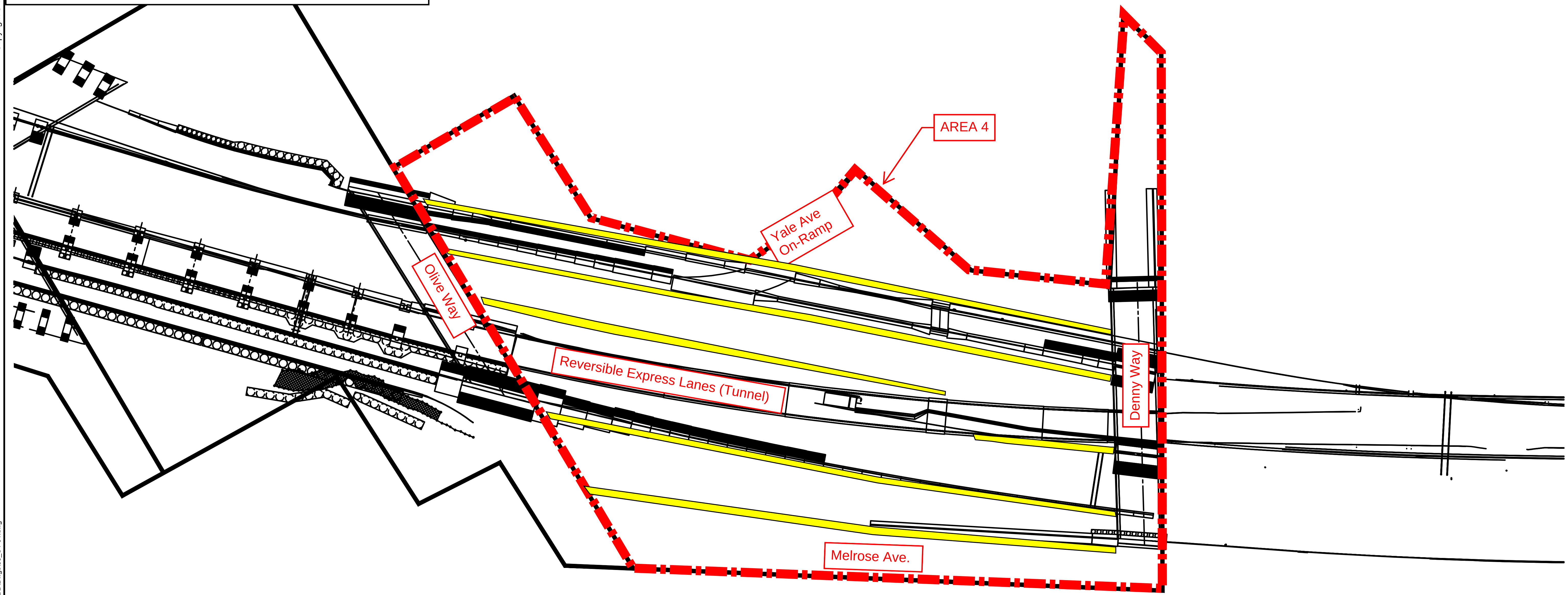
LEGEND:

Potential Pier Locations

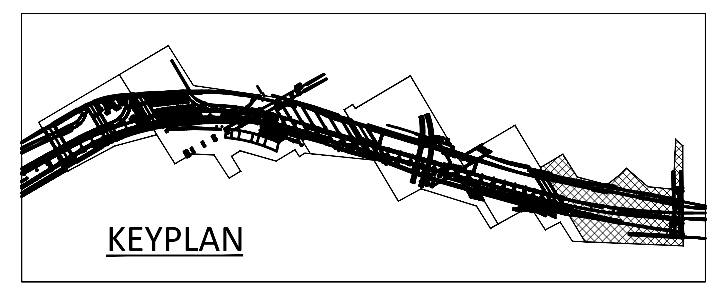


PLAN - AREA A4

1" = 120'

60 0 60 120

scale feet



PRELIMINARY

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CITY OF SEATTLE

I-5 LID FEASIBILITY STUDY

AREA 4 PLAN

DRAWING NO.
PROJECT NO.
DATE:
SHEET NO.

I-5 Lid Feasibility Study

Appendix D
Preliminary Geotechnical Information

Prepared for:

Seattle
Office of Planning &
Community Development

Prepared by:

wsp

OJB
Magnusson Klemencic Assoc.

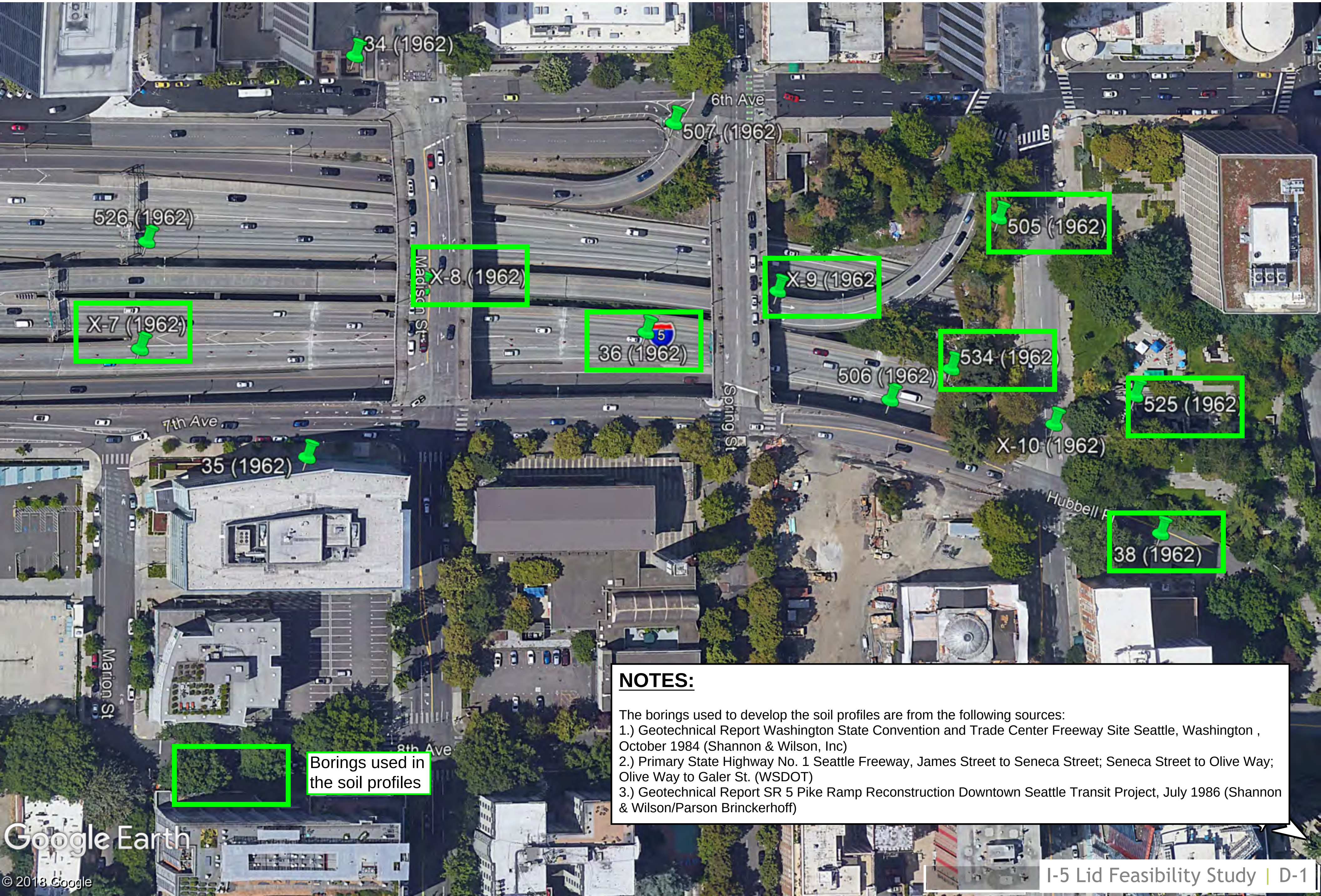
EnviroIssues
Framework

HR&A Advisors
Shiels Obletz Johnsen

December 5, 2019

SITE MAP

(Marion St. to Seneca St.)

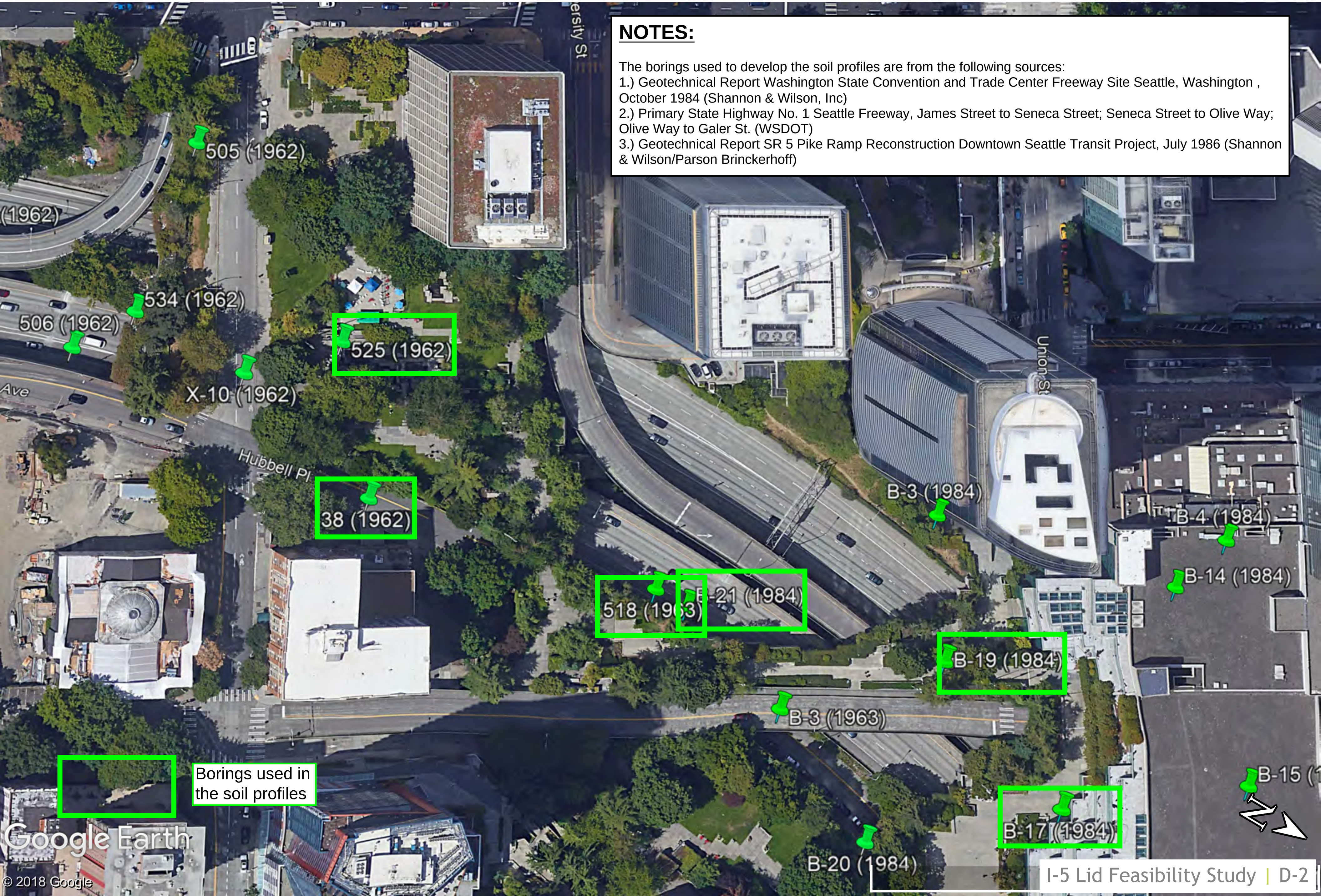


NOTES:

The borings used to develop the soil profiles are from the following sources:
1.) Geotechnical Report Washington State Convention and Trade Center Freeway Site Seattle, Washington , October 1984 (Shannon & Wilson, Inc)
2.) Primary State Highway No. 1 Seattle Freeway, James Street to Seneca Street; Seneca Street to Olive Way; Olive Way to Galer St. (WSDOT)
3.) Geotechnical Report SR 5 Pike Ramp Reconstruction Downtown Seattle Transit Project, July 1986 (Shannon & Wilson/Parson Brinckerhoff)

SITE MAP

(Seneca St. to Union St.)



NOTES:

The borings used to develop the soil profiles are from the following sources:

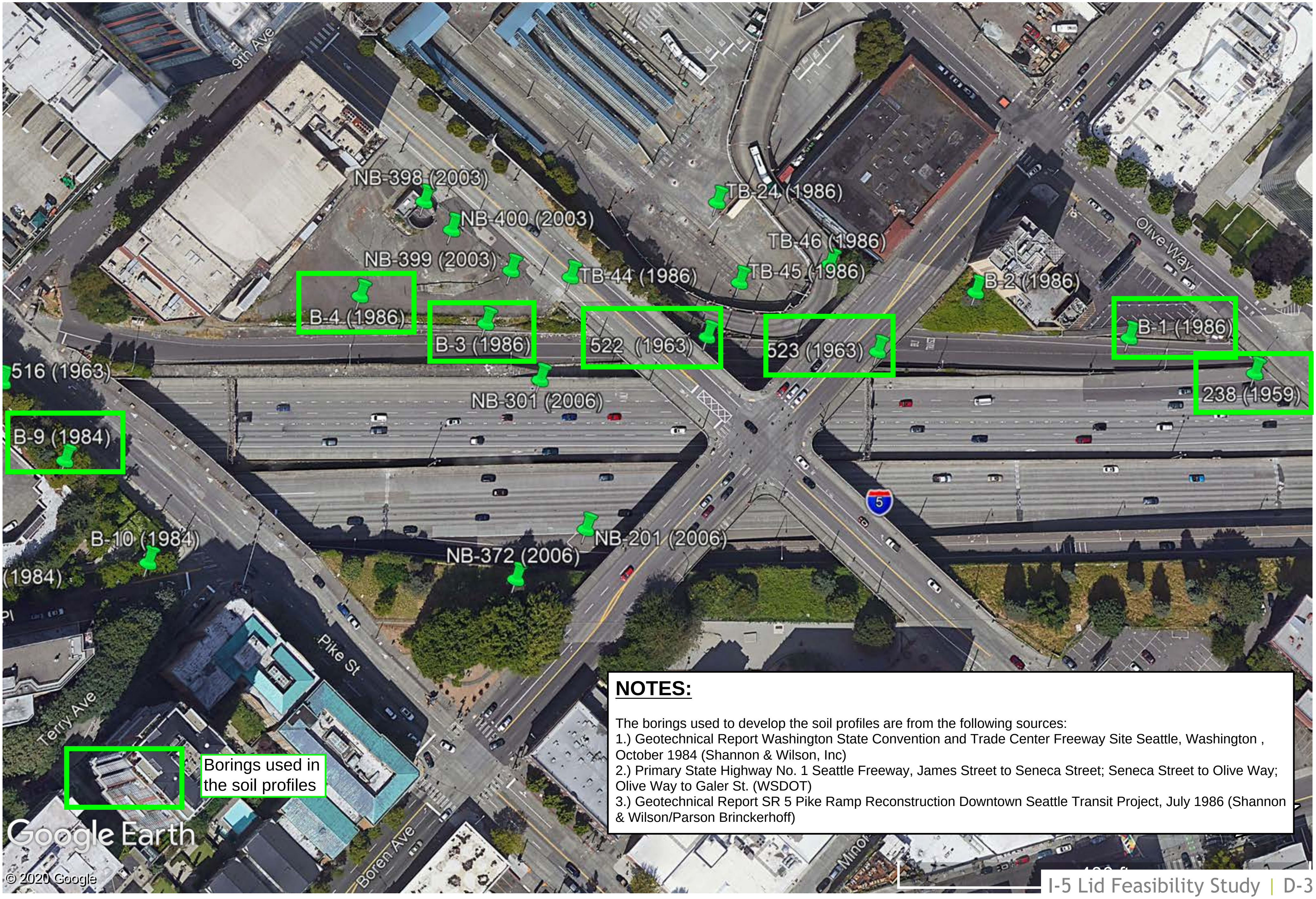
1.) Geotechnical Report Washington State Convention and Trade Center Freeway Site Seattle, Washington , October 1984 (Shannon & Wilson, Inc)

2.) Primary State Highway No. 1 Seattle Freeway, James Street to Seneca Street; Seneca Street to Olive Way; Olive Way to Galer St. (WSDOT)

3.) Geotechnical Report SR 5 Pike Ramp Reconstruction Downtown Seattle Transit Project, July 1986 (Shannon & Wilson/Parson Brinckerhoff)

SITE MAP

(Pike St. to Olive Way)

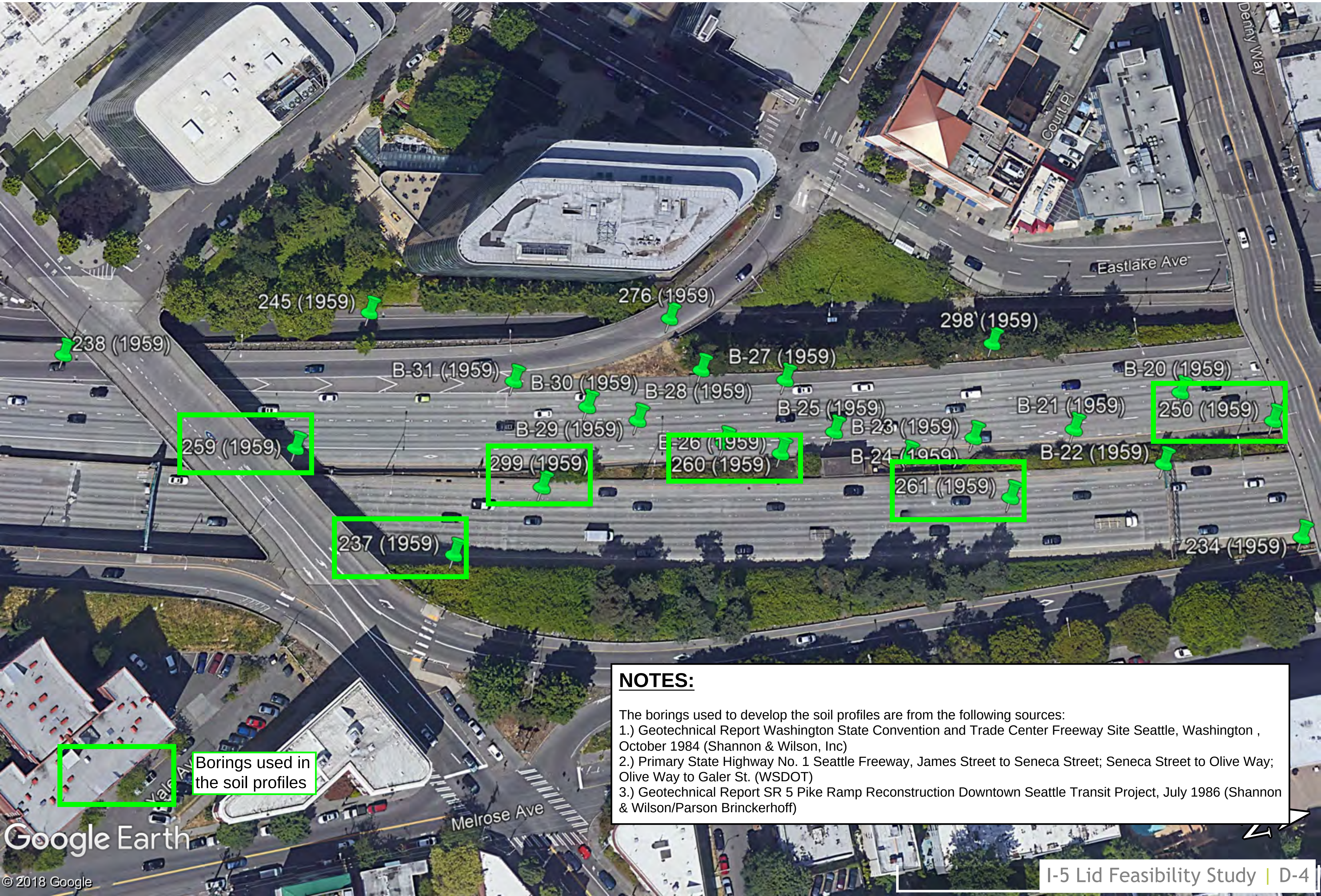


NOTES:

The borings used to develop the soil profiles are from the following sources:
1.) Geotechnical Report Washington State Convention and Trade Center Freeway Site Seattle, Washington , October 1984 (Shannon & Wilson, Inc)
2.) Primary State Highway No. 1 Seattle Freeway, James Street to Seneca Street; Seneca Street to Olive Way; Olive Way to Galer St. (WSDOT)
3.) Geotechnical Report SR 5 Pike Ramp Reconstruction Downtown Seattle Transit Project, July 1986 (Shannon & Wilson/Parson Brinckerhoff)

SITE MAP

(Olive Way to Denny Way)



NOTES:

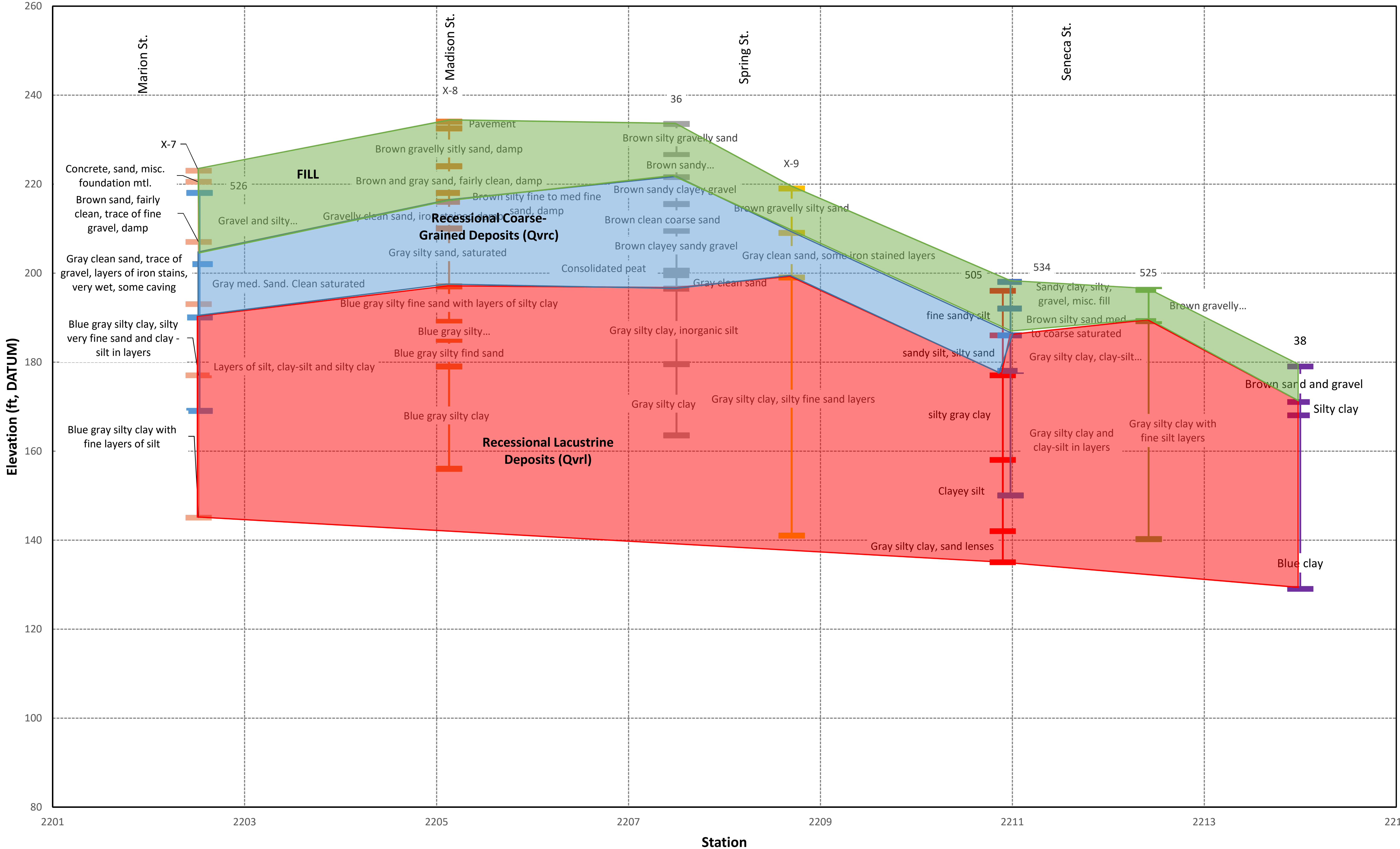
The borings used to develop the soil profiles are from the following sources:

1.) Geotechnical Report Washington State Convention and Trade Center Freeway Site Seattle, Washington , October 1984 (Shannon & Wilson, Inc)

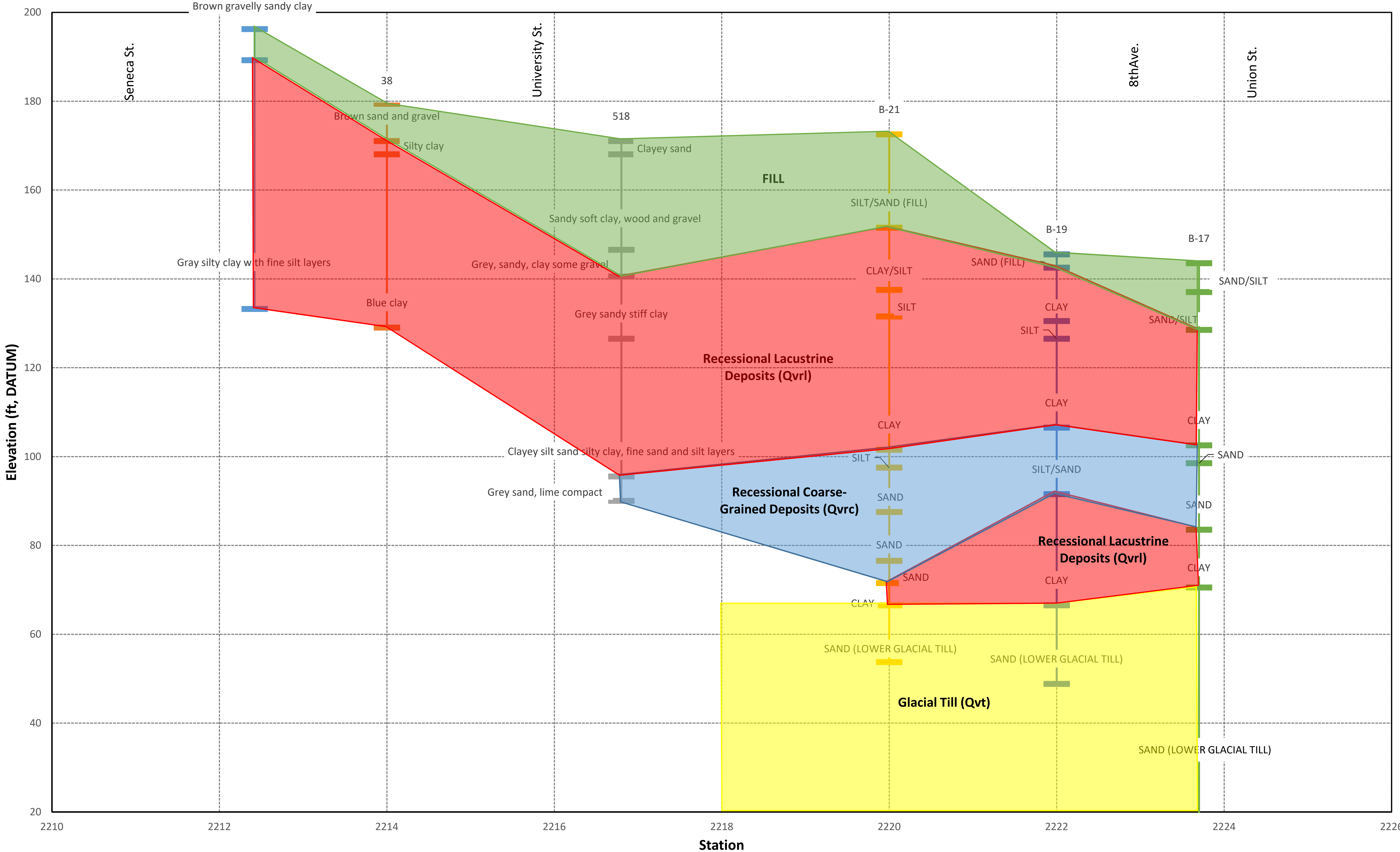
2.) Primary State Highway No. 1 Seattle Freeway, James Street to Seneca Street; Seneca Street to Olive Way; Olive Way to Galer St. (WSDOT)

3.) Geotechnical Report SR 5 Pike Ramp Reconstruction Downtown Seattle Transit Project, July 1986 (Shannon & Wilson/Parson Brinckerhoff)

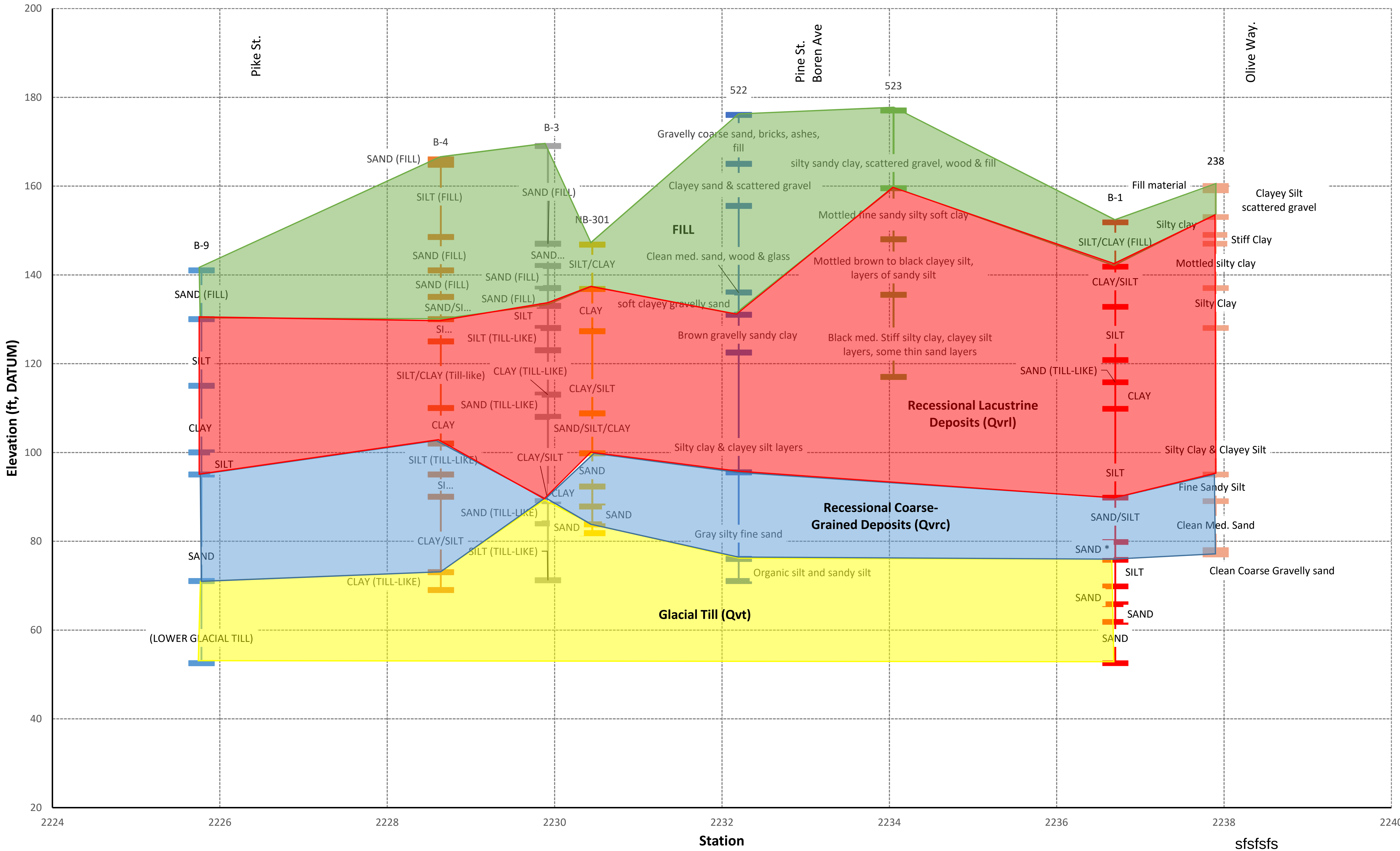
SOIL PROFILE



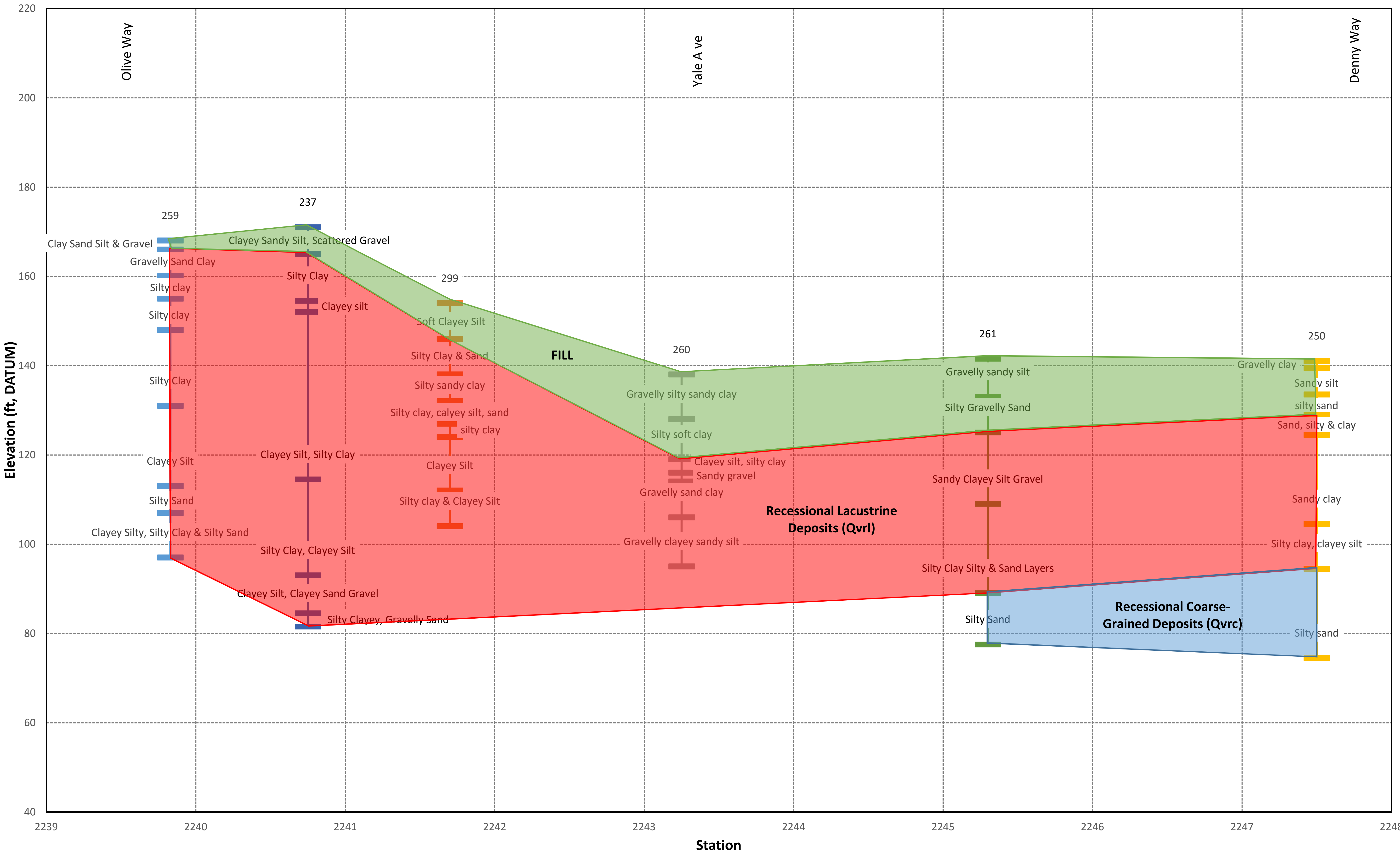
SOIL PROFILE



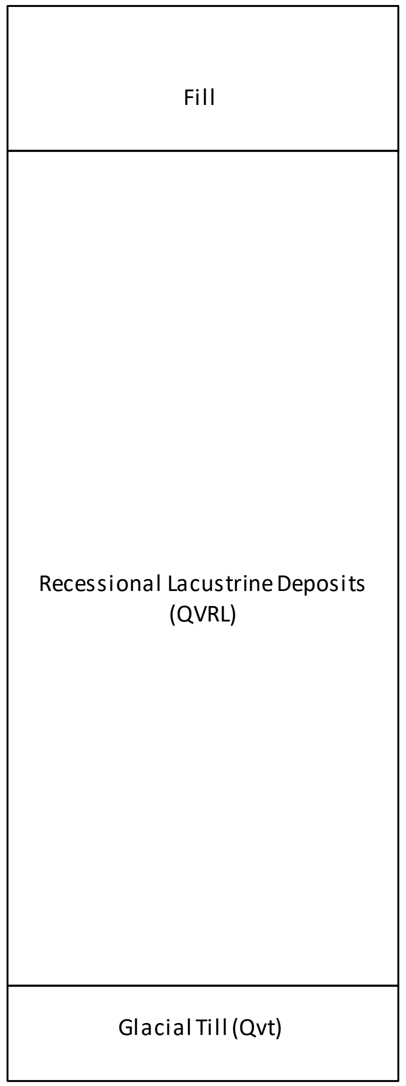
SOIL PROFILE



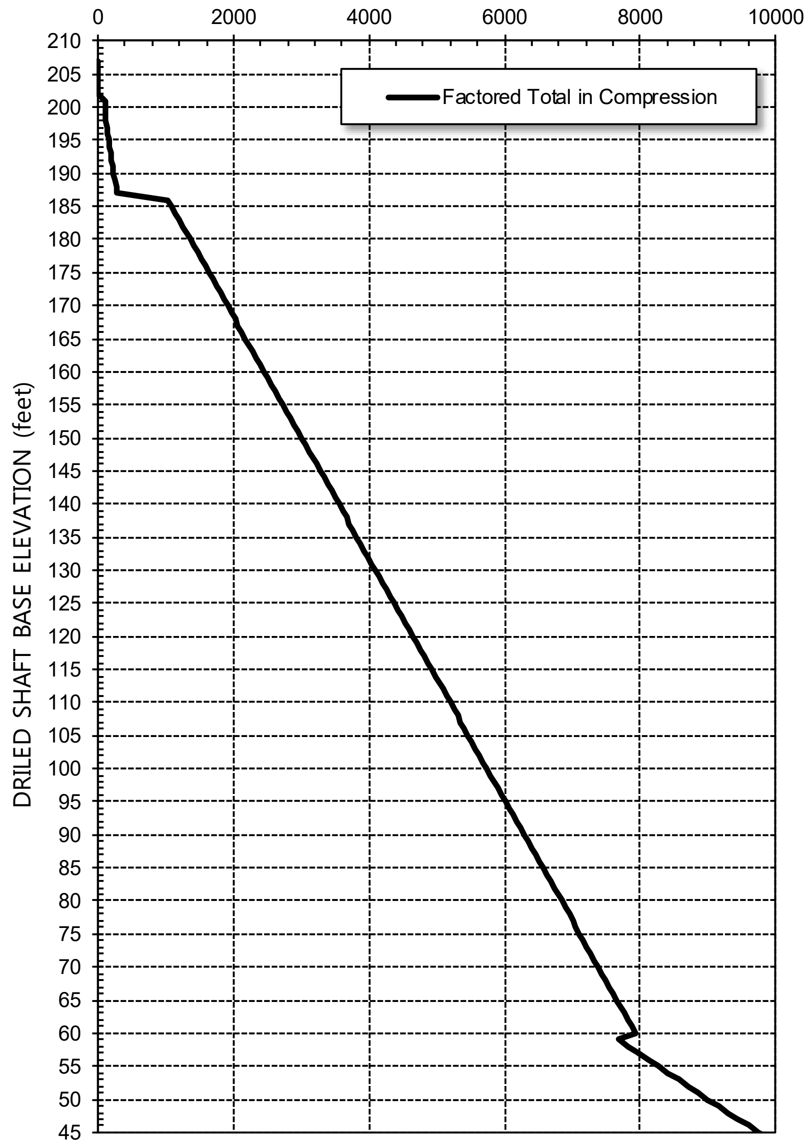
SOIL PROFILE



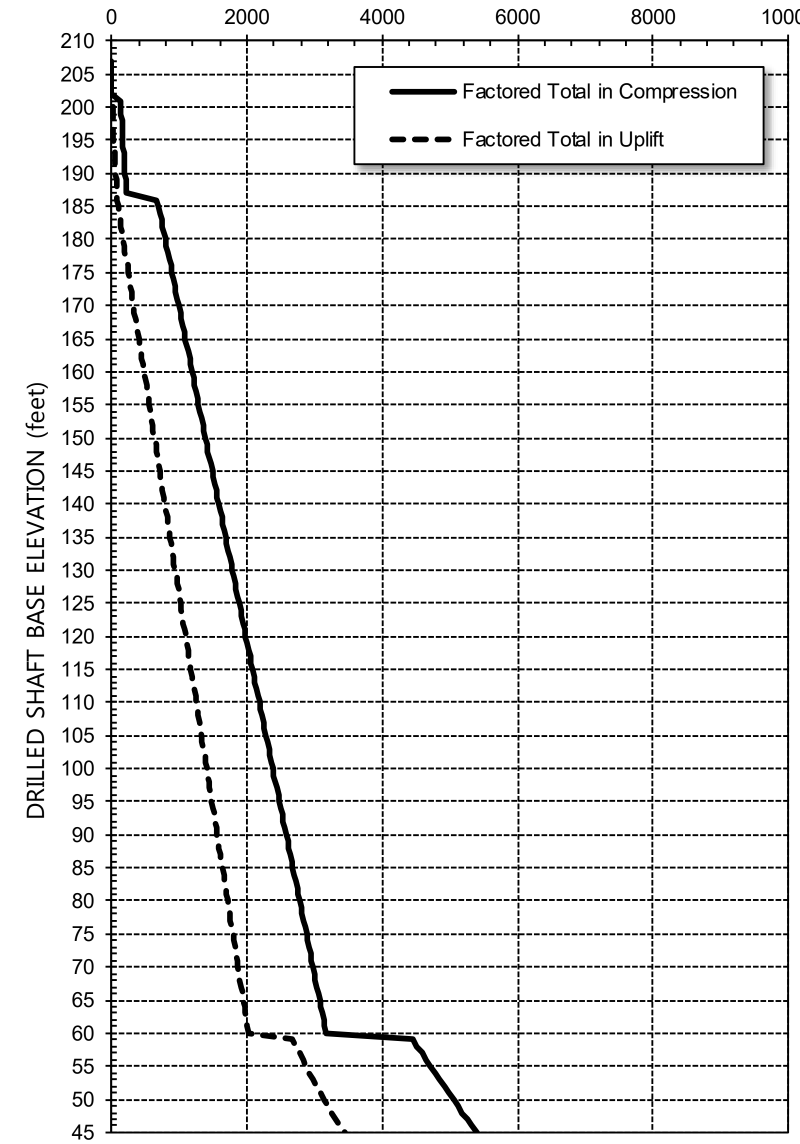
ASSUMED SUBSURFACE PROFILE
(525 - East)



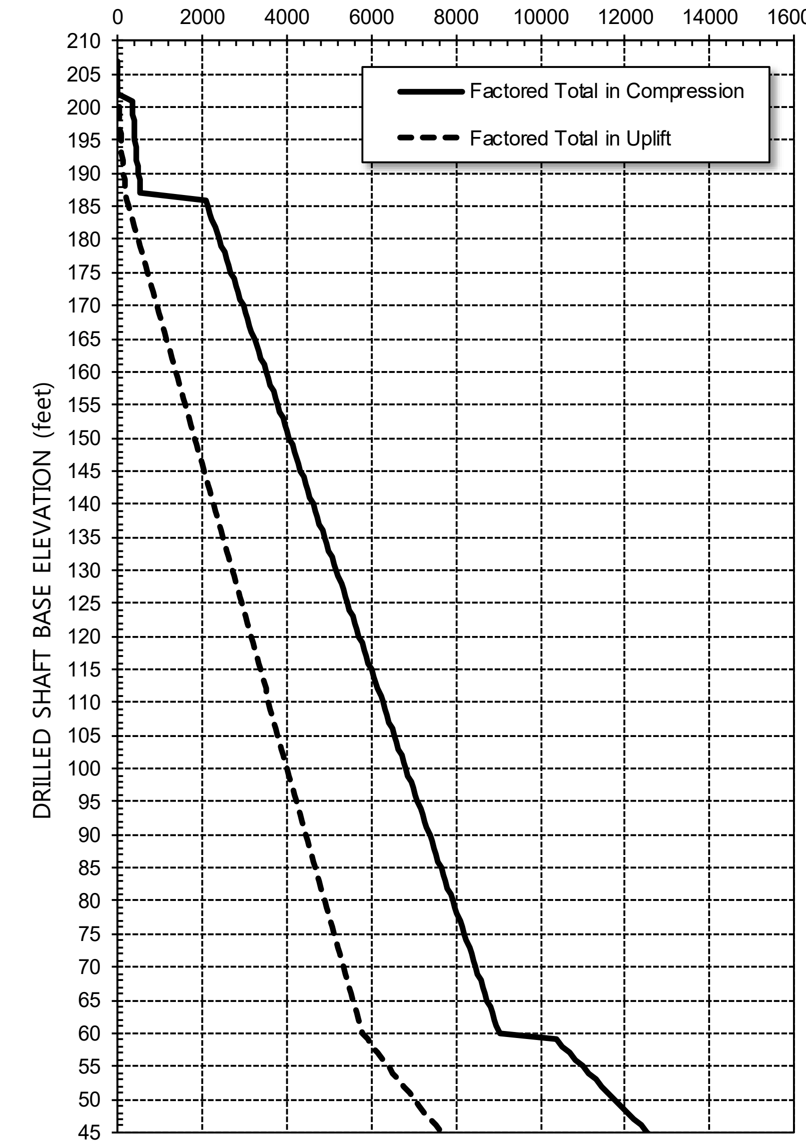
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

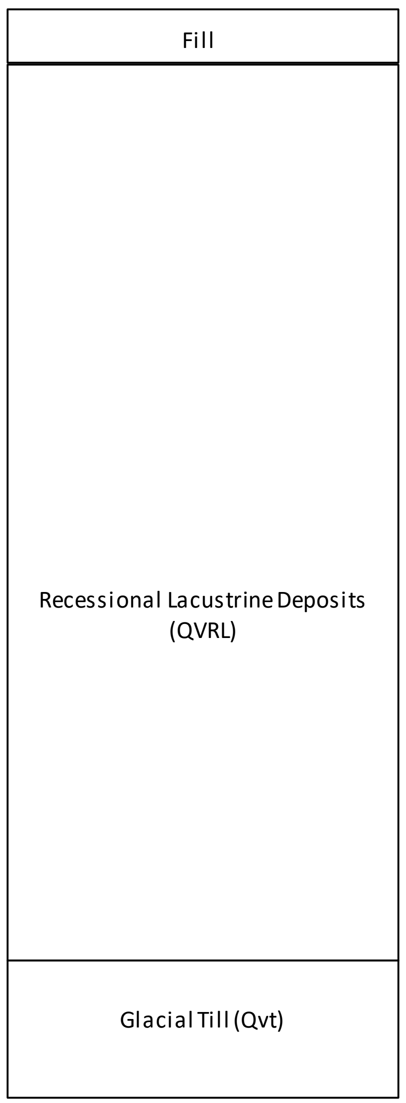
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

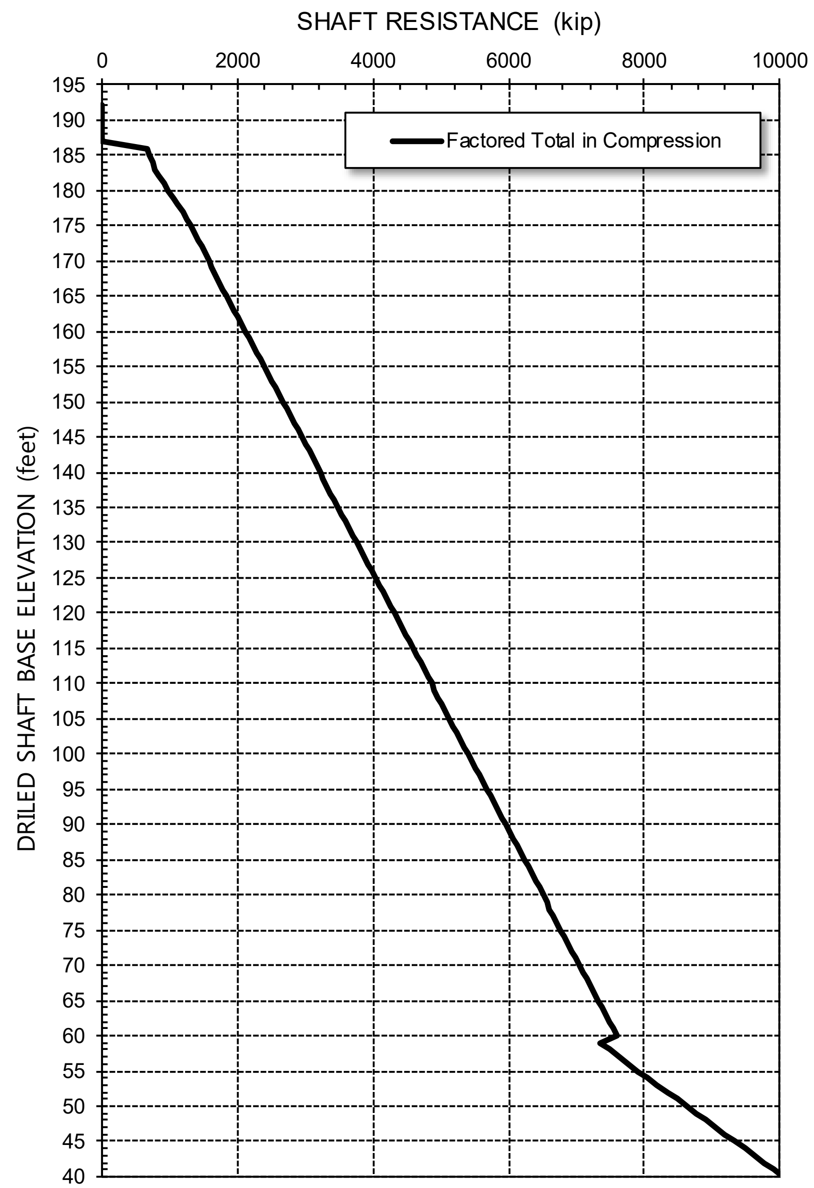
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 1
Drilled Shaft Axial Resistance Charts Seneca_East_6.5ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

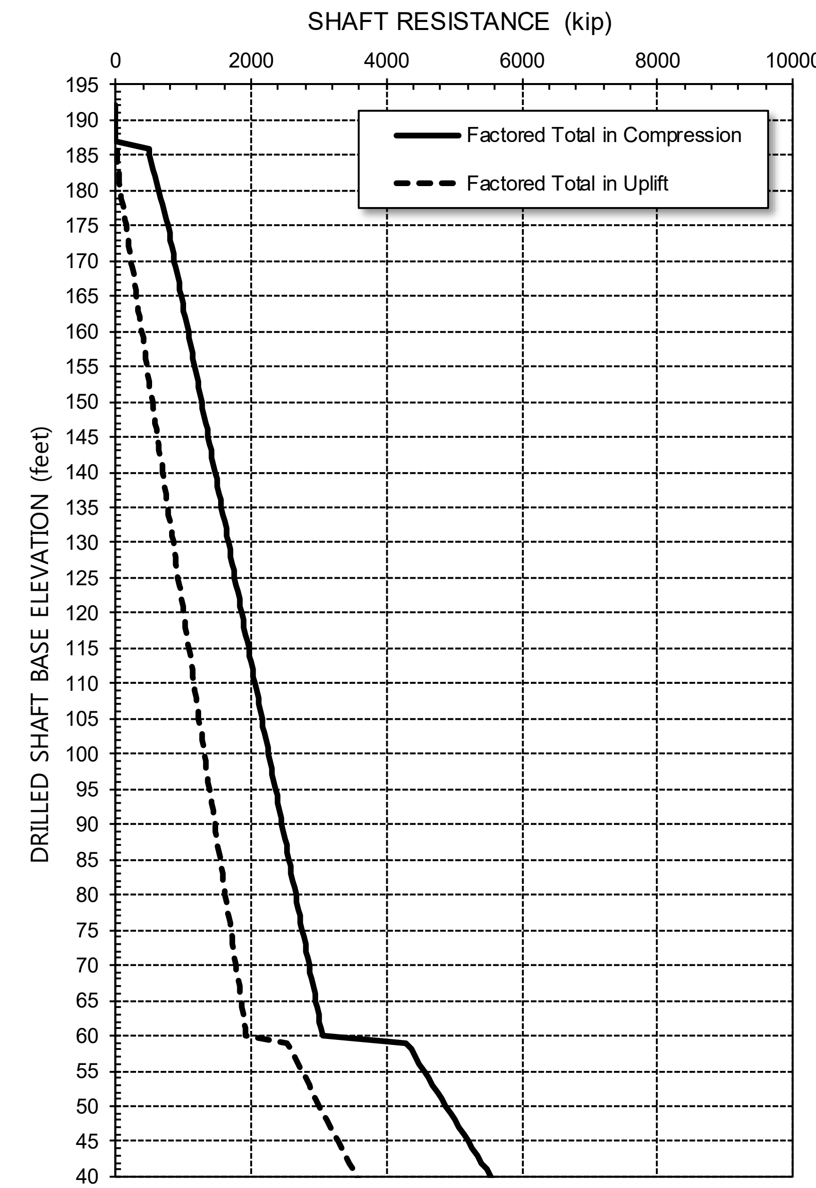
ASSUMED SUBSURFACE PROFILE
(525 - West)



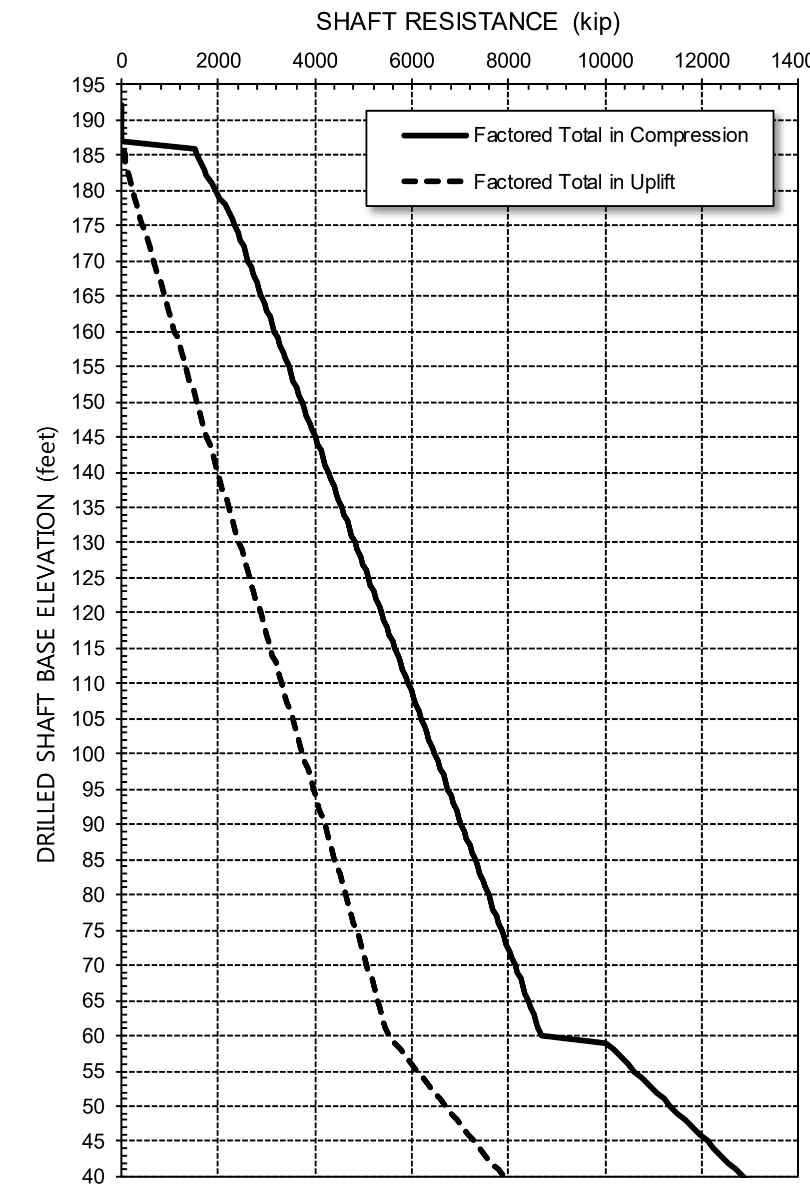
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

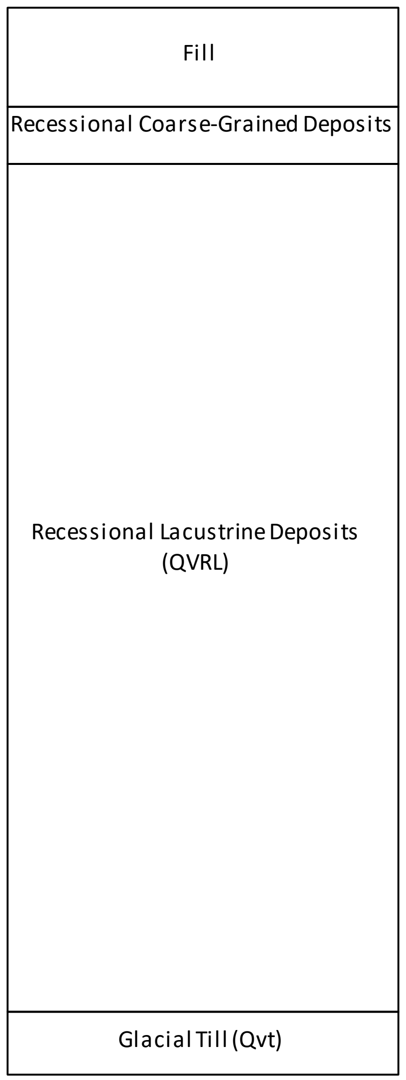
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

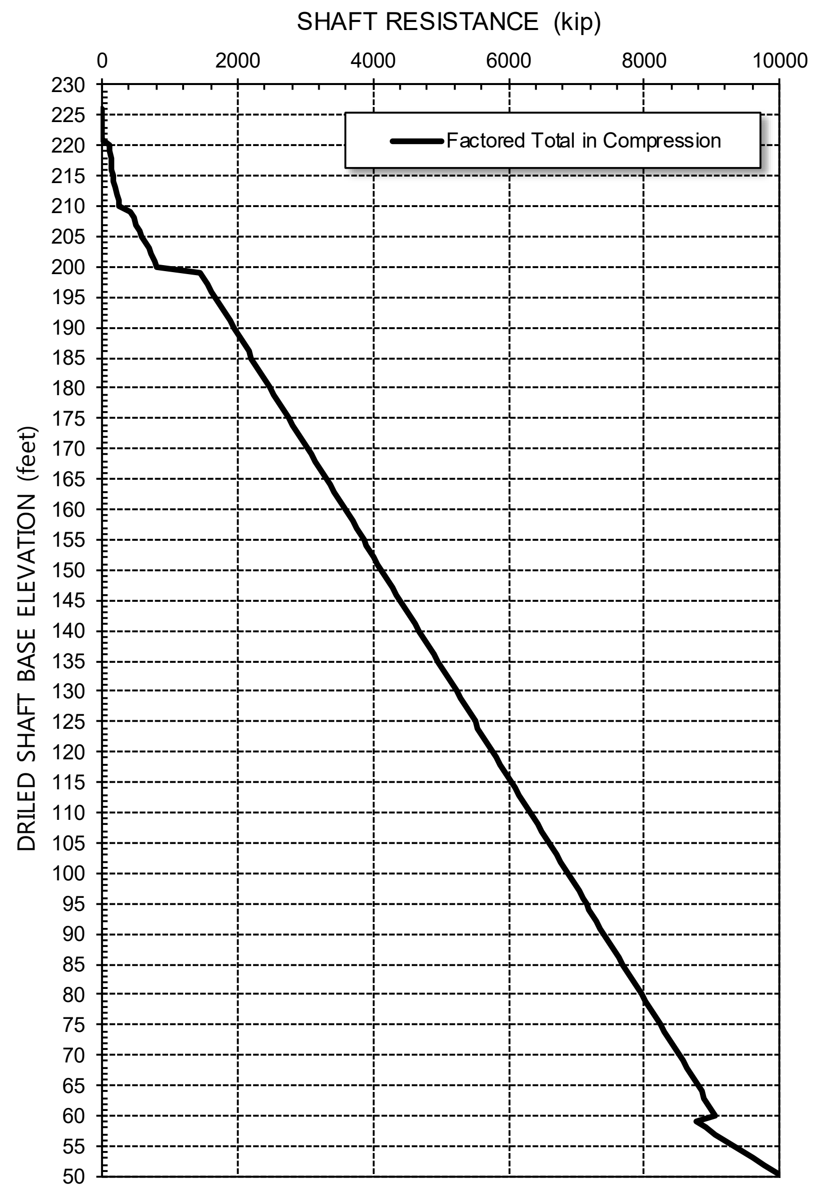
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 2
Drilled Shaft Axial Resistance Charts Seneca_West_6.5ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

ASSUMED SUBSURFACE PROFILE
(X-9 - East Side)

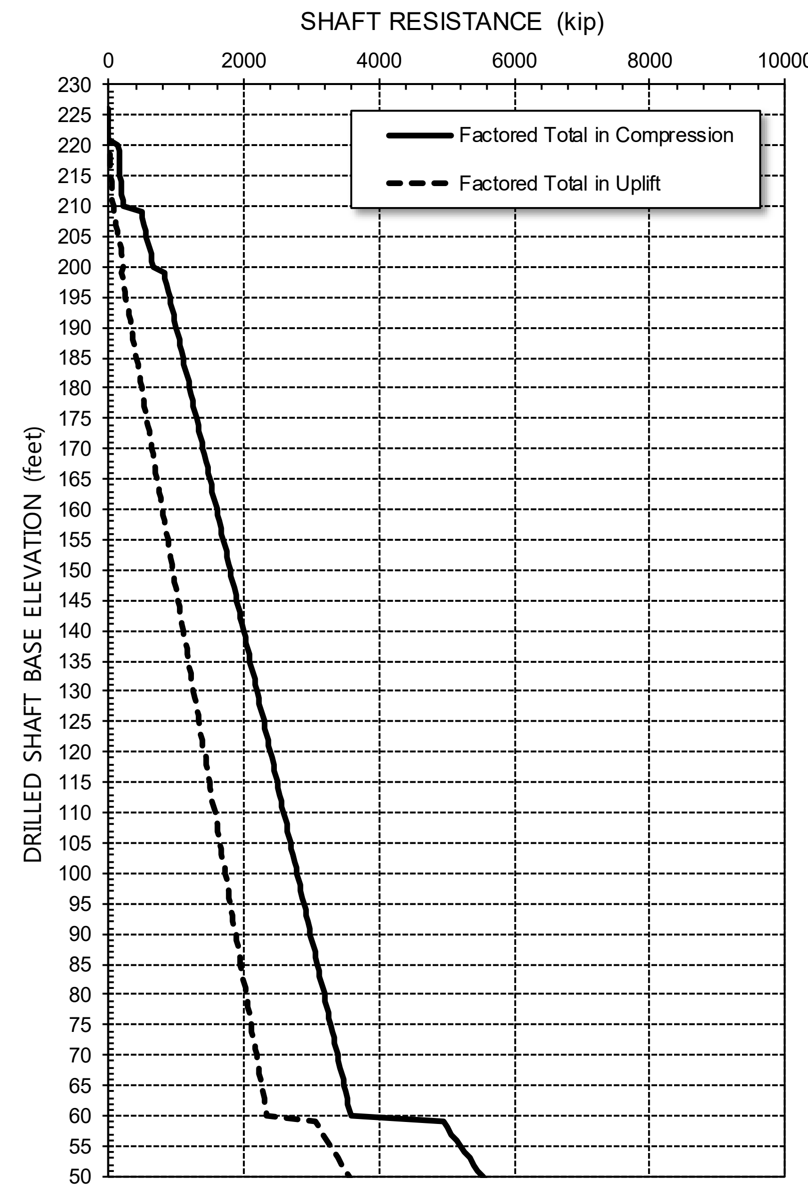


SERVICE LIMIT



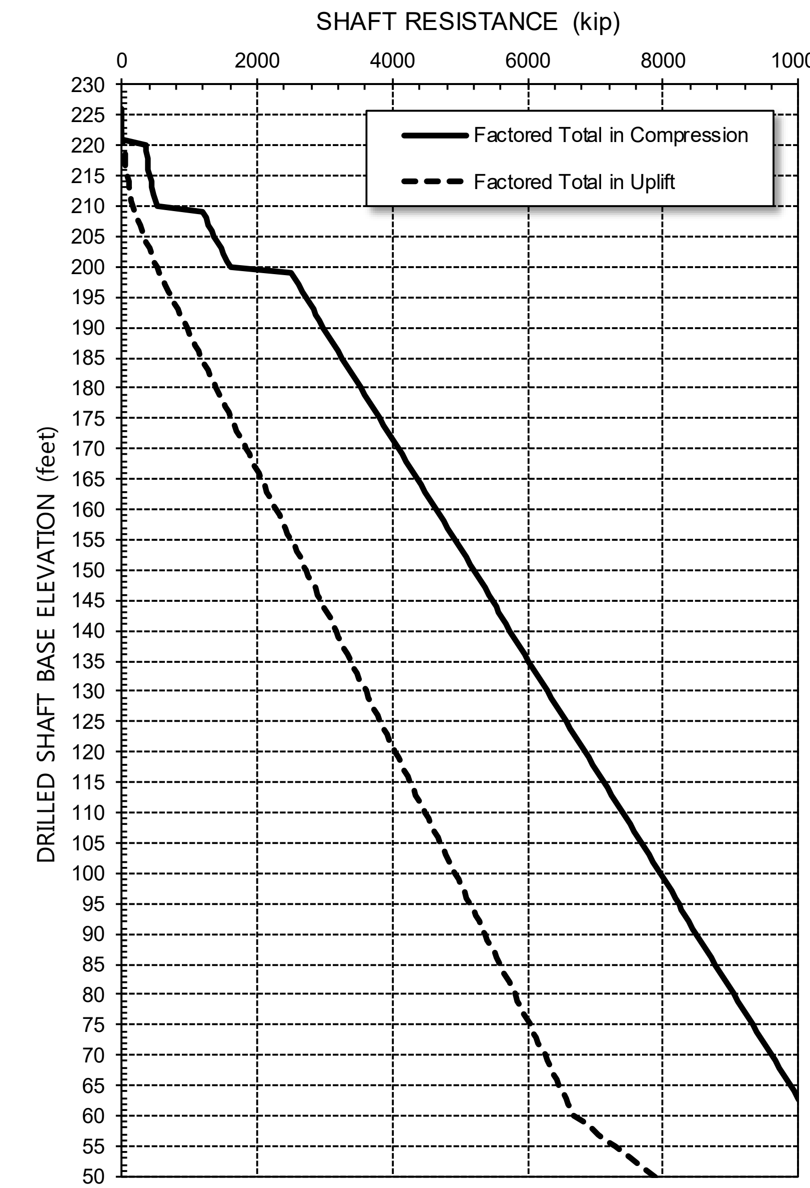
SERVICE LIMIT NOTES:
1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT



STRENGTH LIMIT NOTES:
1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT

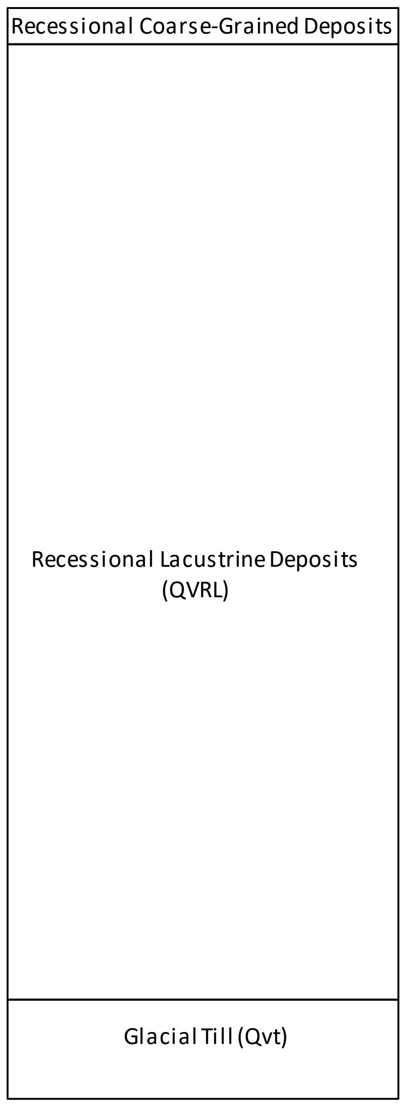


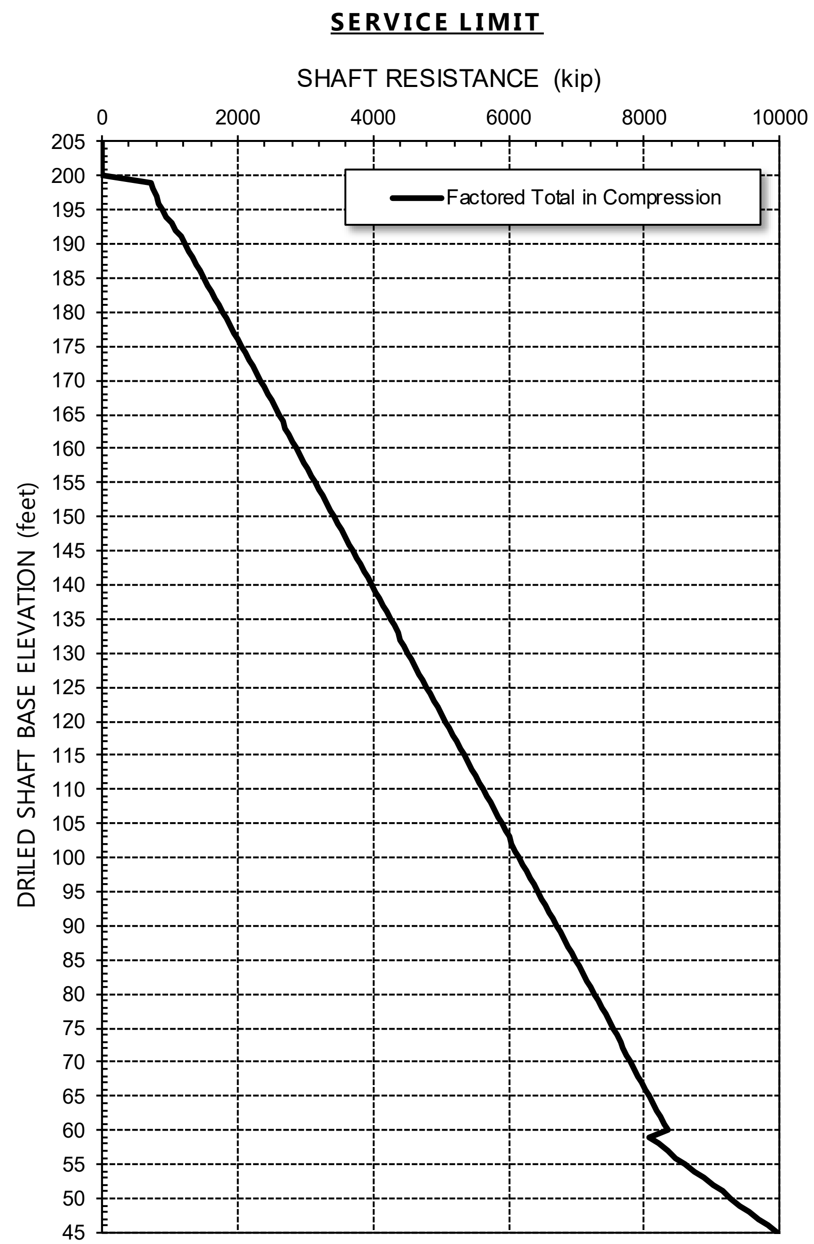
EXTREME EVENT LIMIT NOTES:
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

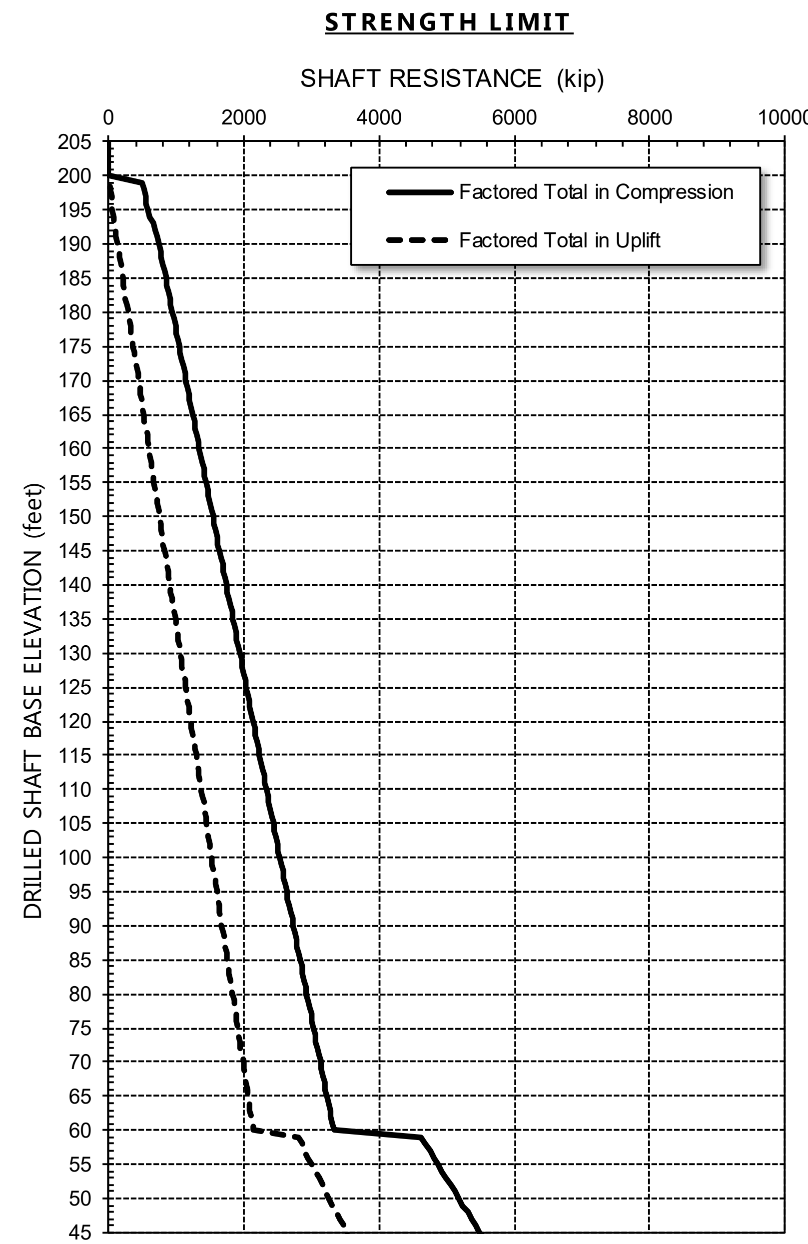
GENERAL NOTES:
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

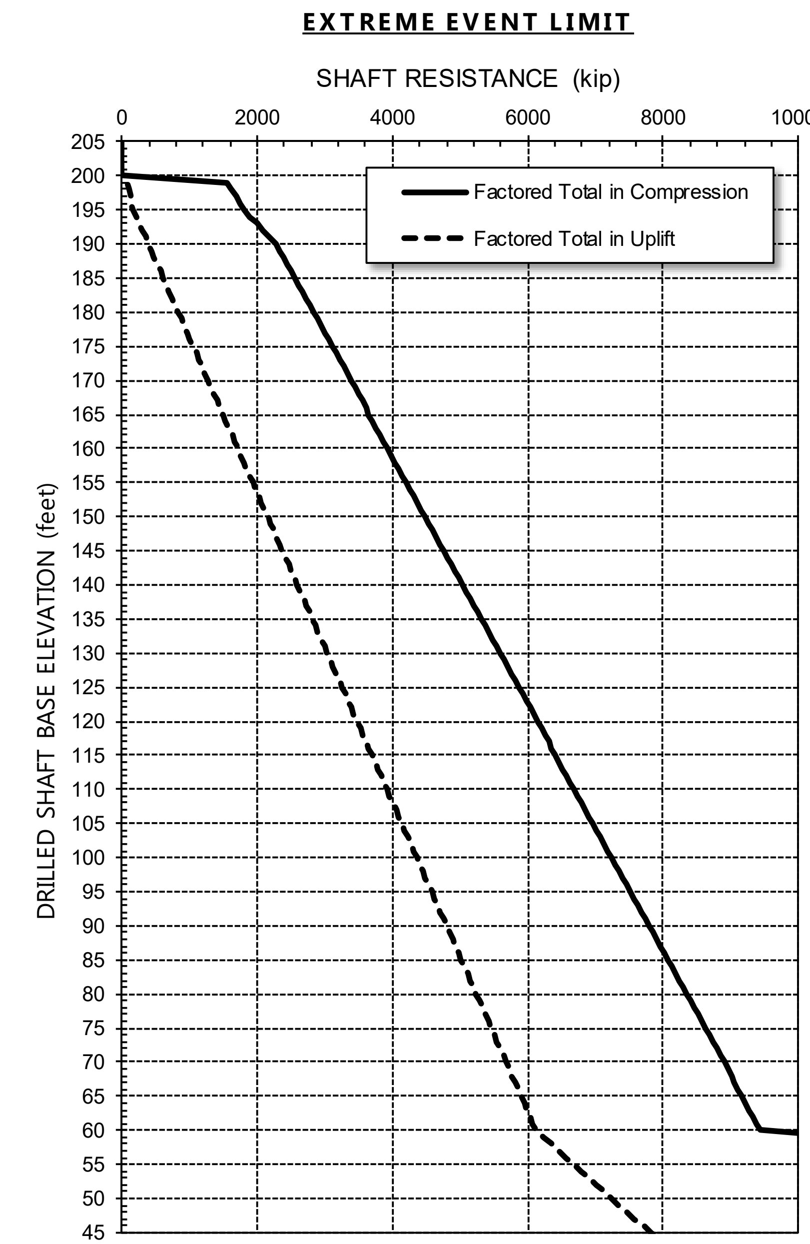
FIGURE 3
Drilled Shaft Axial Resistance Charts Spring_East_6.5ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

ASSUMED SUBSURFACE PROFILE
(X-9 - West Side)









SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

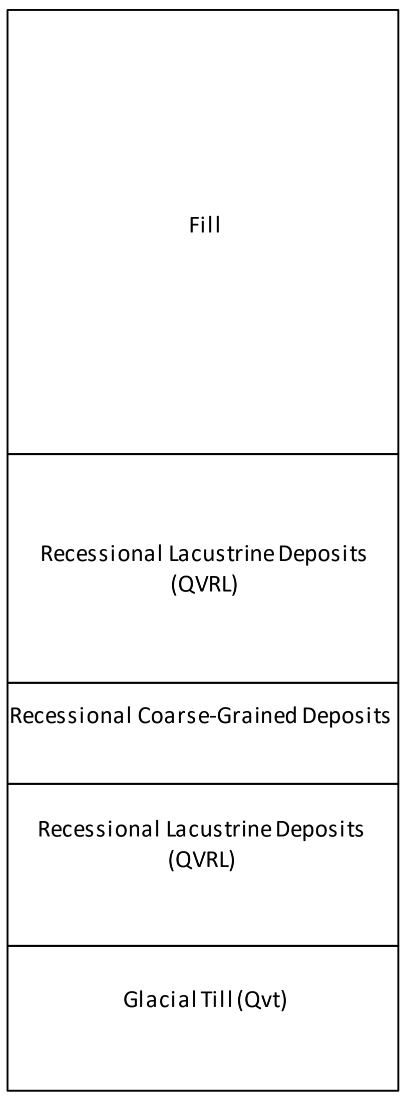
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

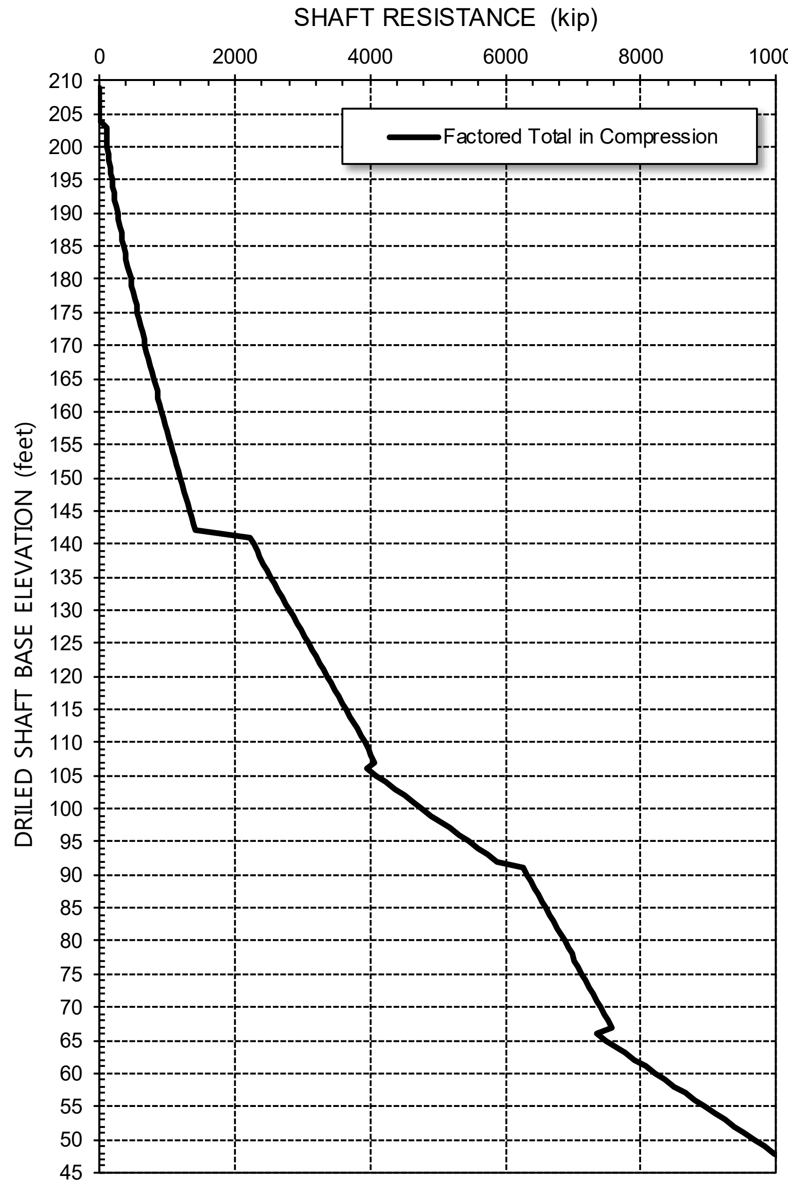
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 4
Drilled Shaft Axial Resistance Charts Spring_West_6.5ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

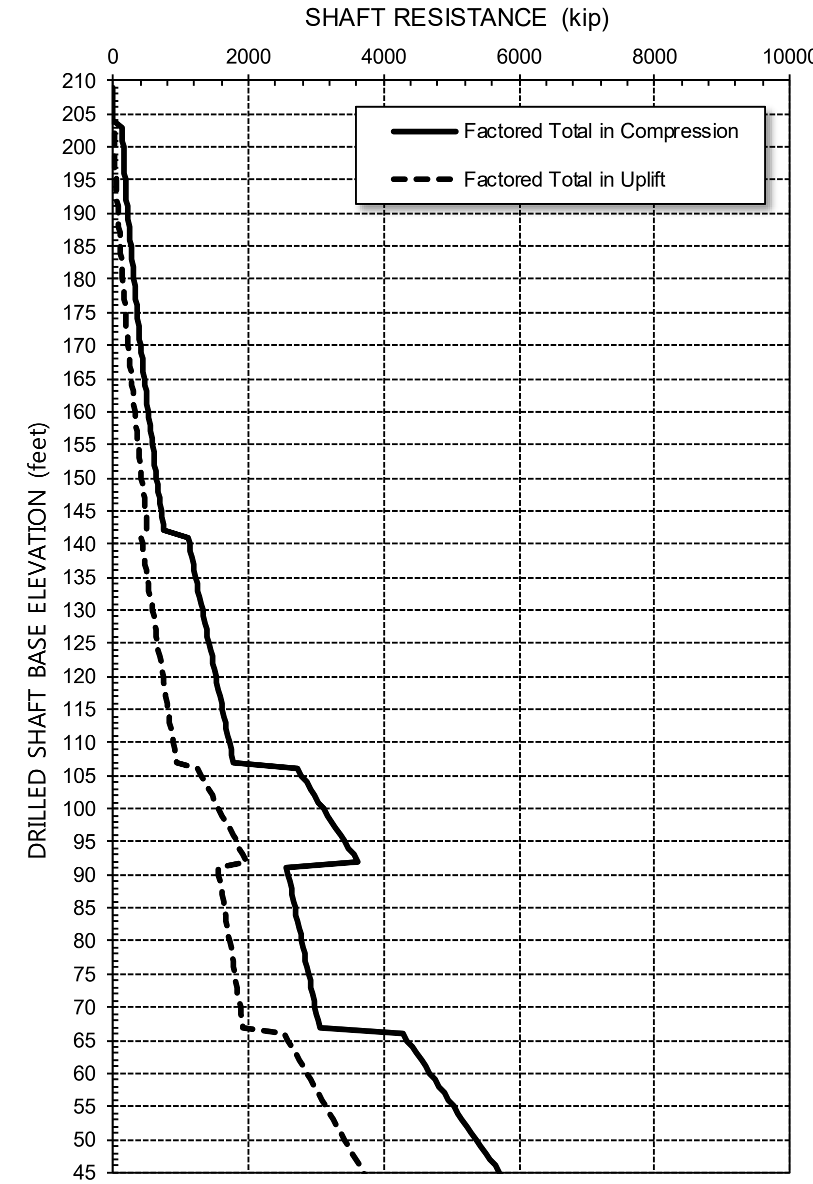
ASSUMED SUBSURFACE PROFILE (B-19 East)



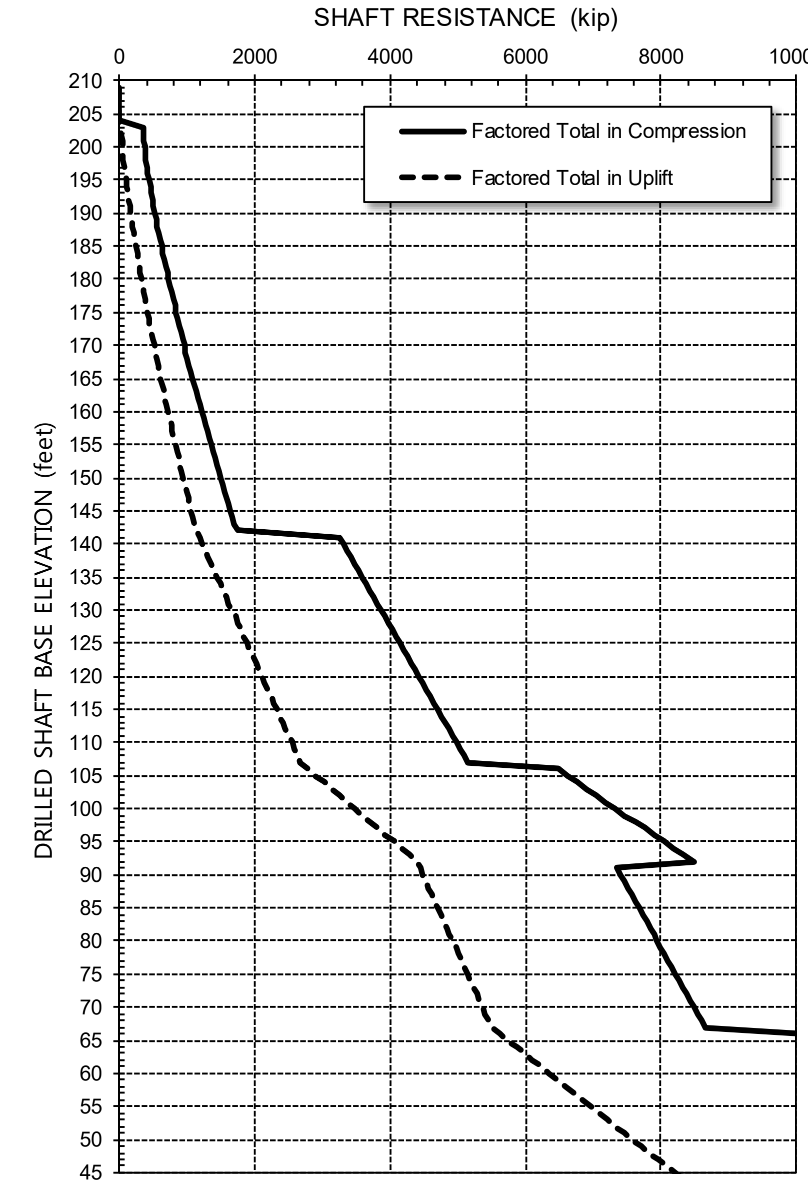
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

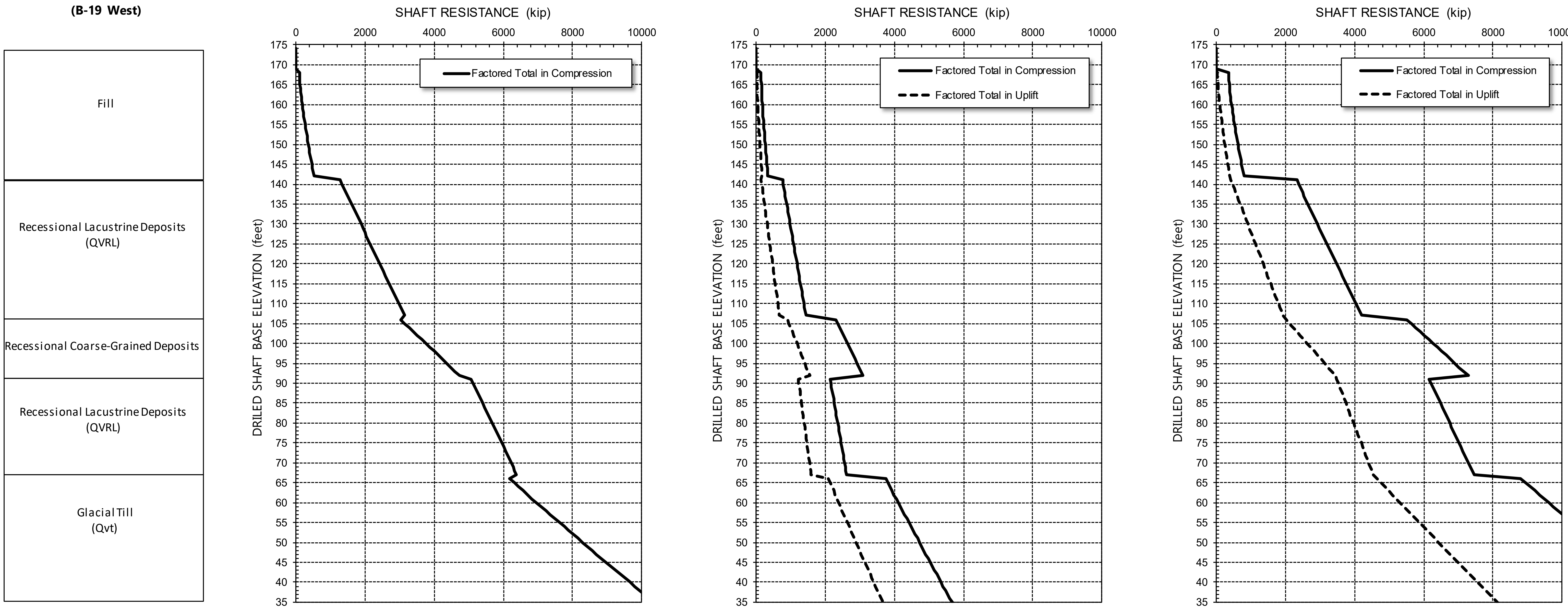
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 5
Drilled Shaft Axial Resistance Charts 8th_East_6.5ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

ASSUMED SUBSURFACE PROFILE (B-19 West) | **SERVICE LIMIT** | **STRENGTH LIMIT** | **EXTREME EVENT LIMIT**



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

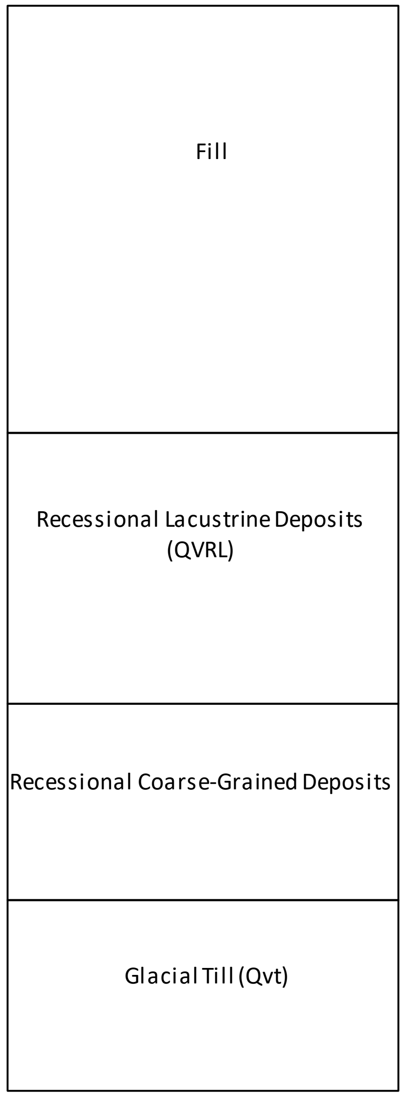
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

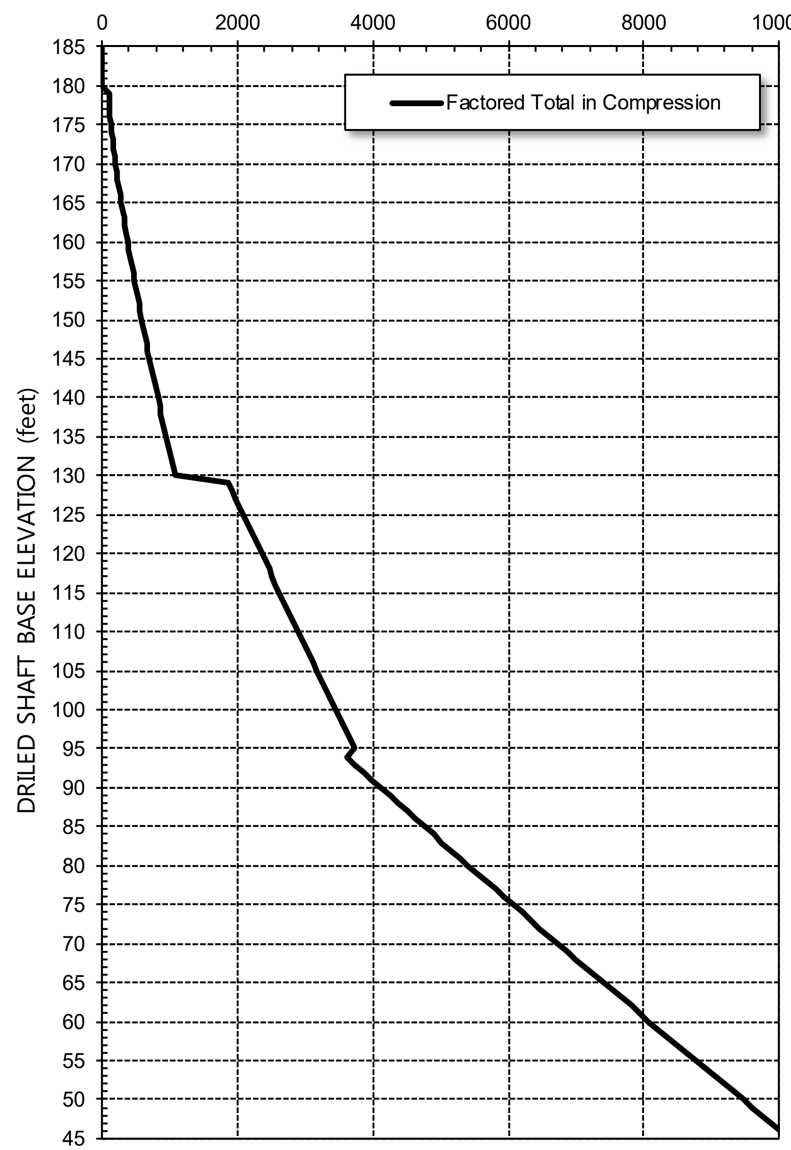
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 6
Drilled Shaft Axial Resistance Charts 8th_West_6.5ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

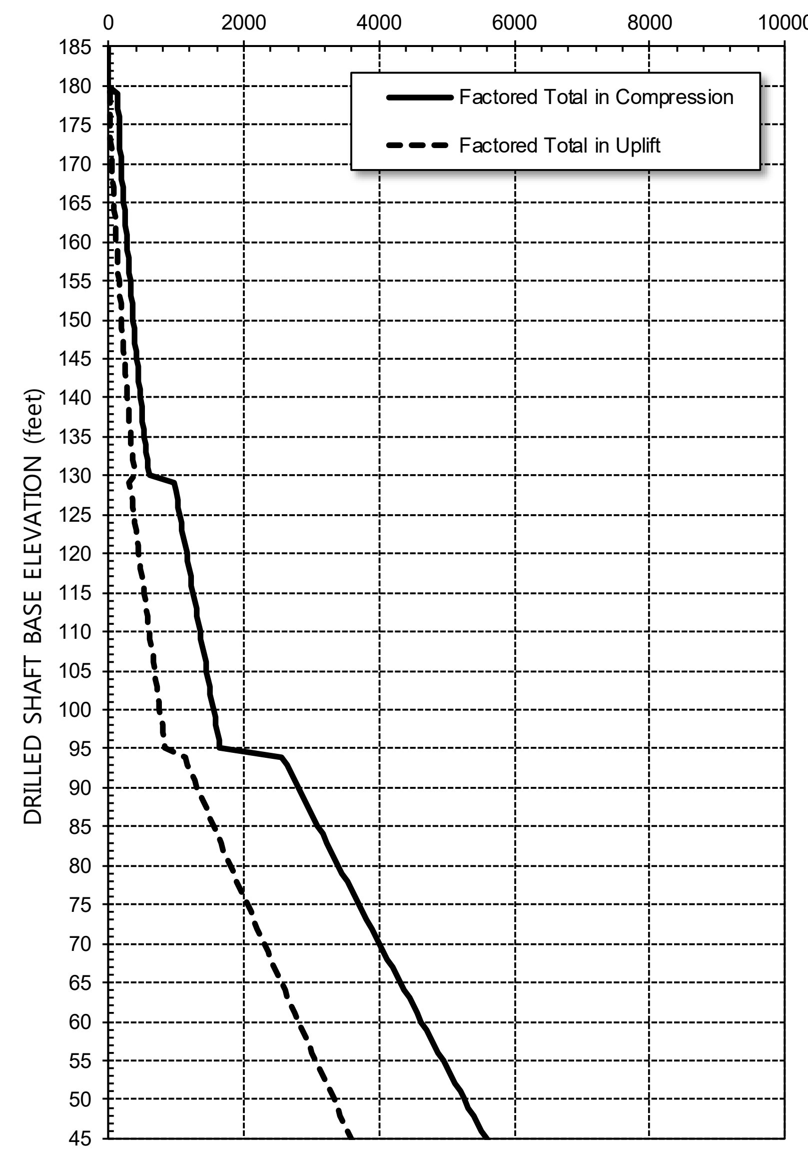
ASSUMED SUBSURFACE PROFILE (B-9 - East)



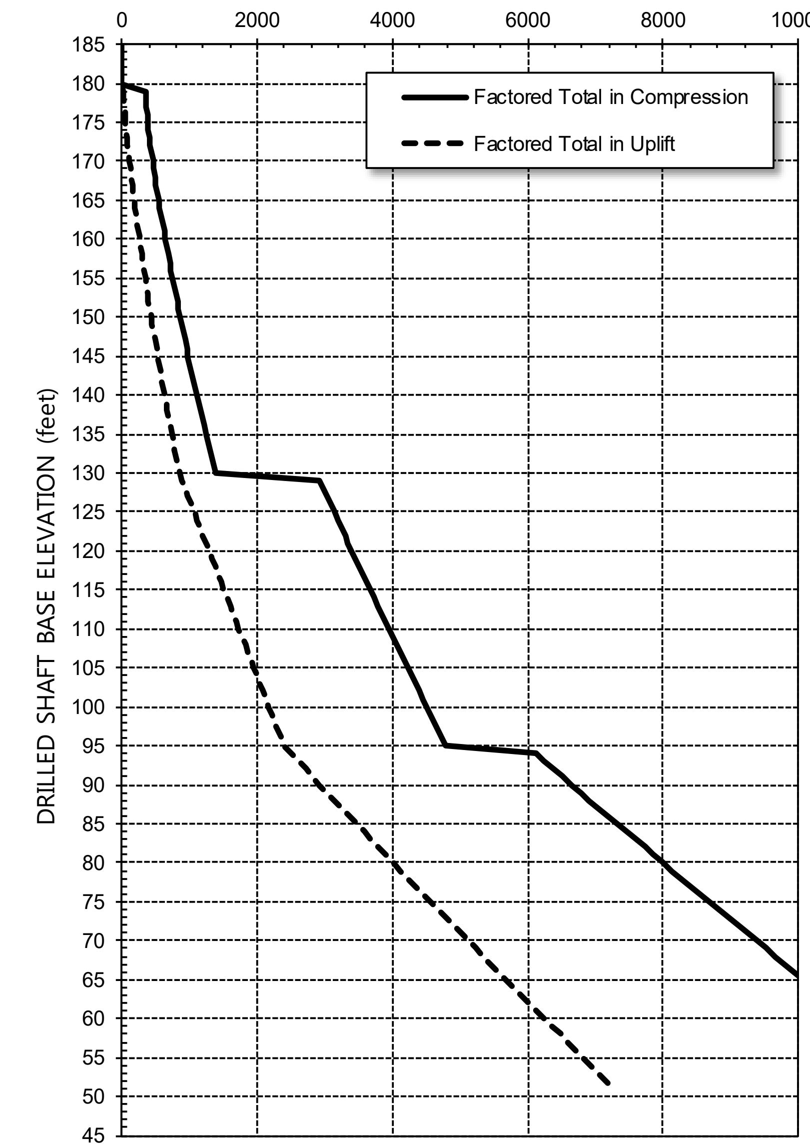
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

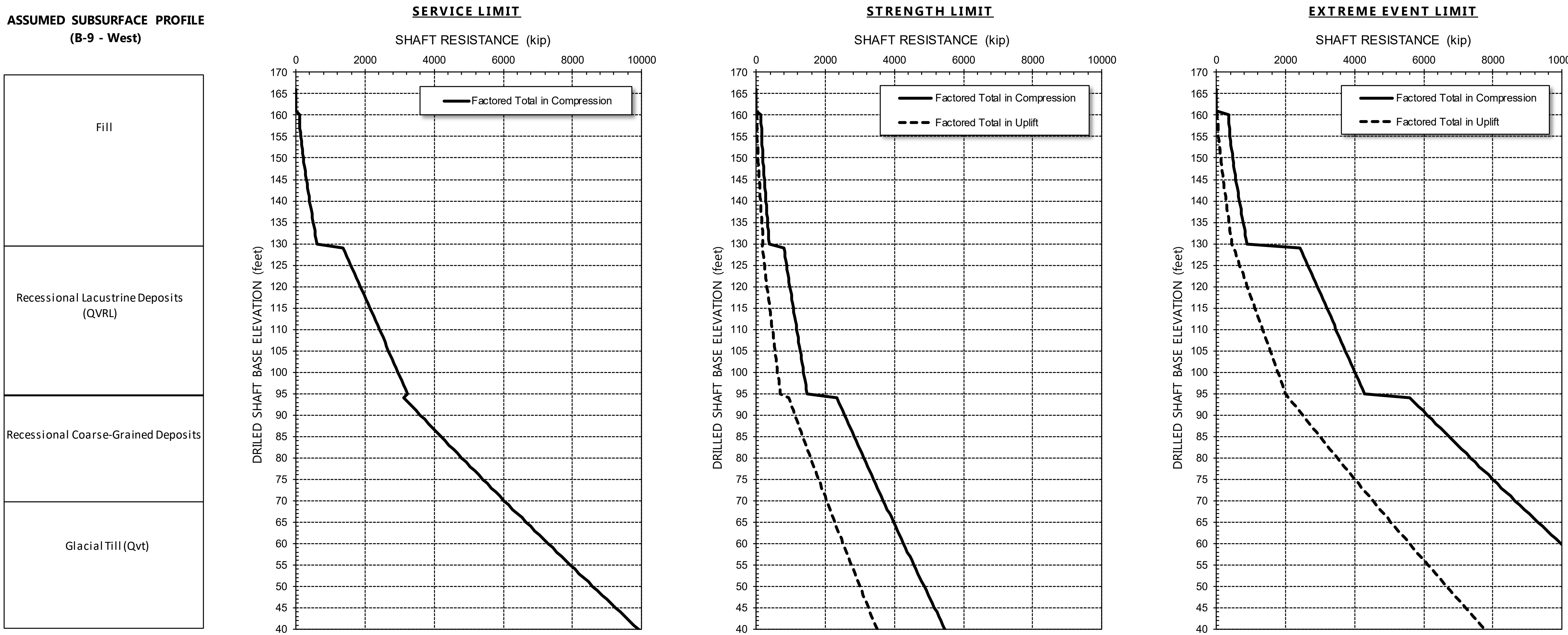
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 7

Drilled Shaft Axial Resistance Charts Pike_East_6.5ft Diameter

I-5 Lid Feasibility Study

Seattle, WA



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

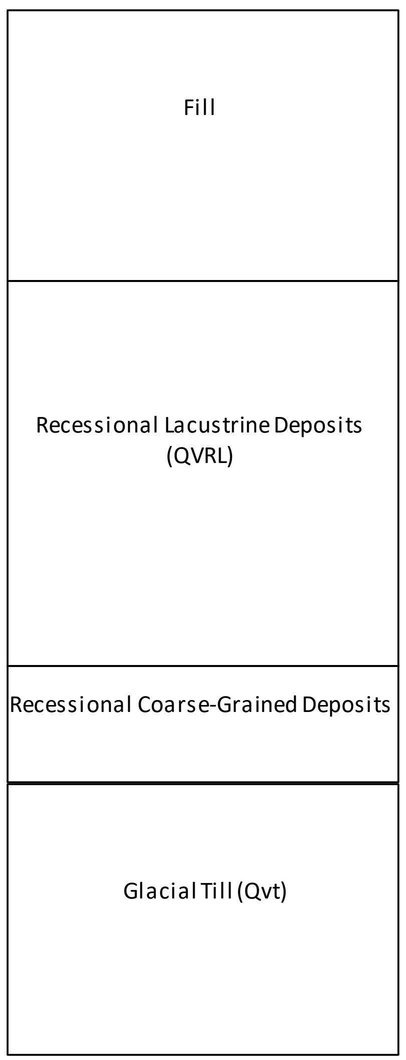
FIGURE 8

Drilled Shaft Axial Resistance Charts Pike_West_6.5ft Diameter

I-5 Lid Feasibility Study

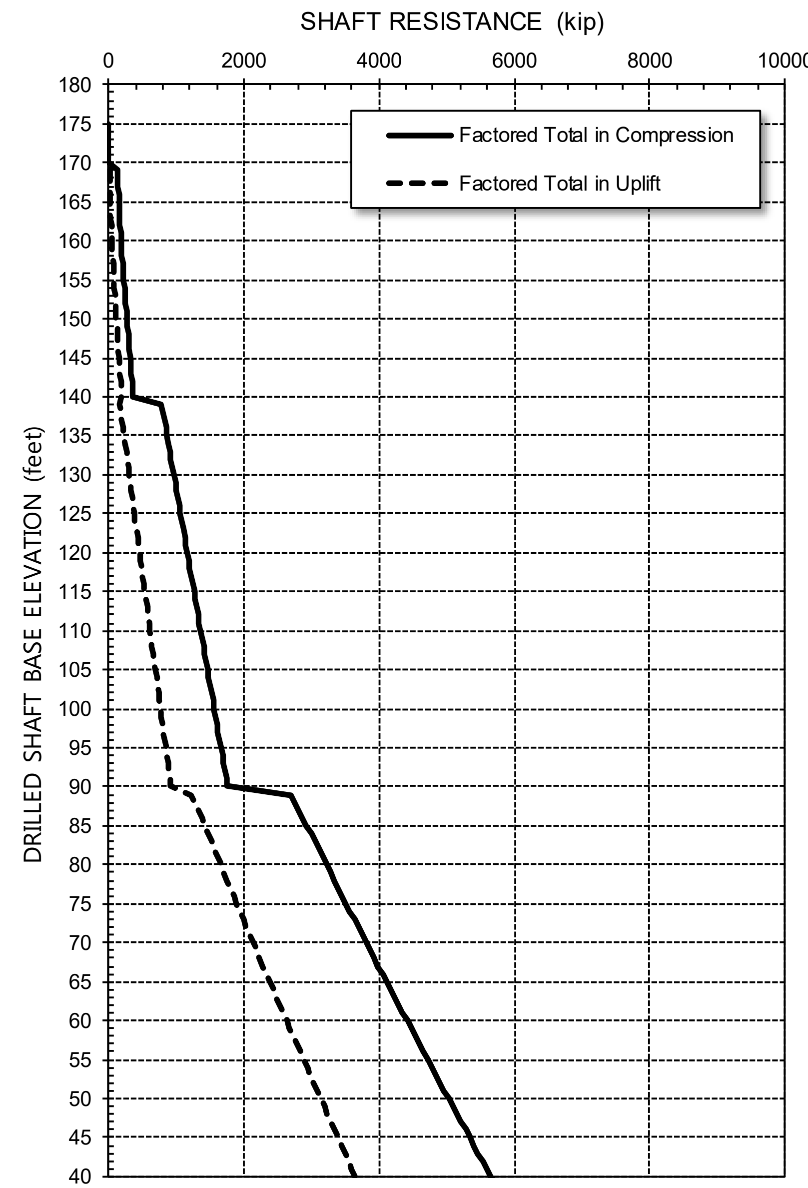
Seattle, WA

ASSUMED SUBSURFACE PROFILE
(B-1 - East)

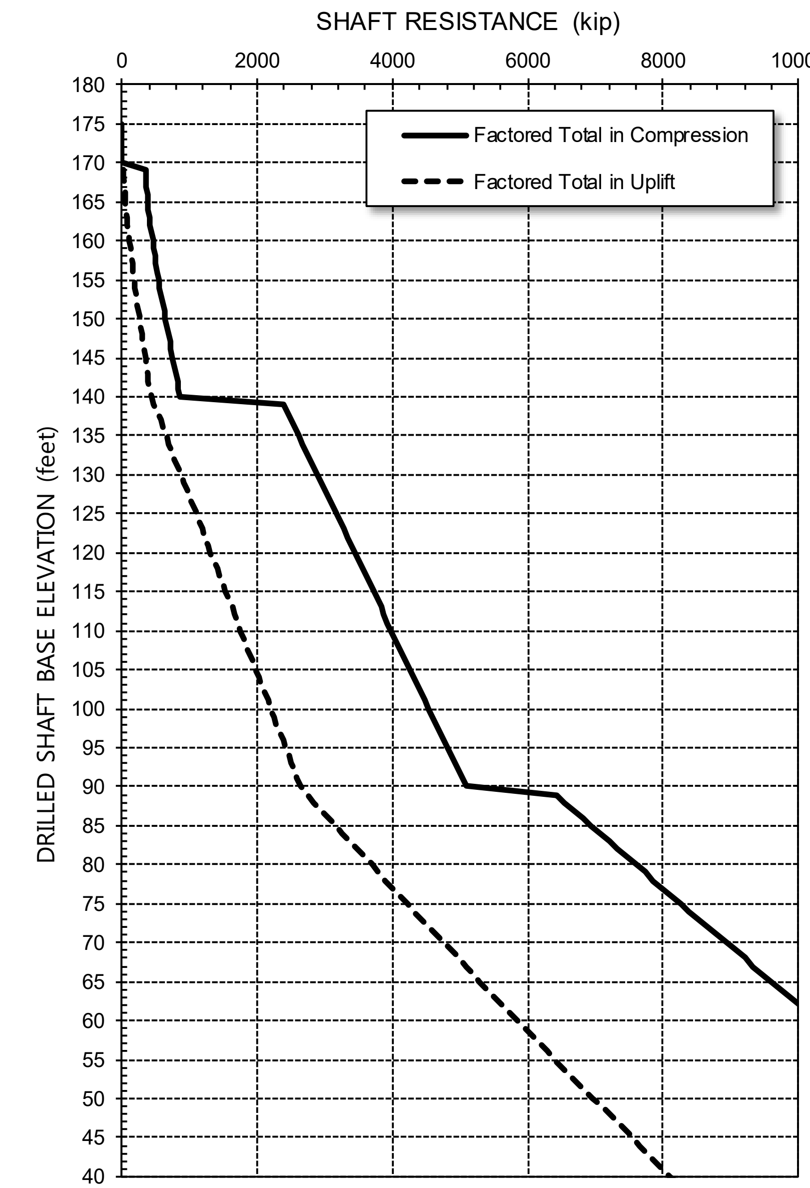


SERVICE LIMIT

STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

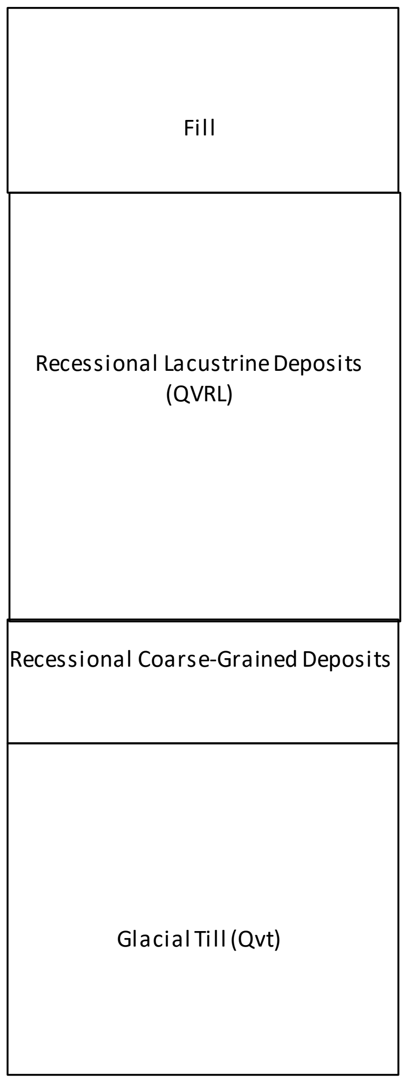
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

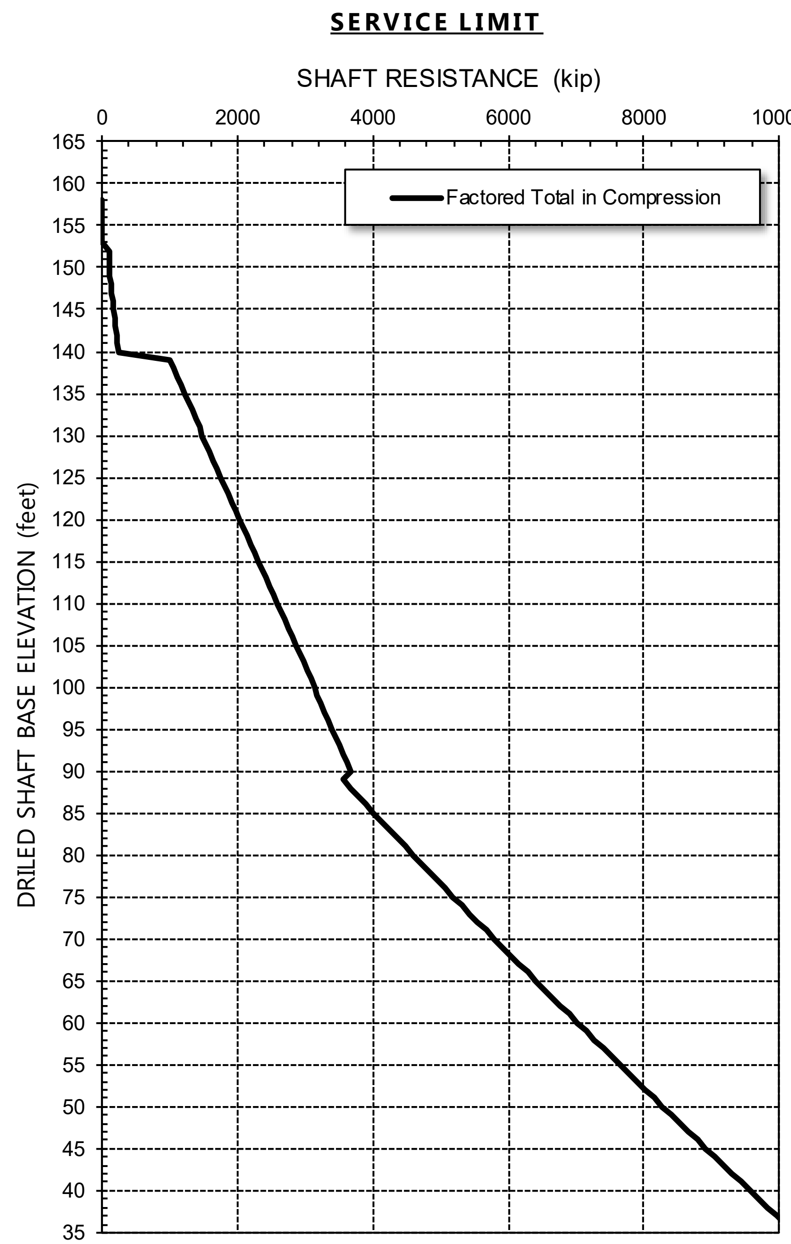
GENERAL NOTES:

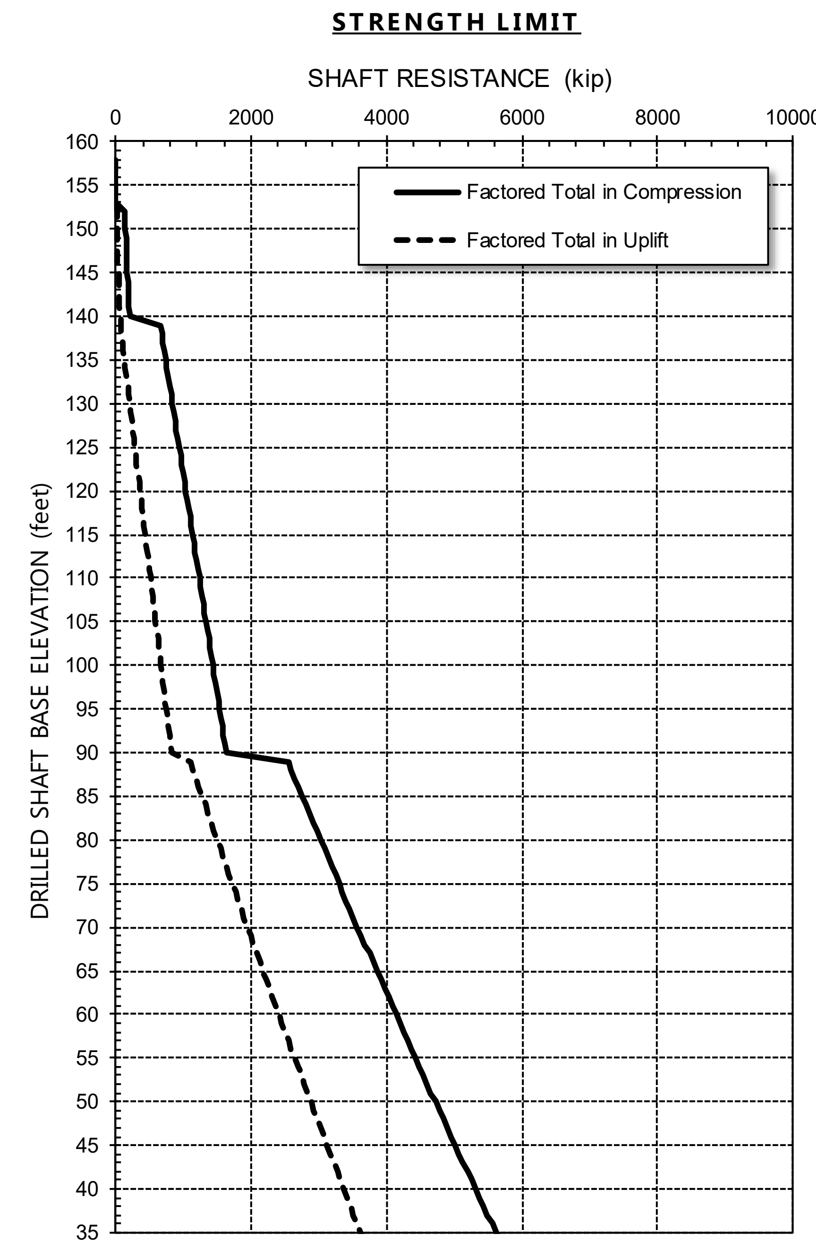
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

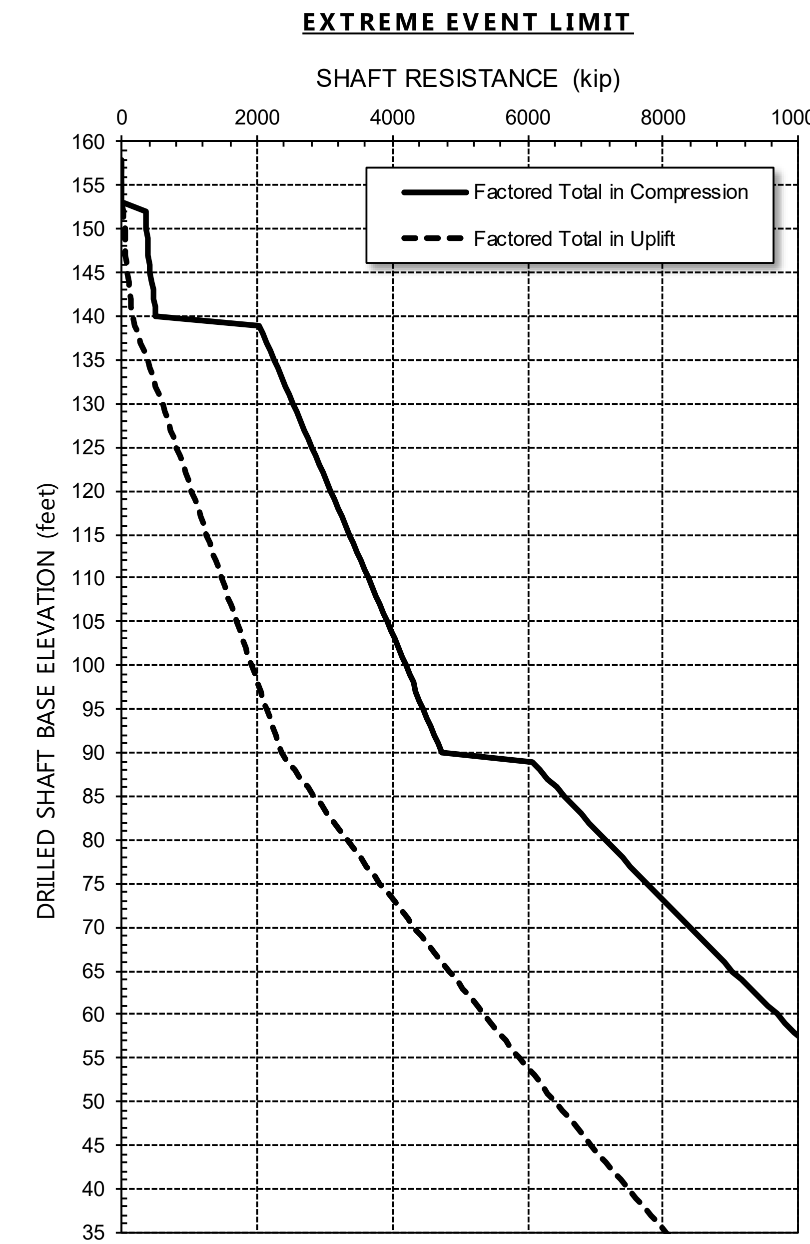
FIGURE 9
Drilled Shaft Axial Resistance Charts South Olive_East_6.5ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

ASSUMED SUBSURFACE PROFILE
(B-1 - West)









SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

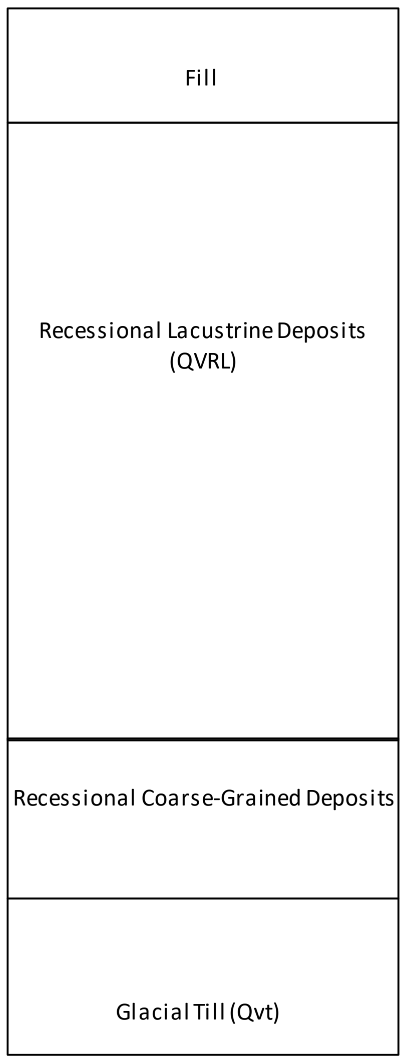
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

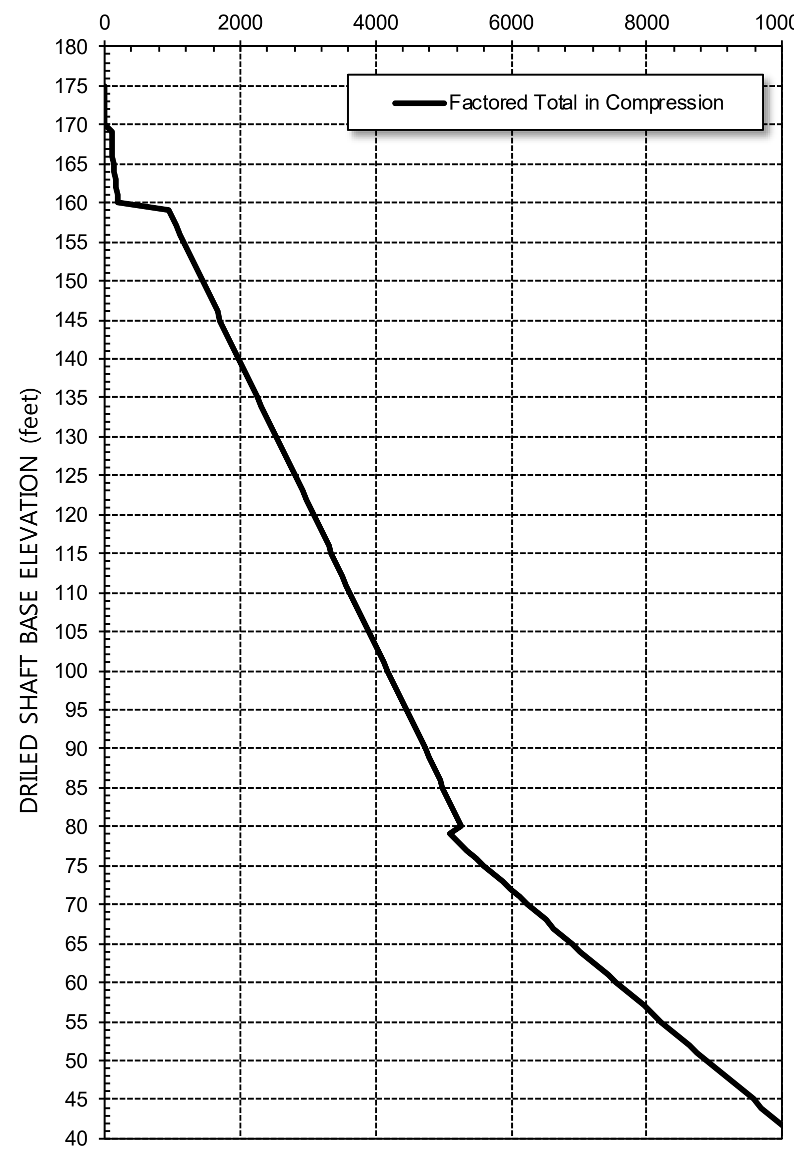
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 10
Drilled Shaft Axial Resistance Charts South Olive_West_6.5ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

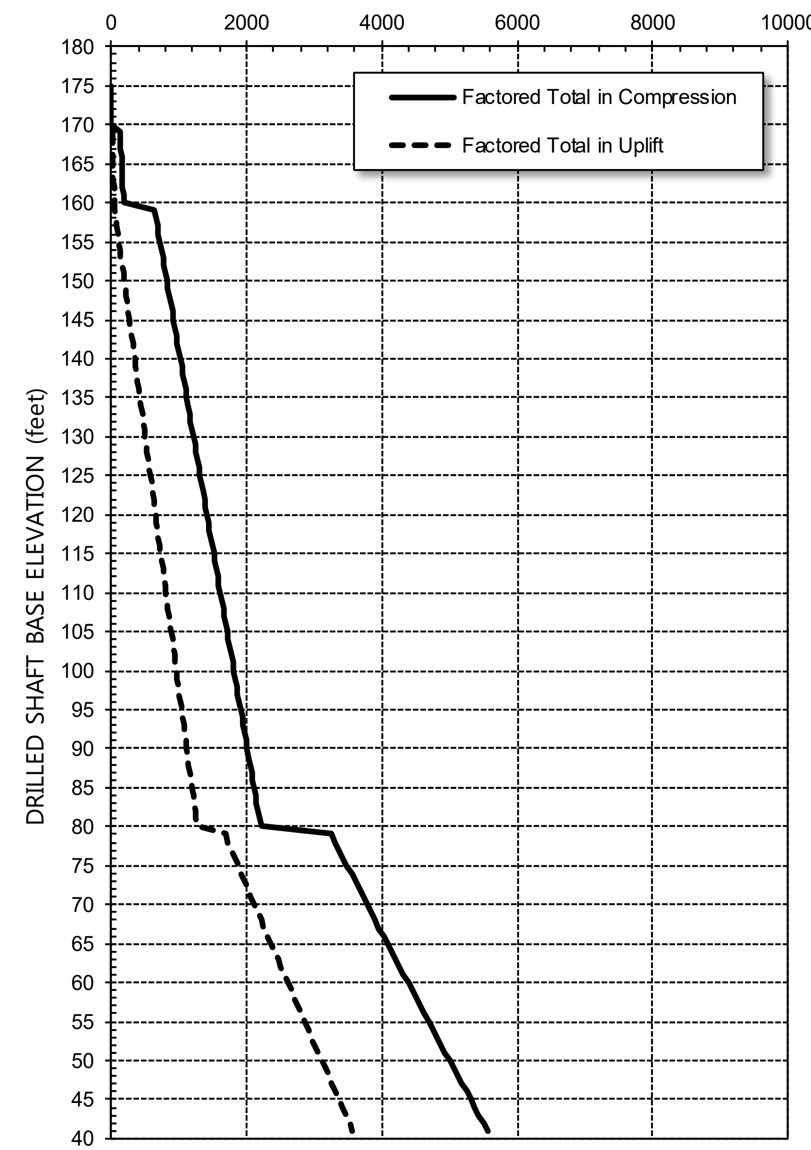
ASSUMED SUBSURFACE PROFILE
(237 - East)



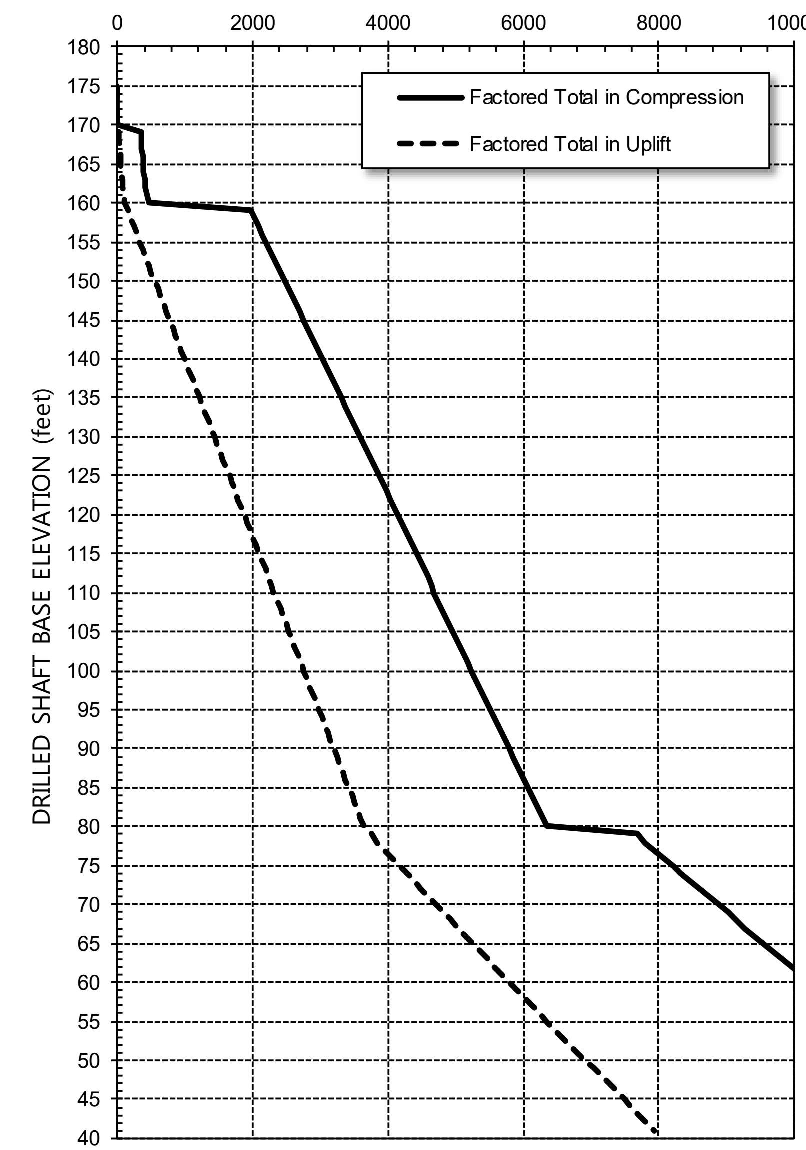
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

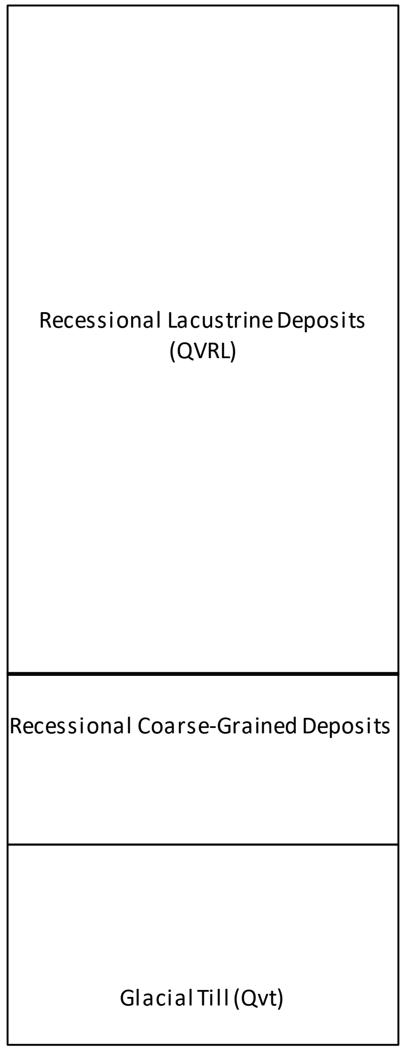
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

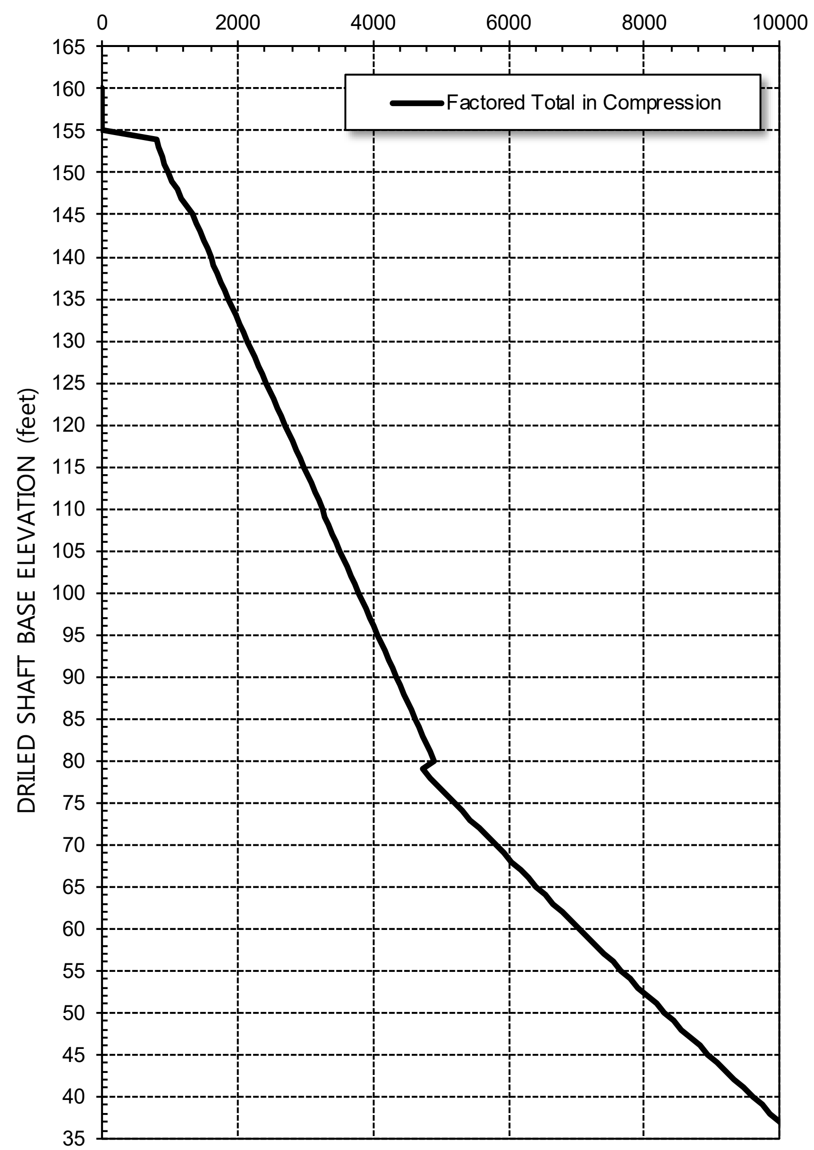
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 11
Drilled Shaft Axial Resistance Charts North Olive_East_6.5ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

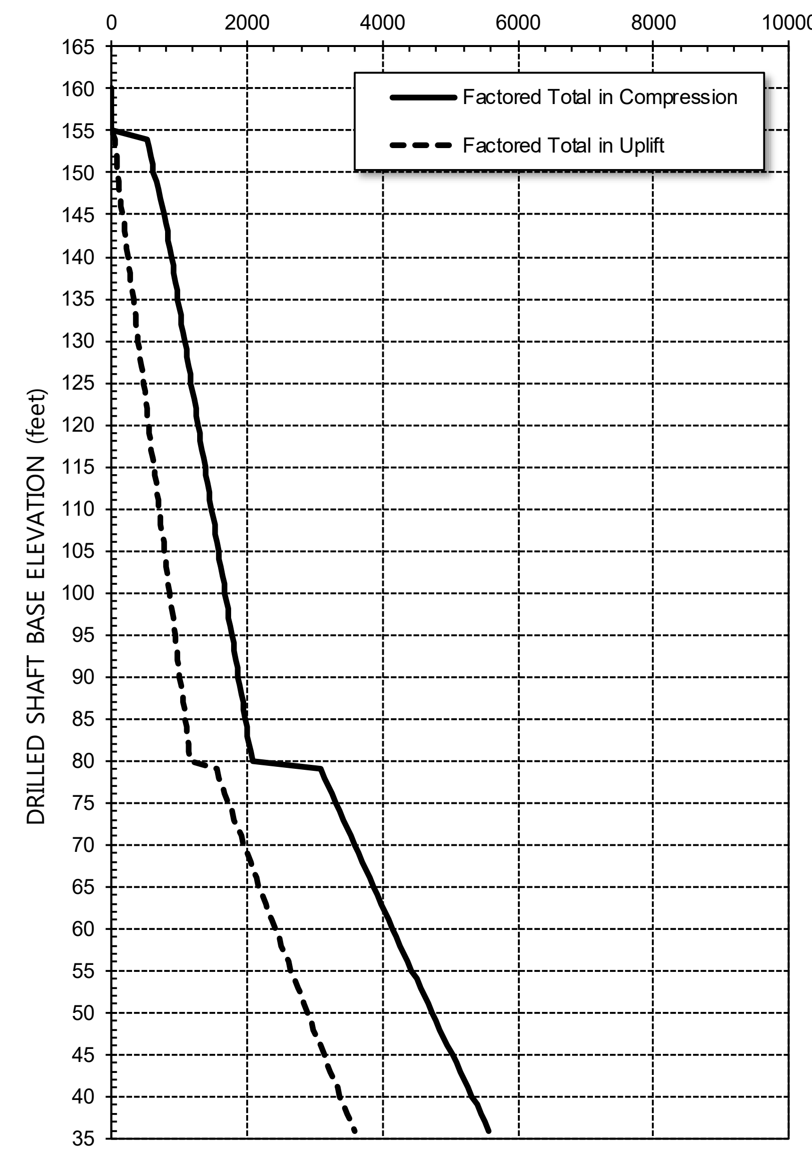
ASSUMED SUBSURFACE PROFILE
(237 - West)



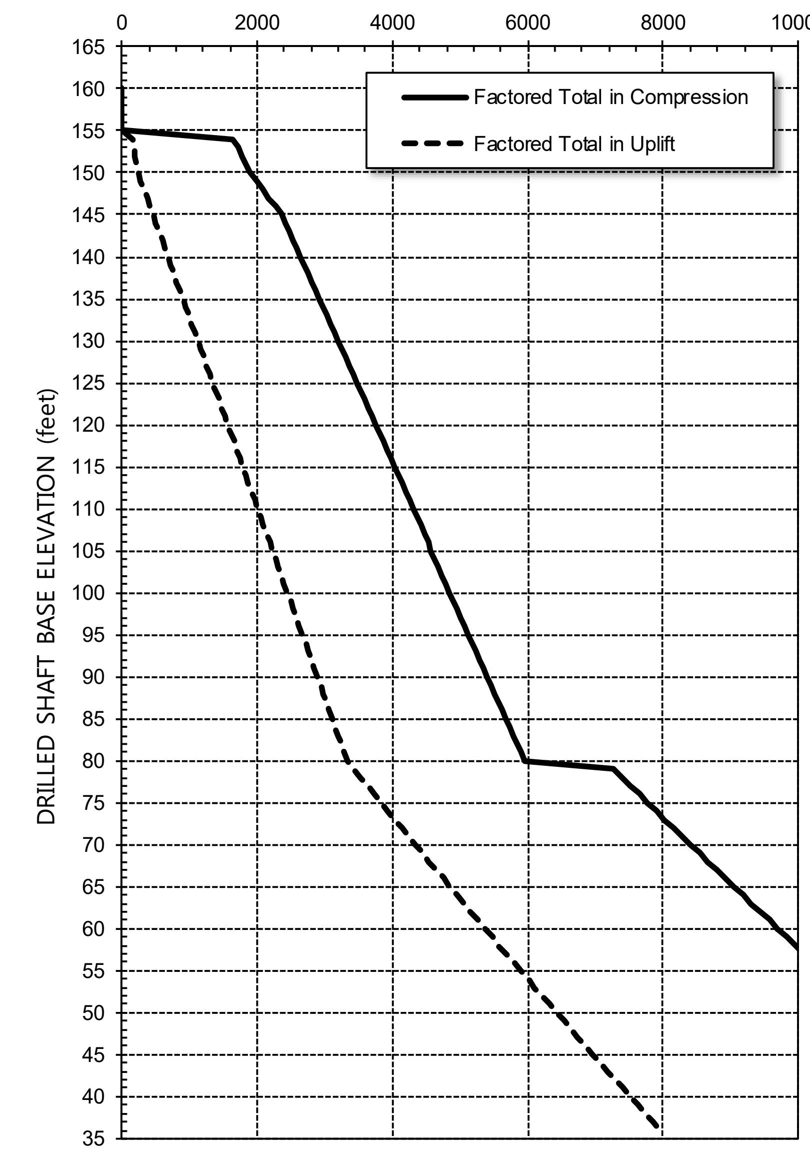
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

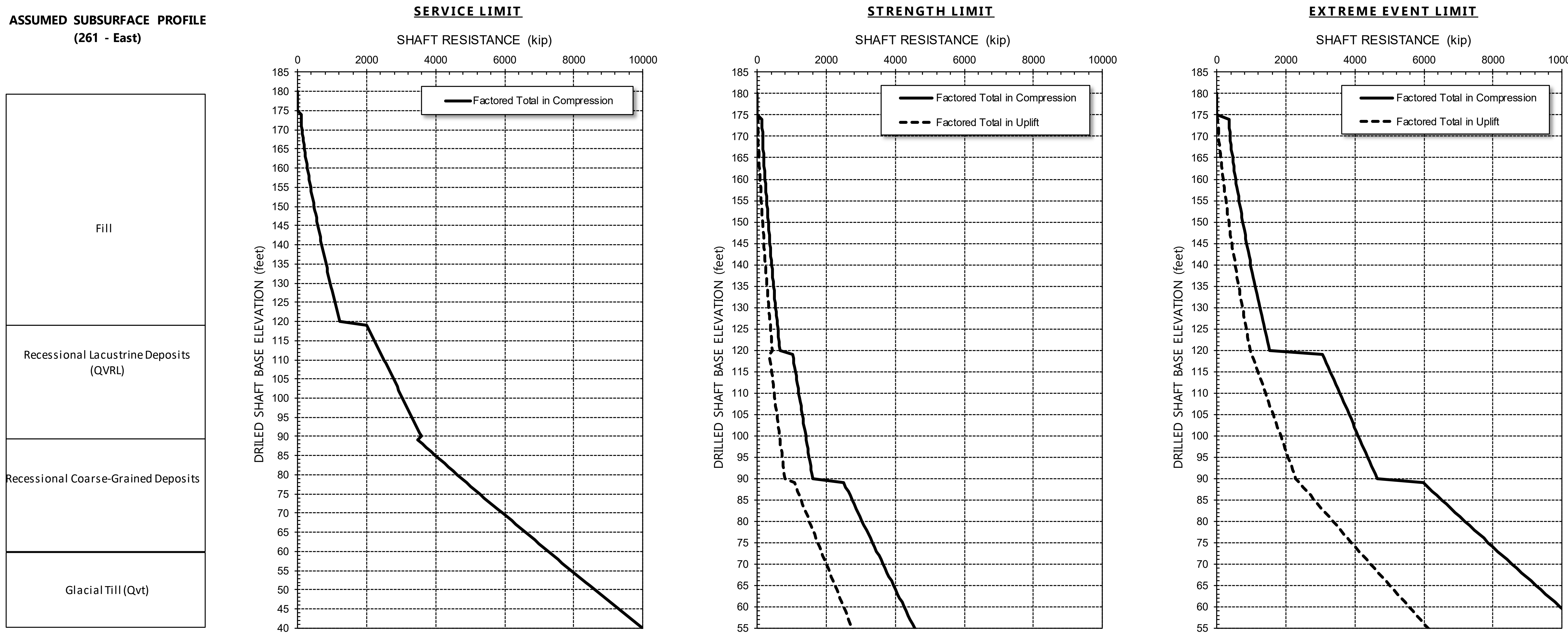
EXTREME EVENT LIMIT NOTES:

1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 12
Drilled Shaft Axial Resistance Charts North Olive_West_6.5ft Diameter
I-5 Lid Feasibility Study
Seattle, WA



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

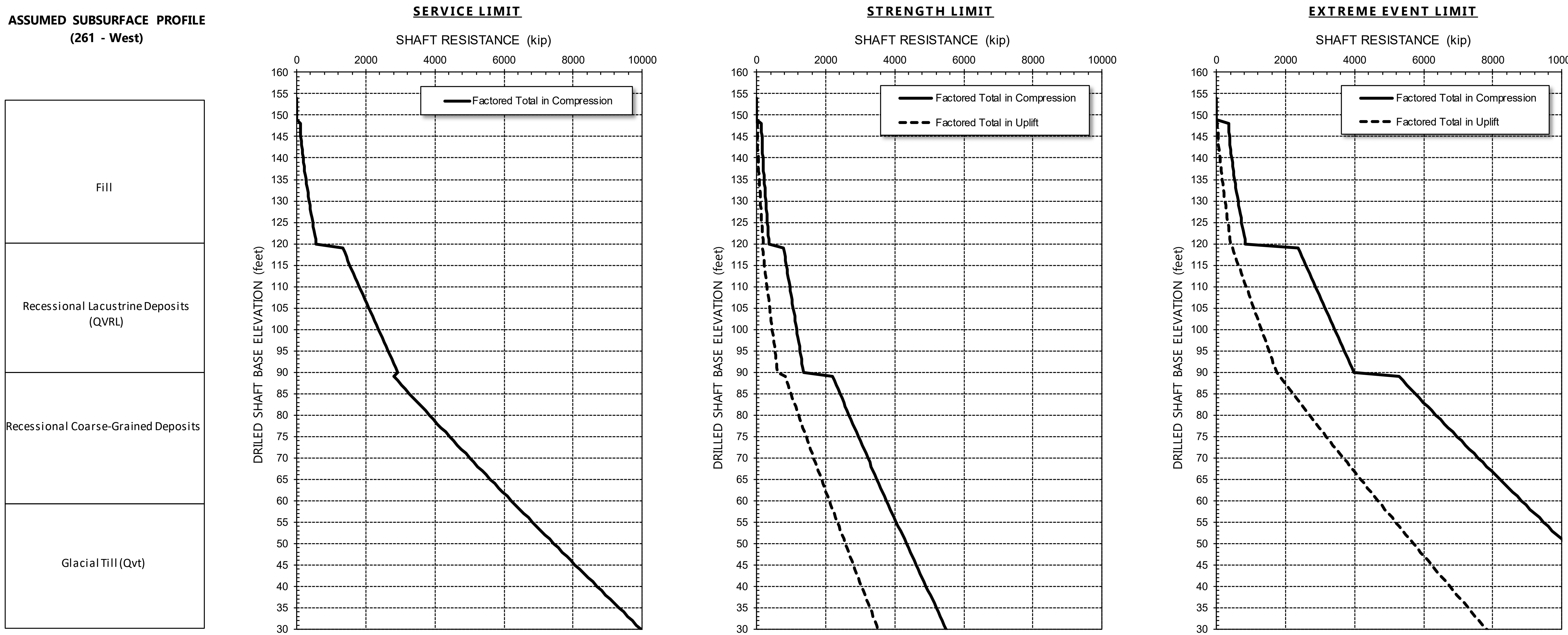
EXTREME EVENT LIMIT NOTES:

1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 13
Drilled Shaft Axial Resistance Charts Denny_East_6.5ft Diameter
I-5 Lid Feasibility Study
Seattle, WA



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

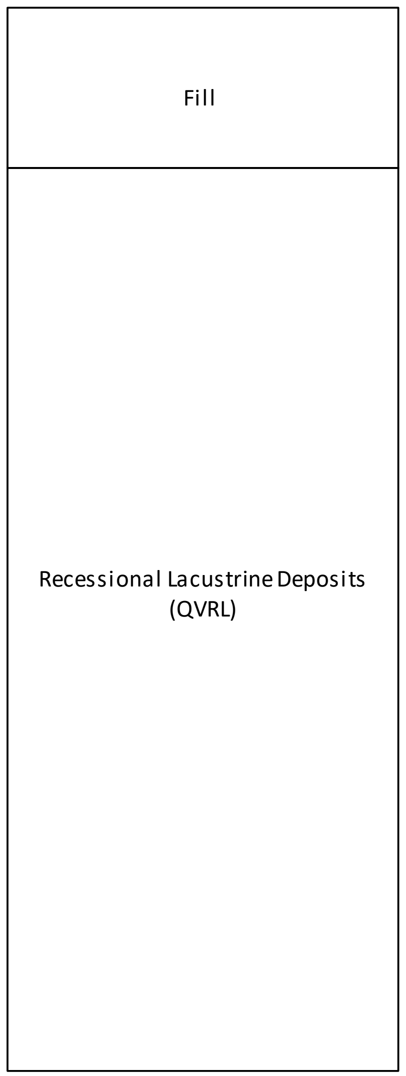
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

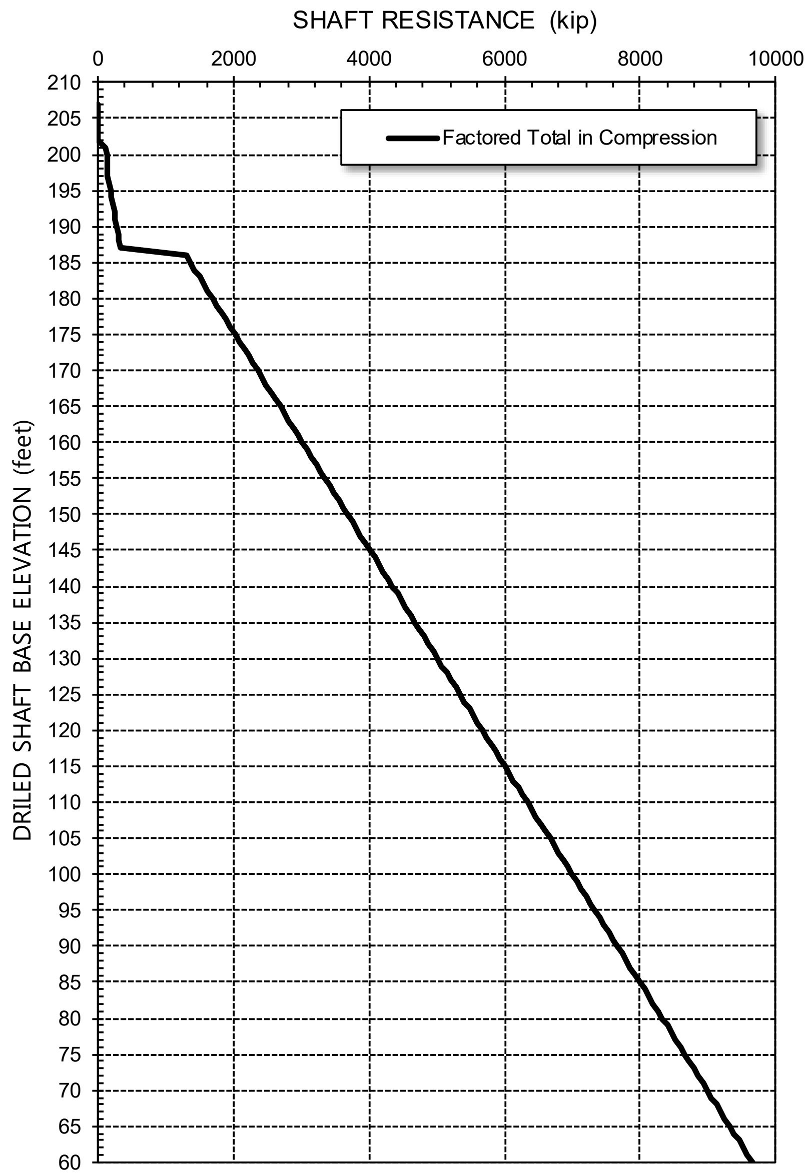
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 14
Drilled Shaft Axial Resistance Charts Denny_West_6.5ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

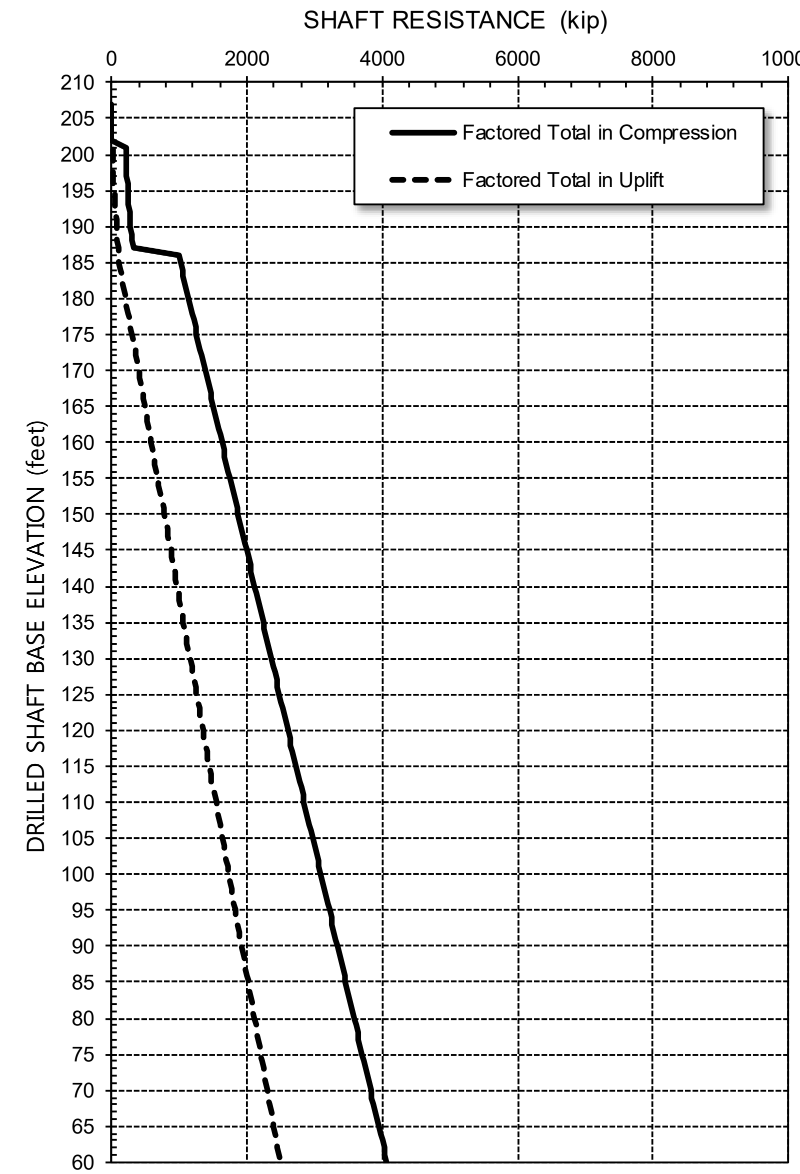
ASSUMED SUBSURFACE PROFILE
(525 - East)



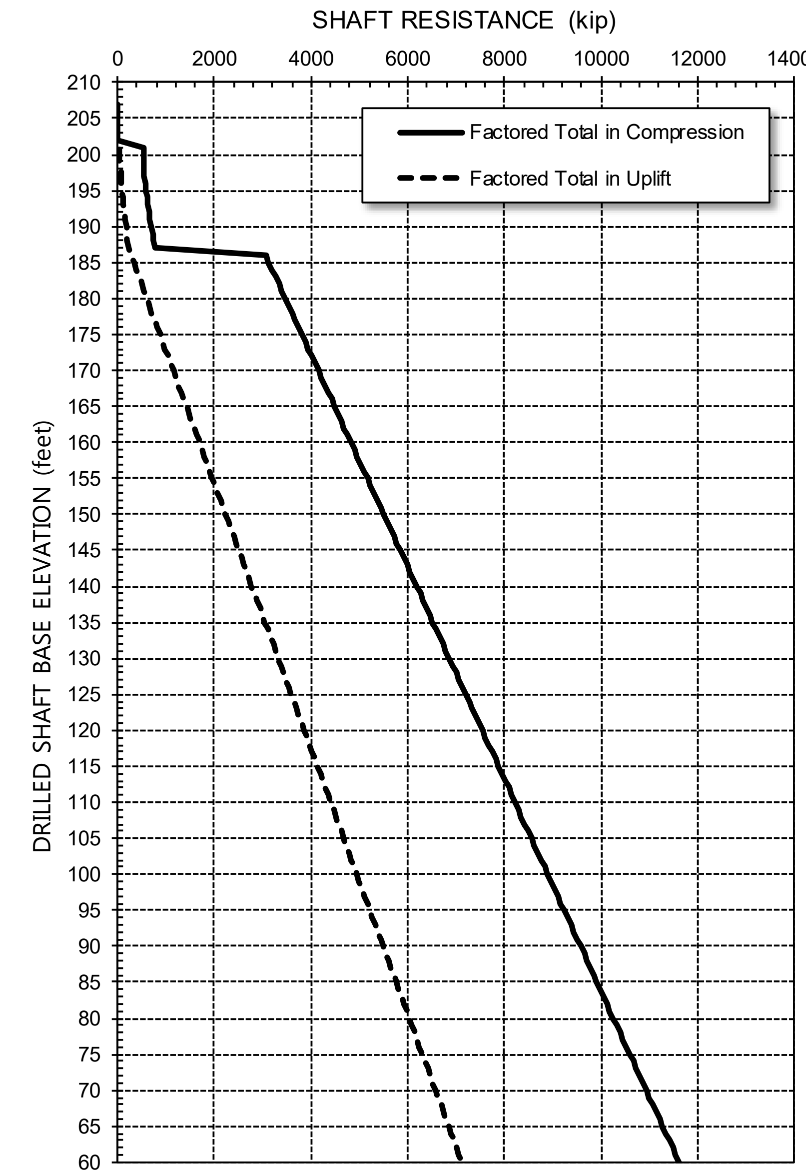
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:
1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

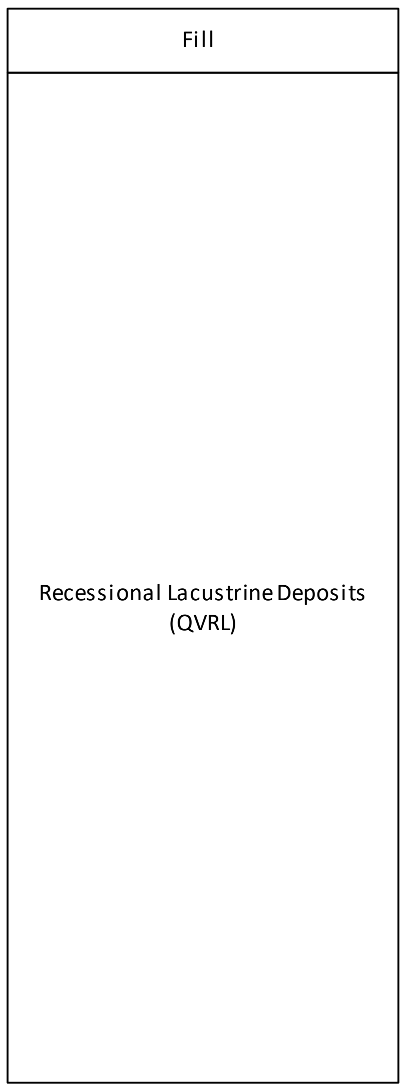
STRENGTH LIMIT NOTES:
1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

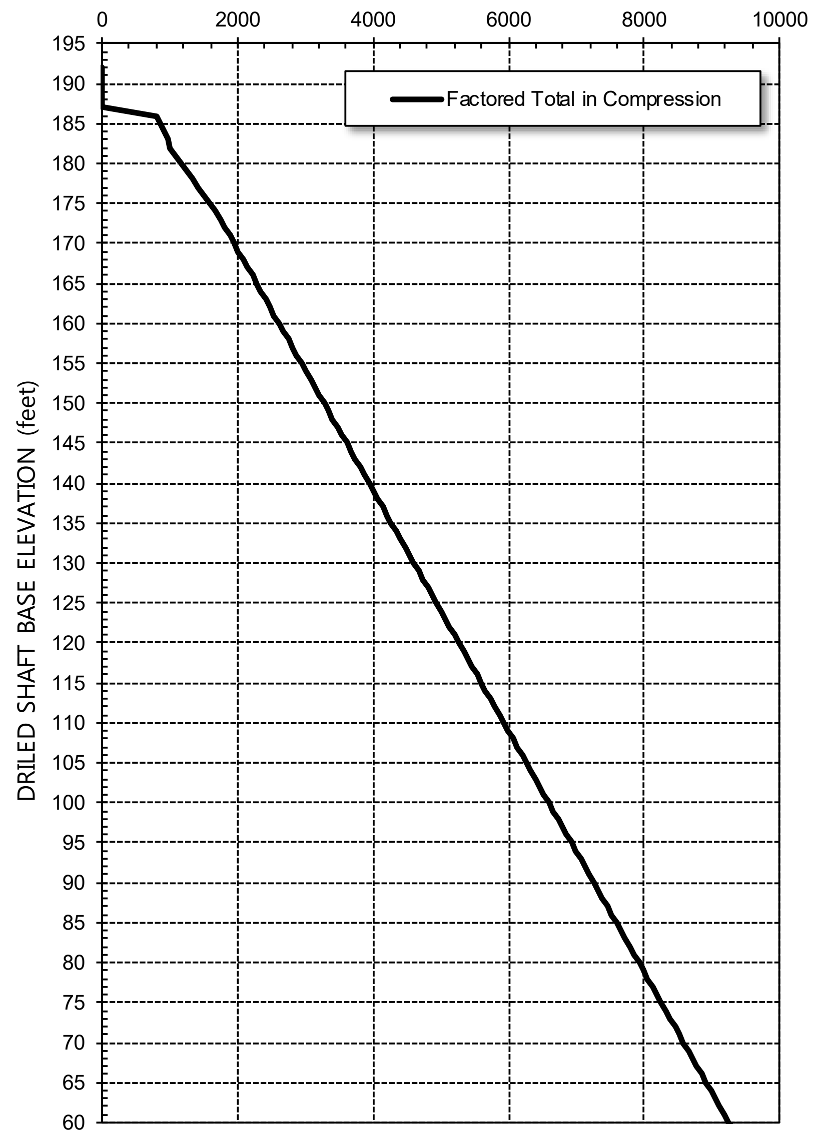
GENERAL NOTES:
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 1
Drilled Shaft Axial Resistance Charts Seneca_East_8ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

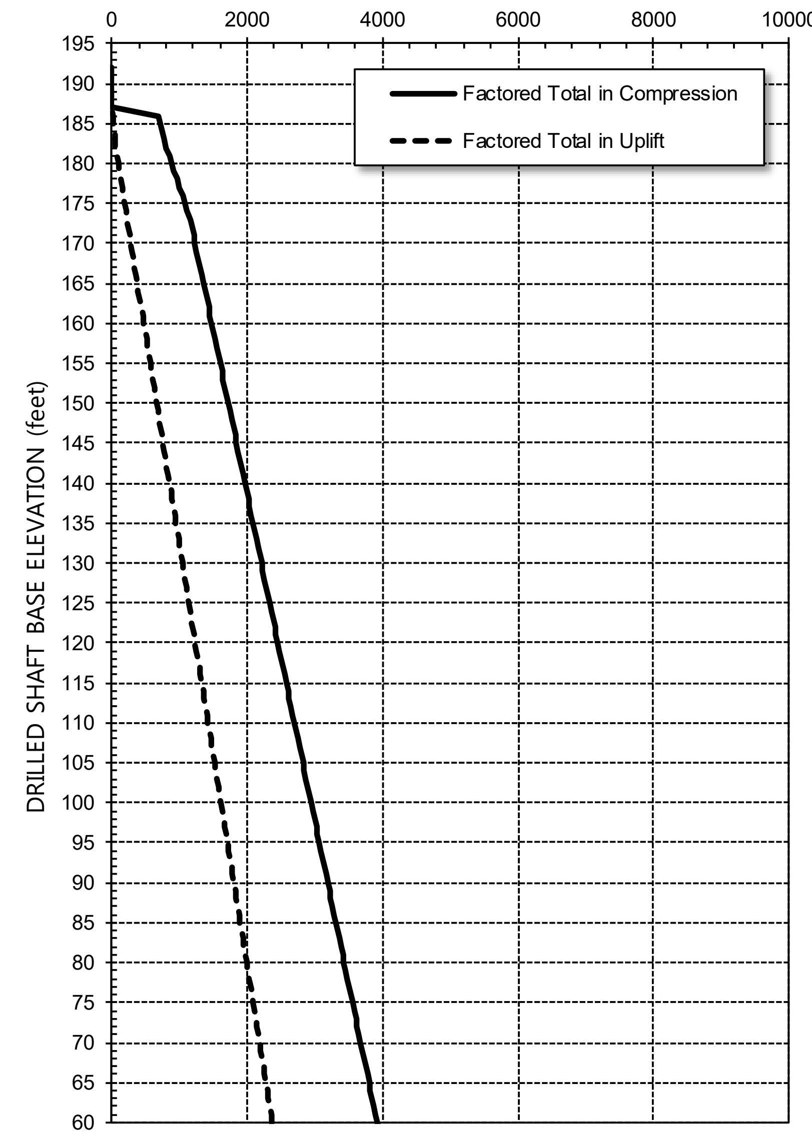
ASSUMED SUBSURFACE PROFILE
(525 - West)



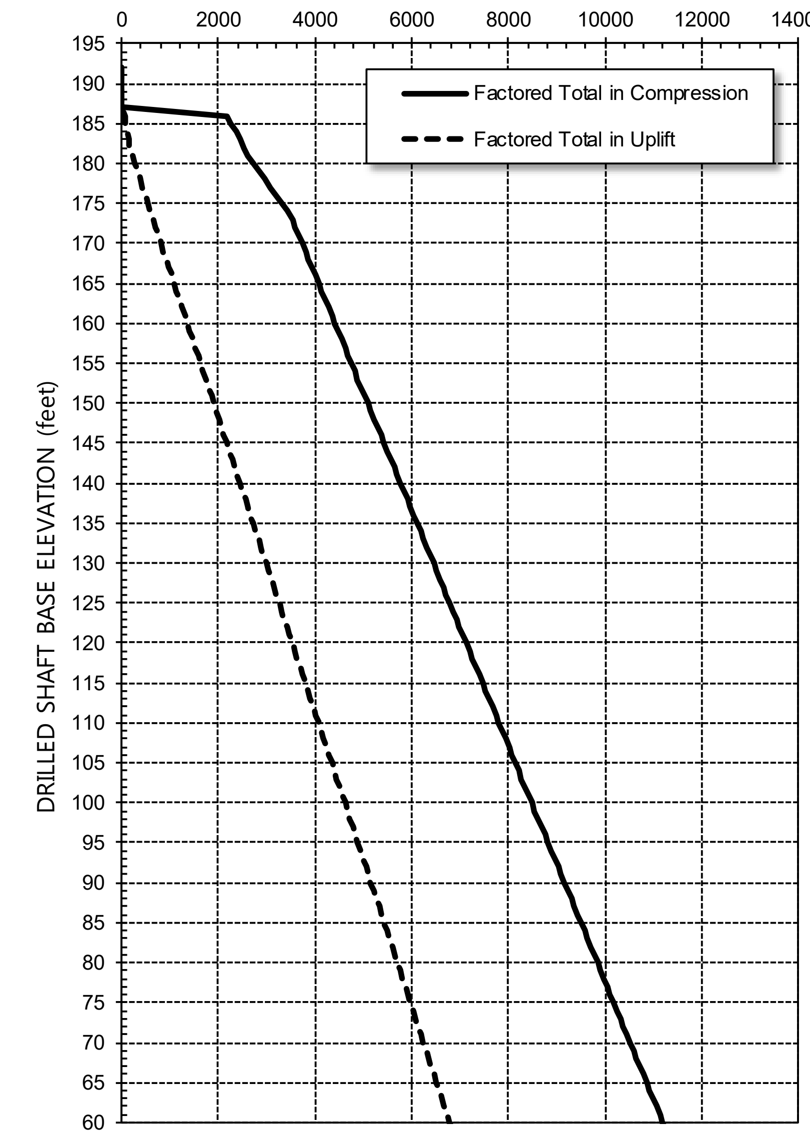
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

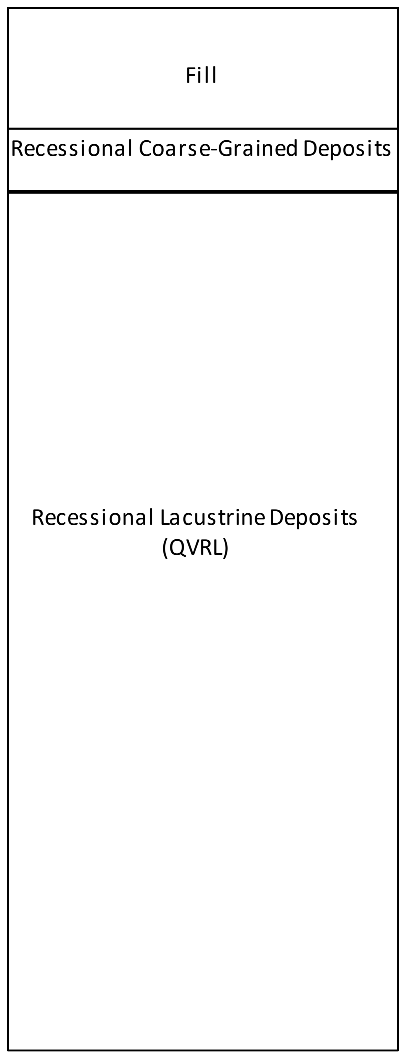
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

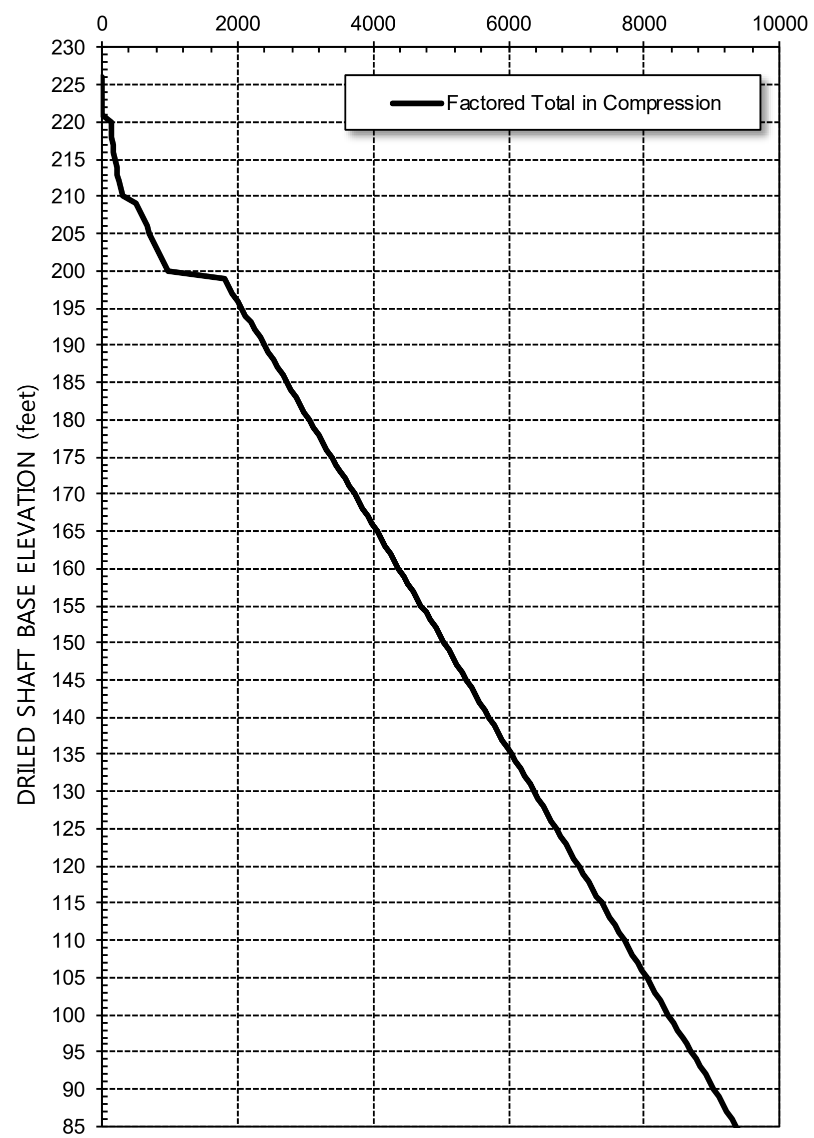
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 2
Drilled Shaft Axial Resistance Charts Seneca_West_8ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

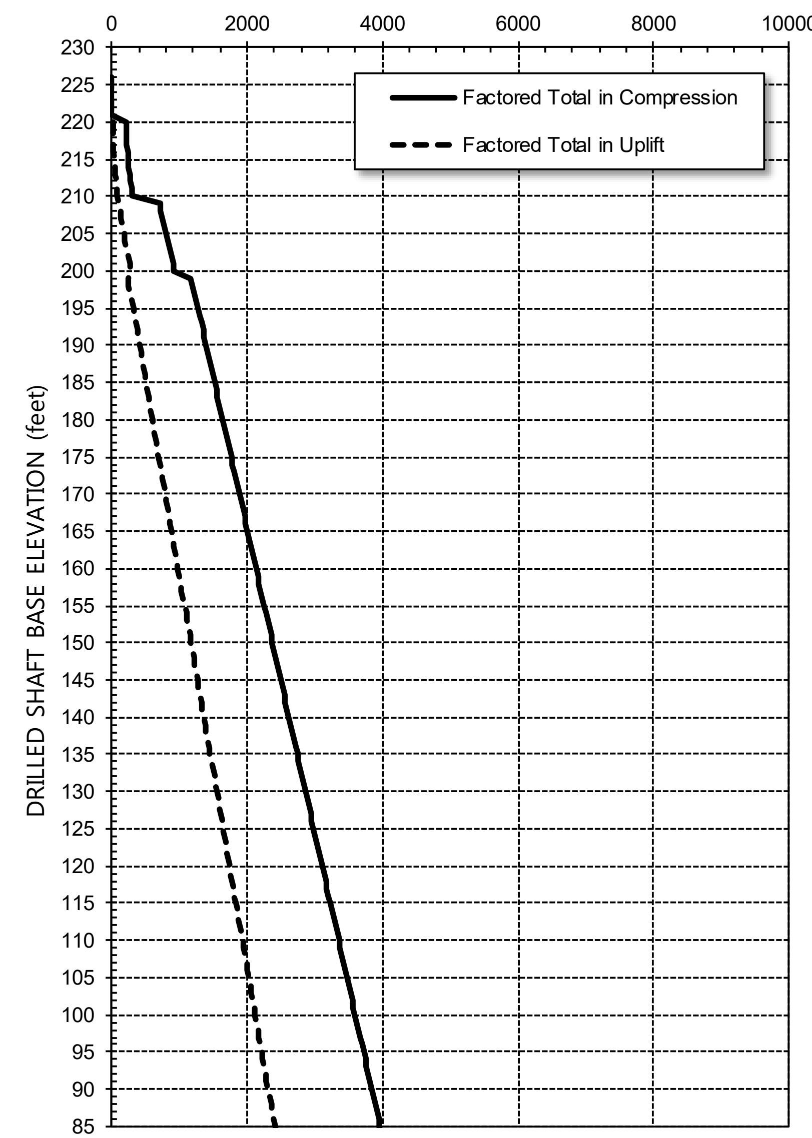
ASSUMED SUBSURFACE PROFILE
(X-9 - East Side)



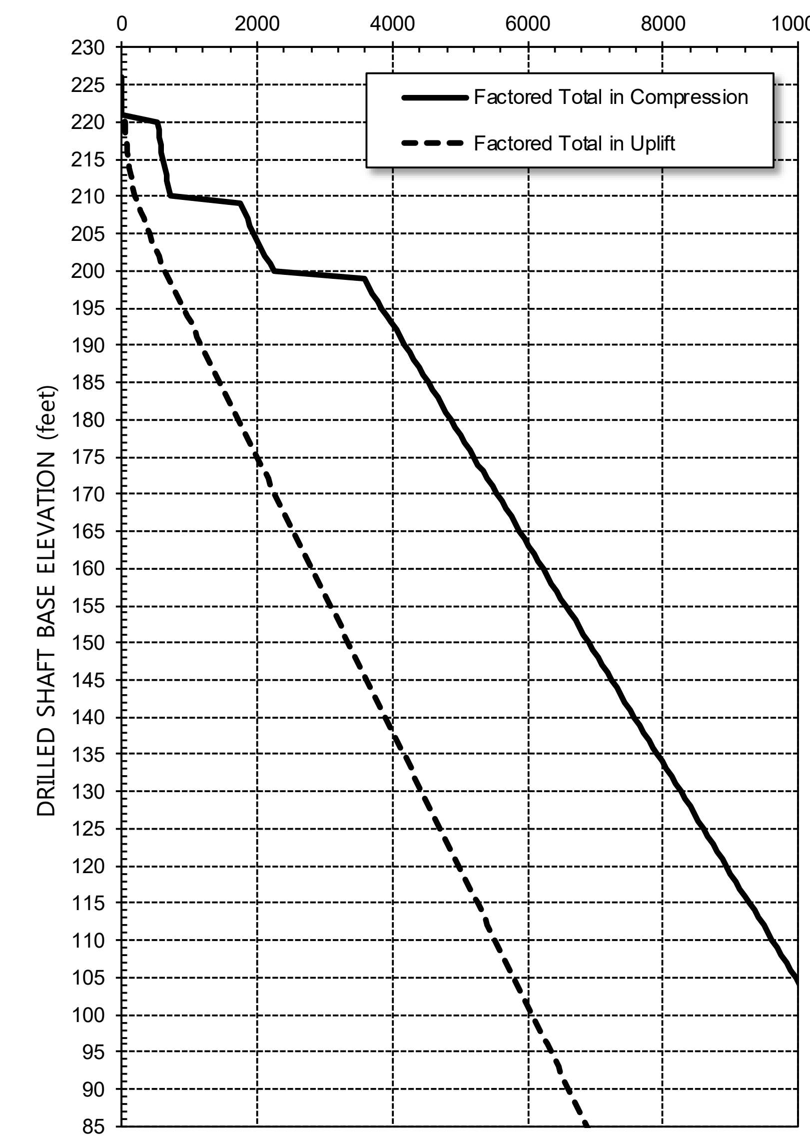
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

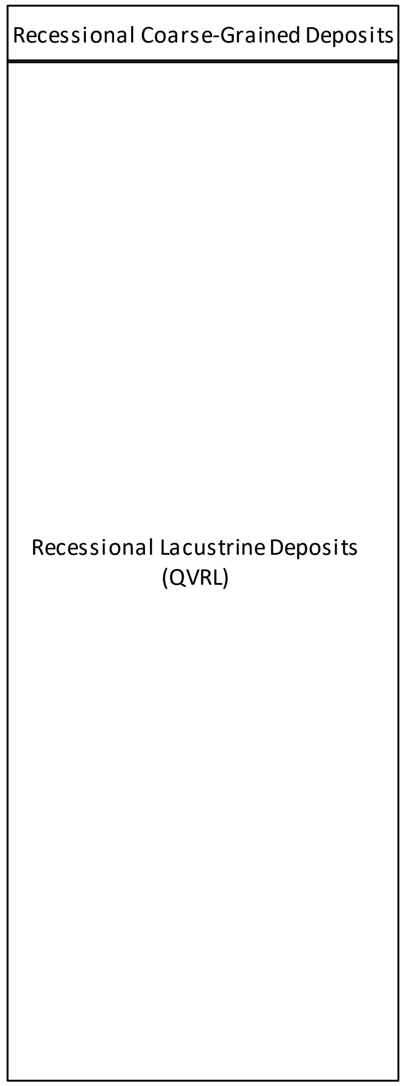
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

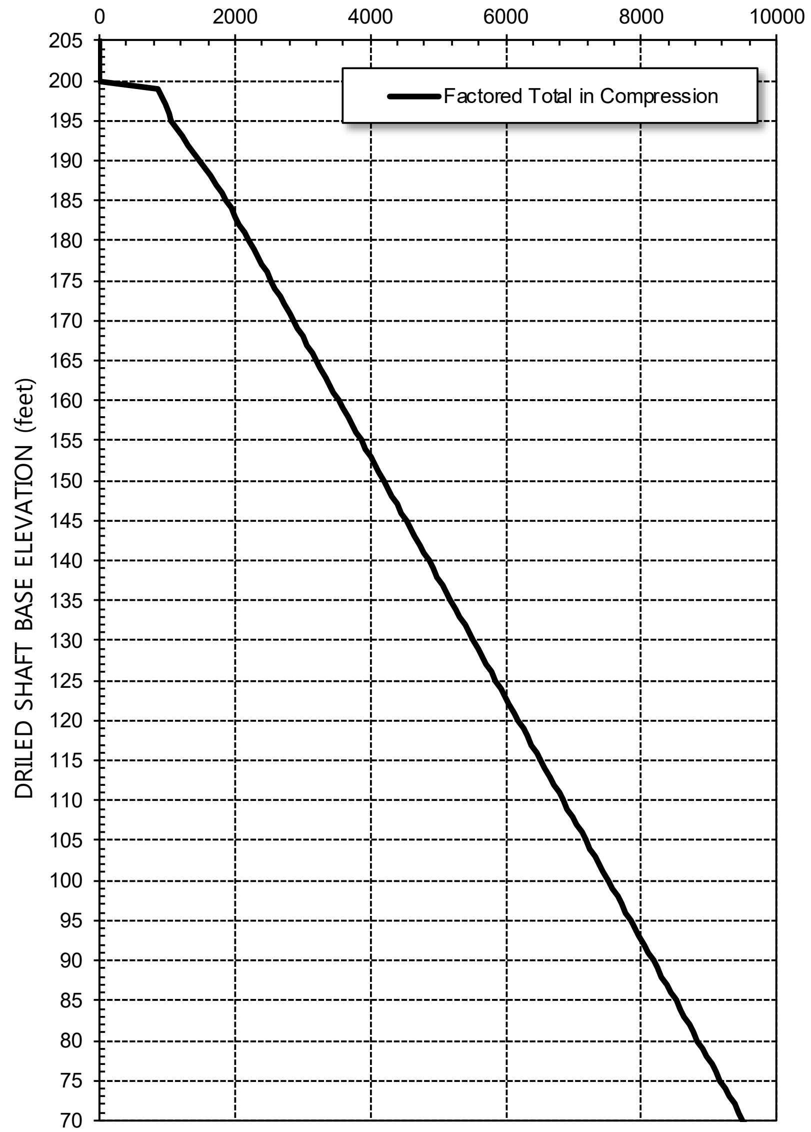
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 3
Drilled Shaft Axial Resistance Charts Spring_East_8ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

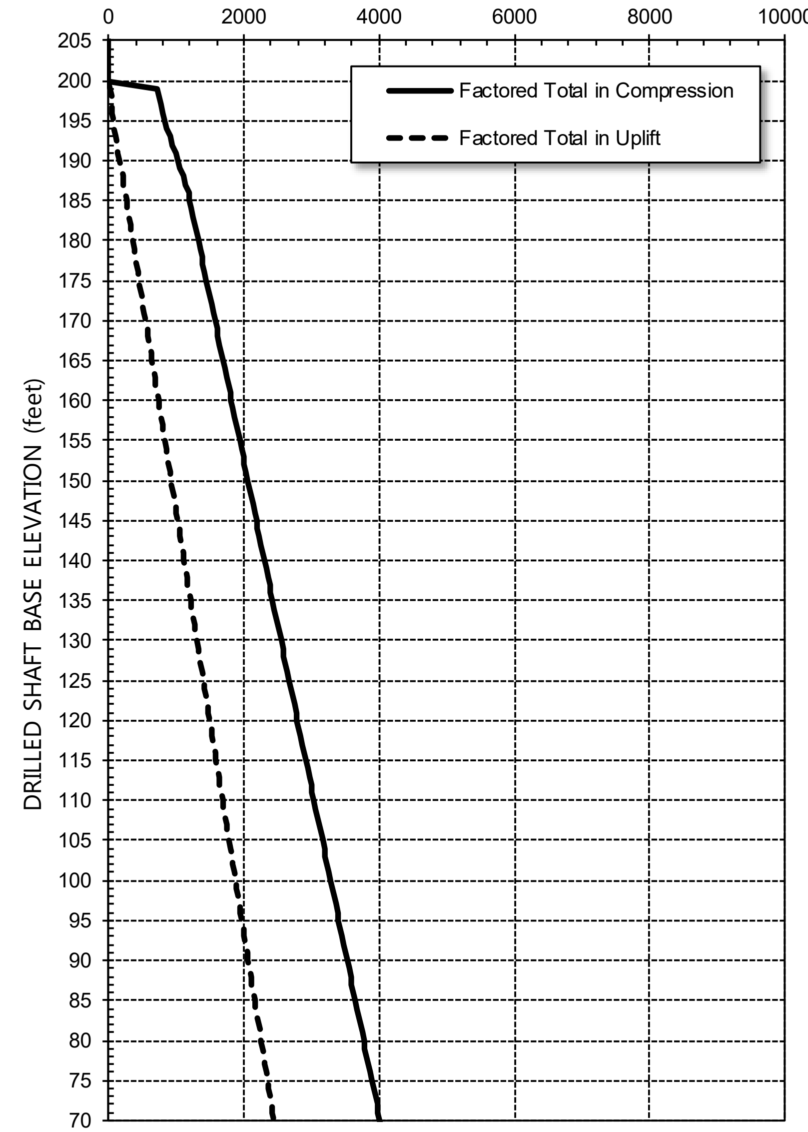
ASSUMED SUBSURFACE PROFILE
(X-9 - West Side)



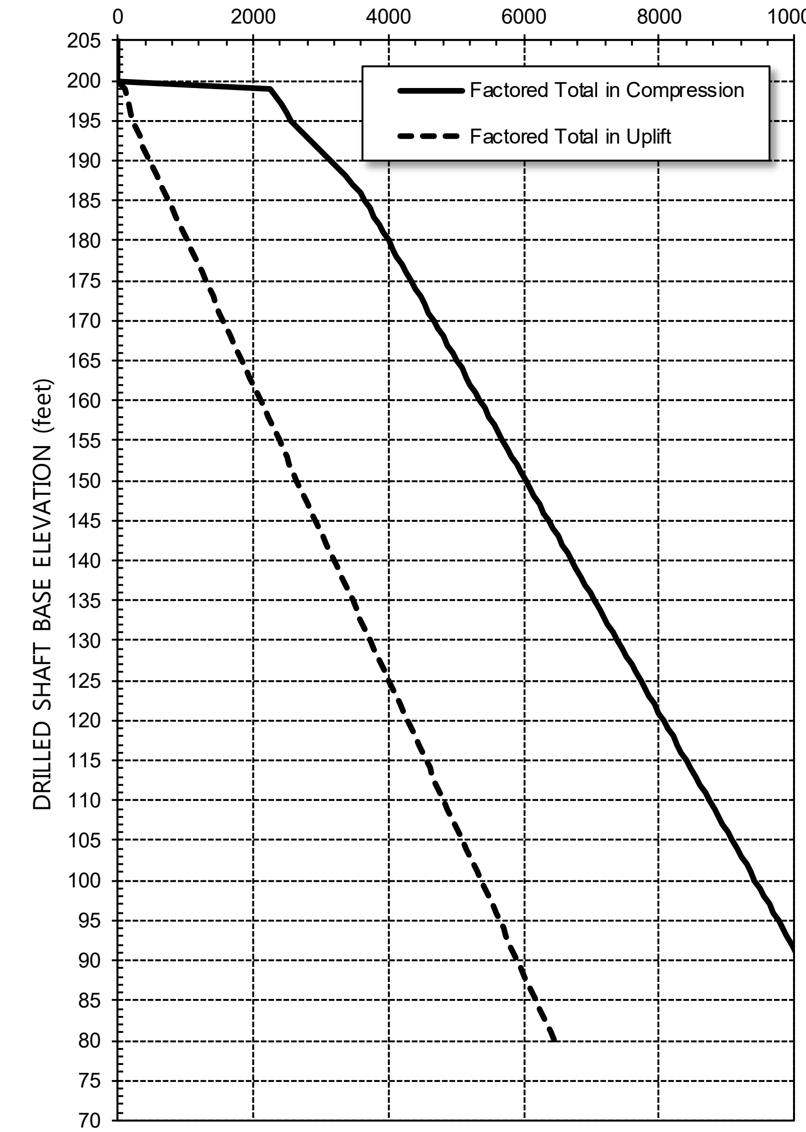
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

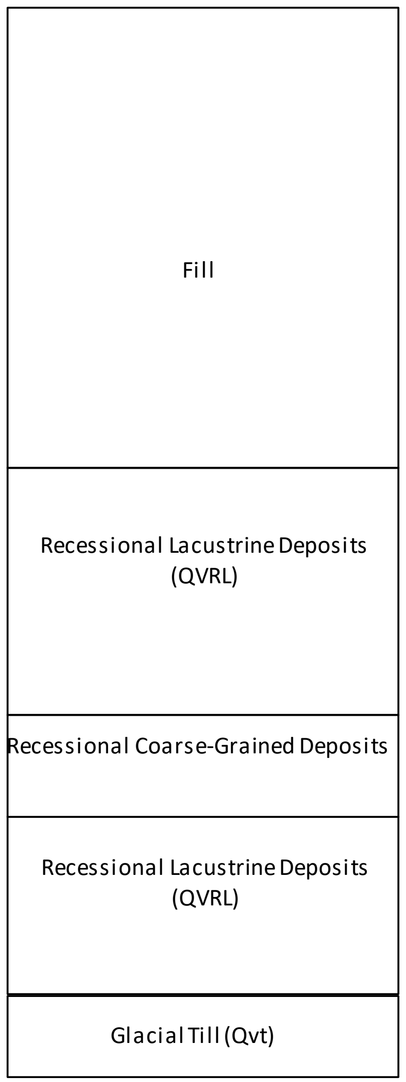
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

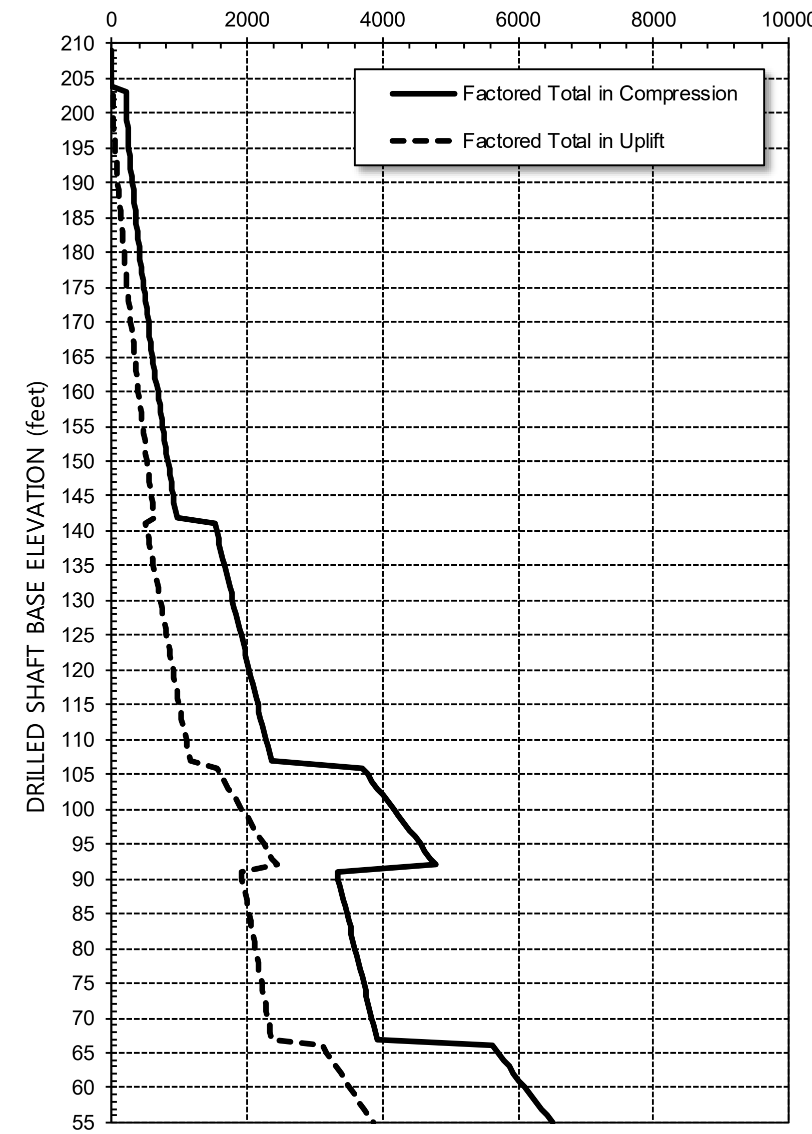
FIGURE 4
Drilled Shaft Axial Resistance Charts Spring_West_8ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

ASSUMED SUBSURFACE PROFILE
(B-19 East)

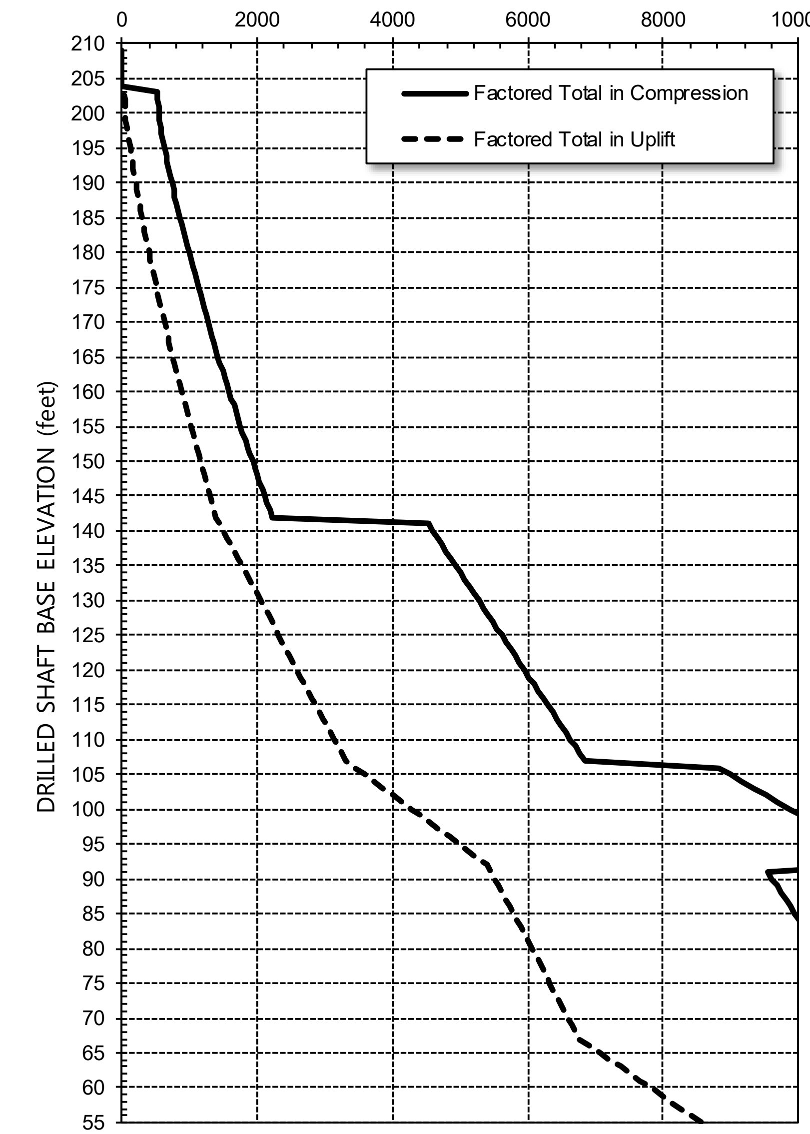


SERVICE LIMIT

STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:
1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

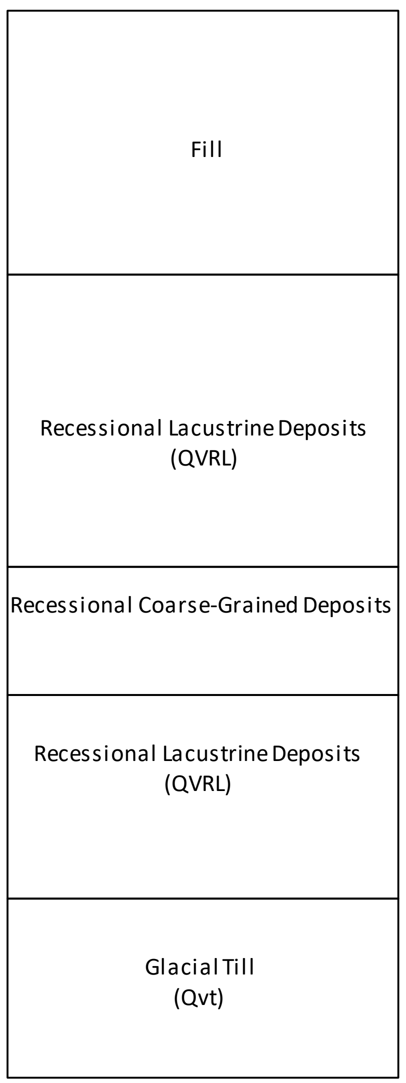
STRENGTH LIMIT NOTES:
1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

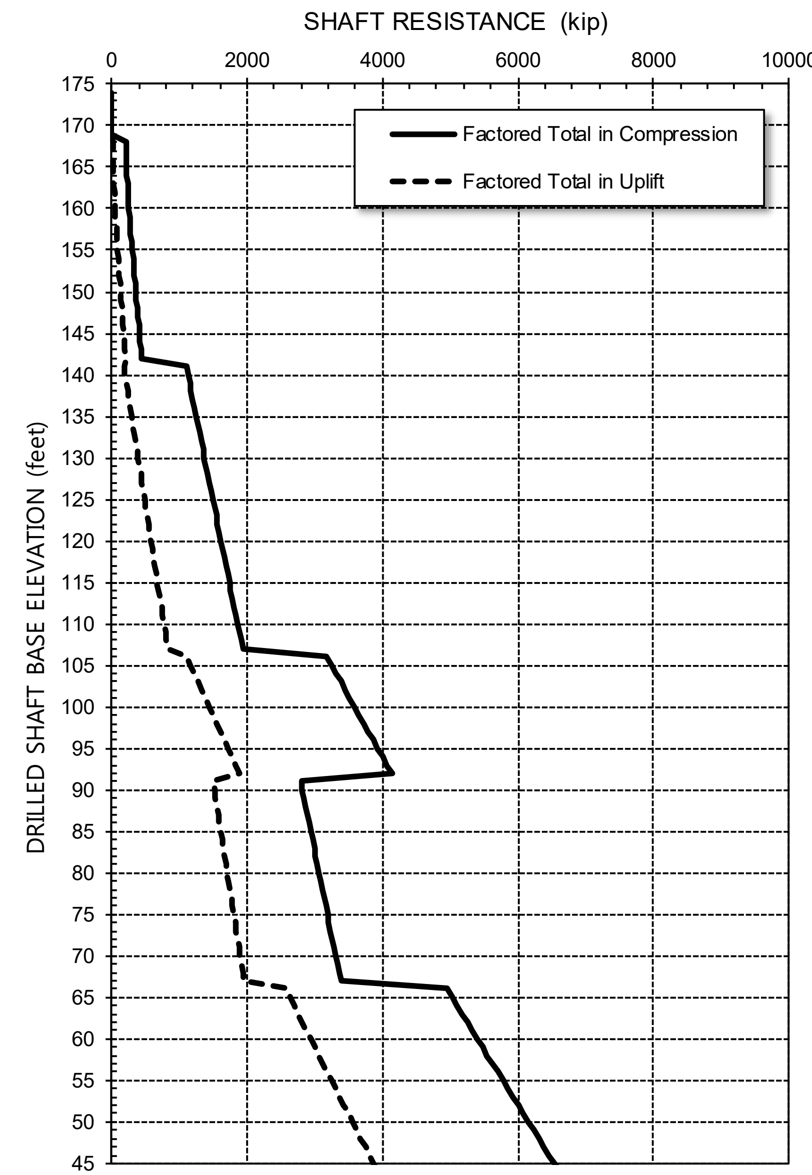
FIGURE 5
Drilled Shaft Axial Resistance Charts 8th_East_8ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

ASSUMED SUBSURFACE PROFILE
(B-19 West)

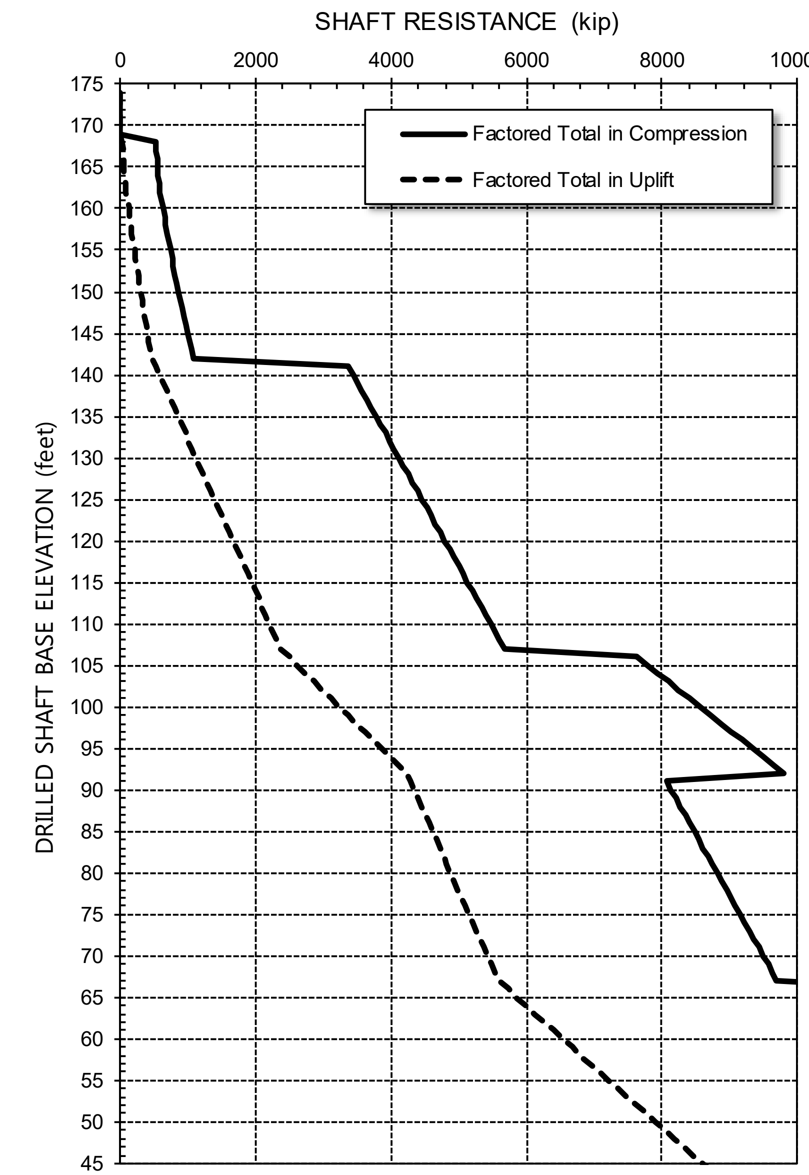


SERVICE LIMIT

STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

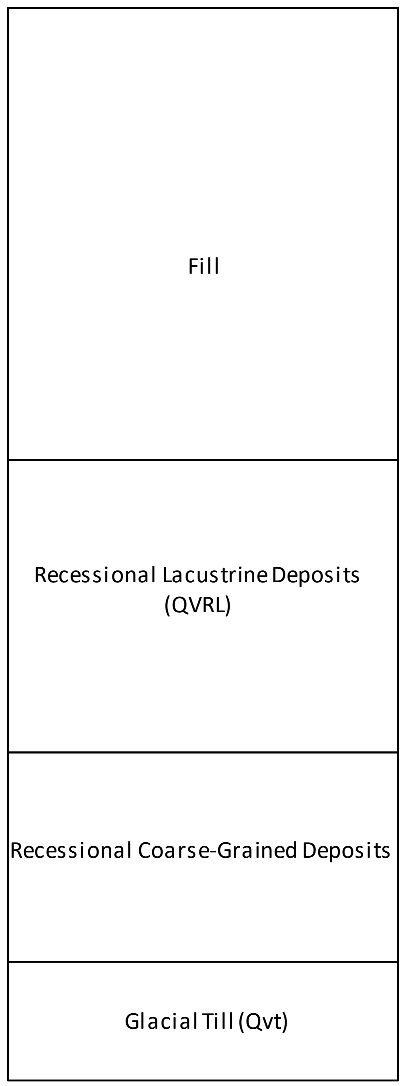
FIGURE 6

Drilled Shaft Axial Resistance Charts 8th_West_8ft Diameter

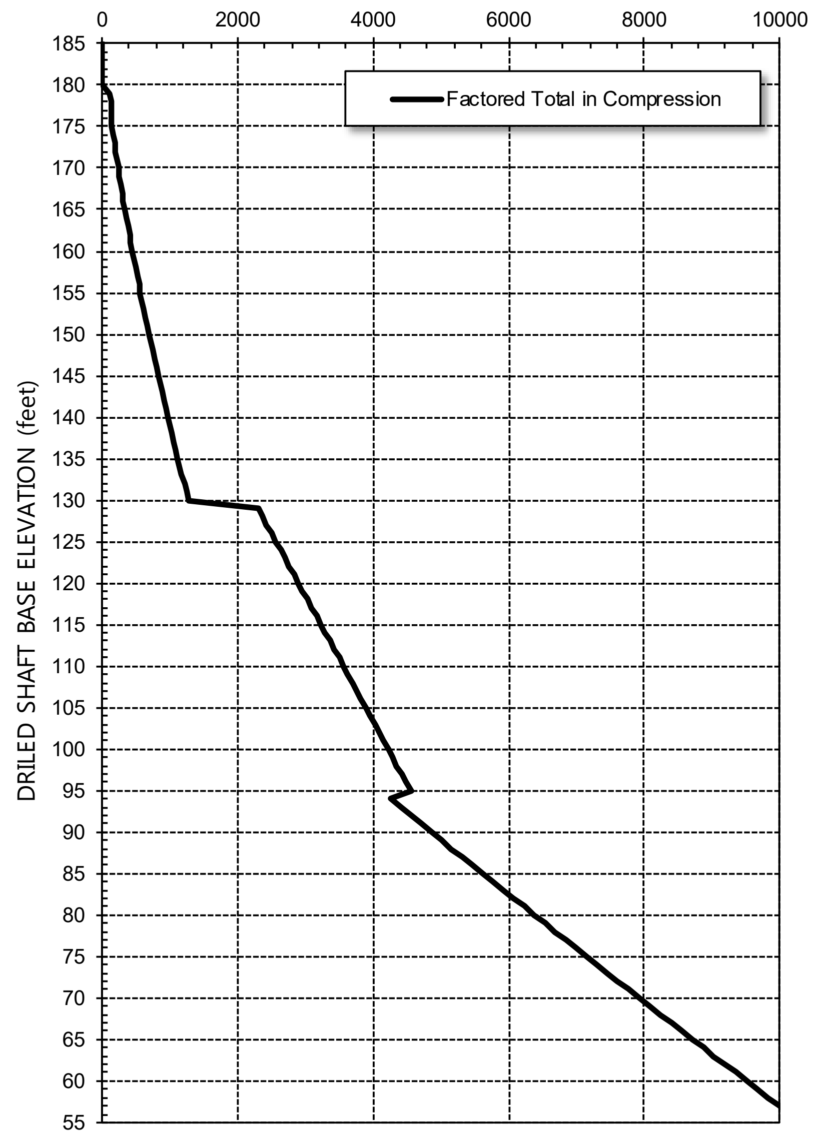
I-5 Lid Feasibility Study

Seattle, WA

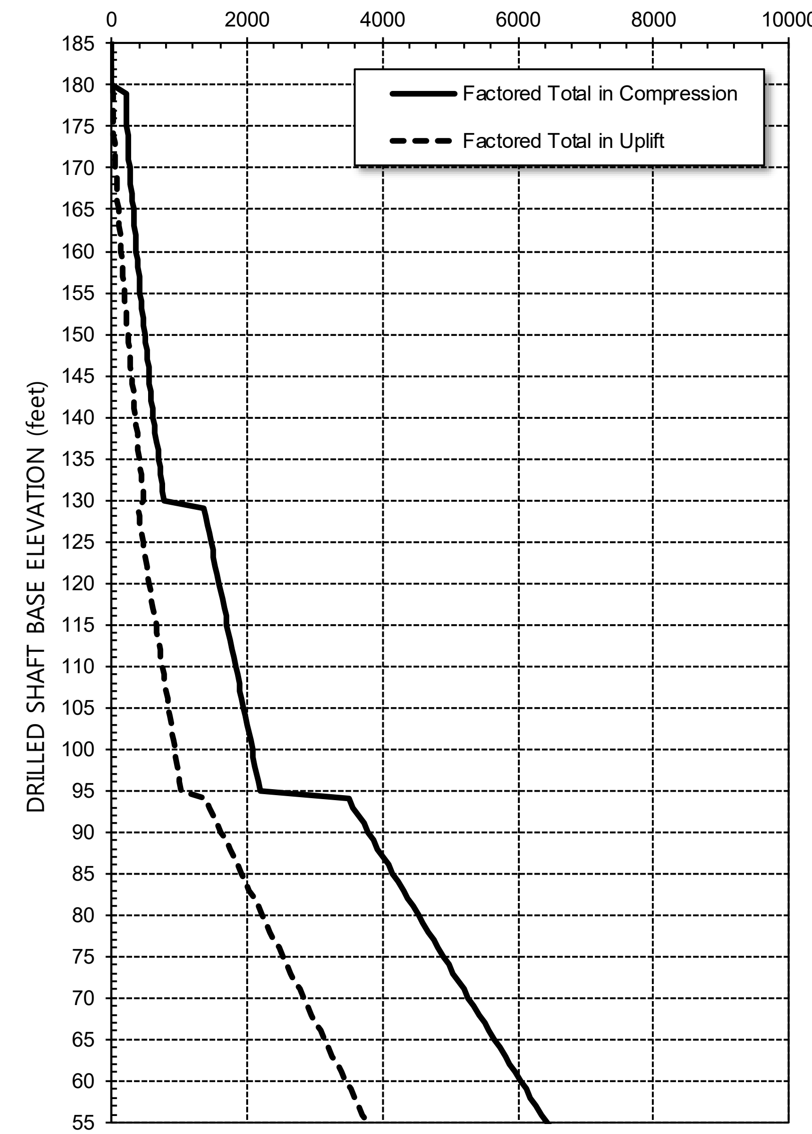
ASSUMED SUBSURFACE PROFILE
(B-9 - East)



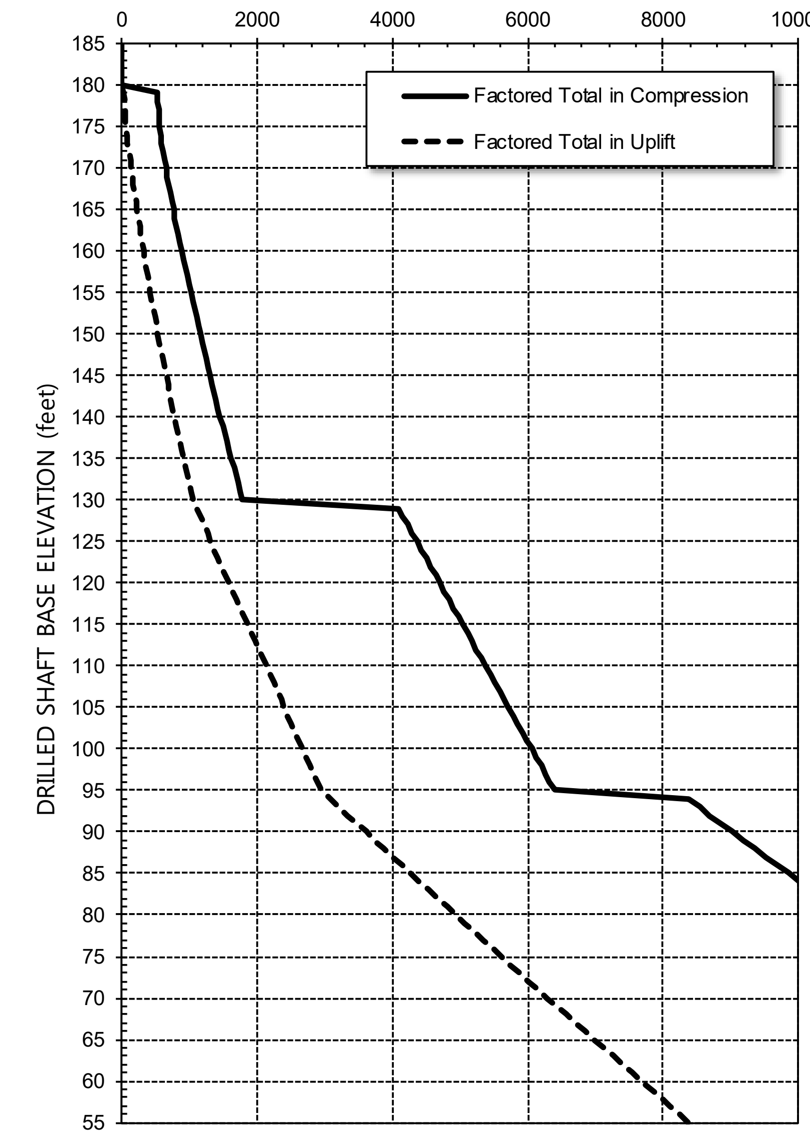
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



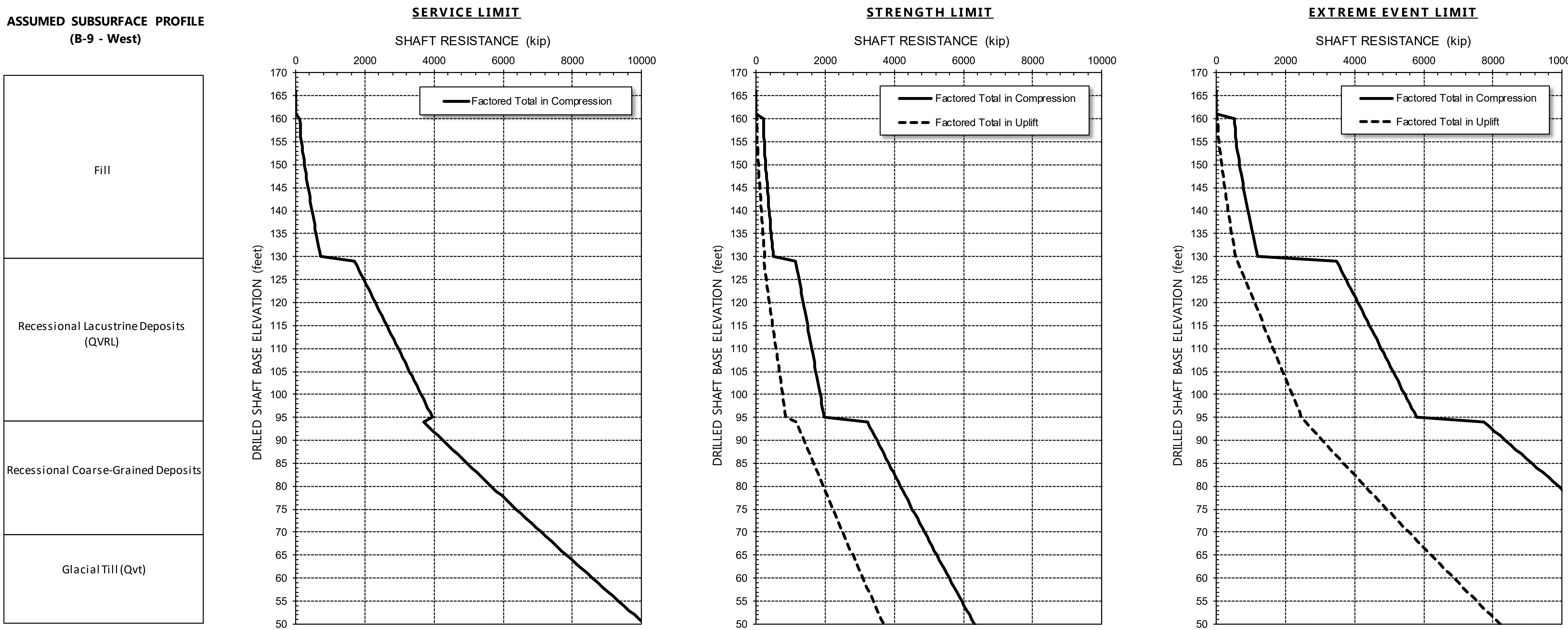
SERVICE LIMIT NOTES:
1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:
1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 7
Drilled Shaft Axial Resistance Charts Pike_East_8ft Diameter
I-5 Lid Feasibility Study
Seattle, WA



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

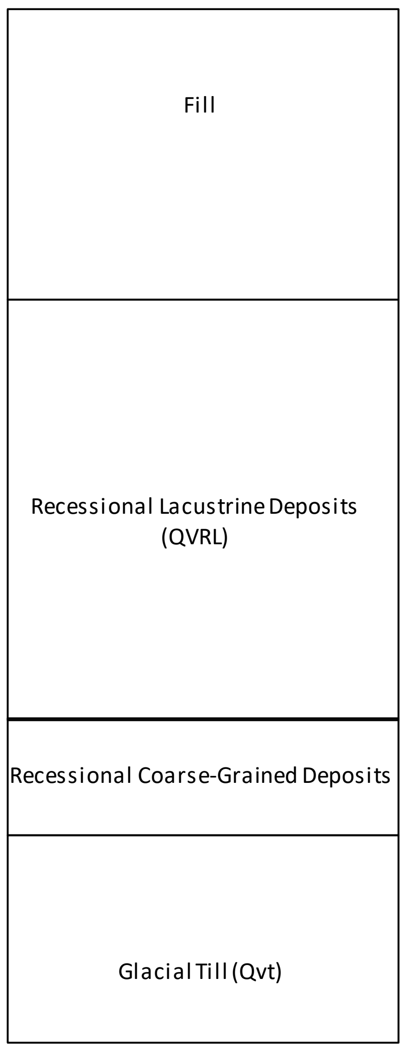
FIGURE 8

Drilled Shaft Axial Resistance Charts Pike_West_8ft Diameter

I-5 Lid Feasibility Study

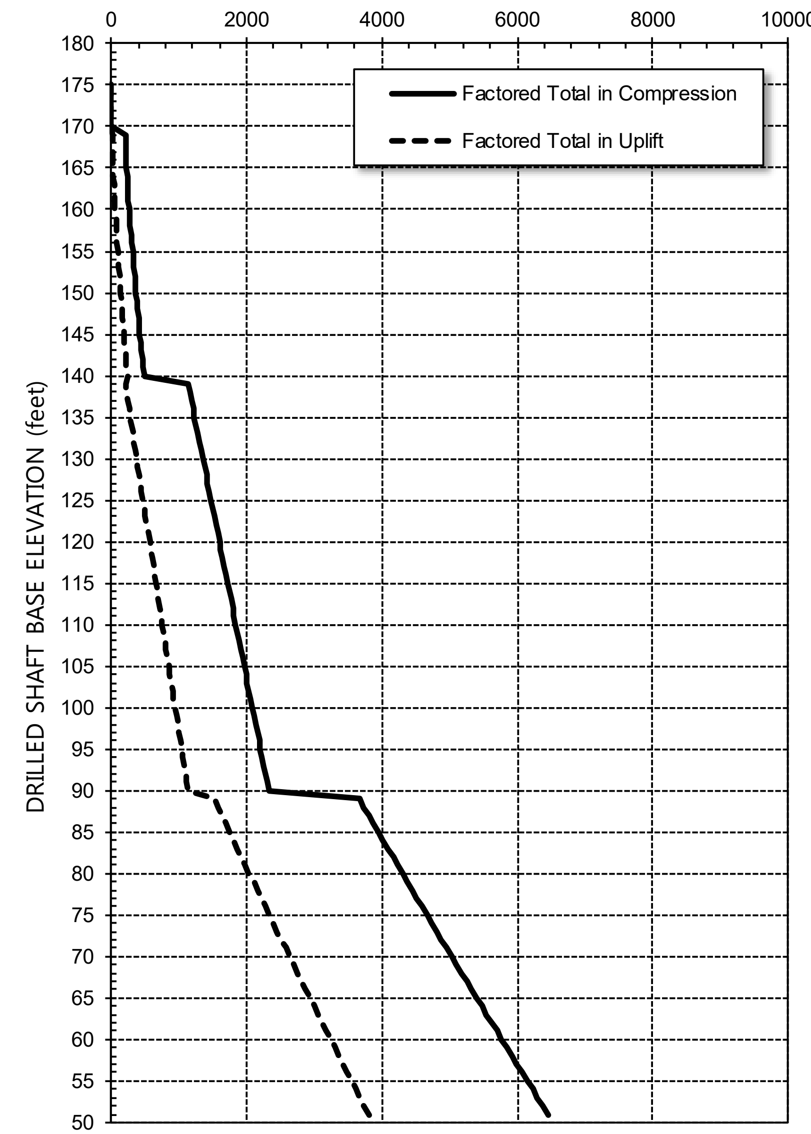
Seattle, WA

ASSUMED SUBSURFACE PROFILE
(B-1 - East)

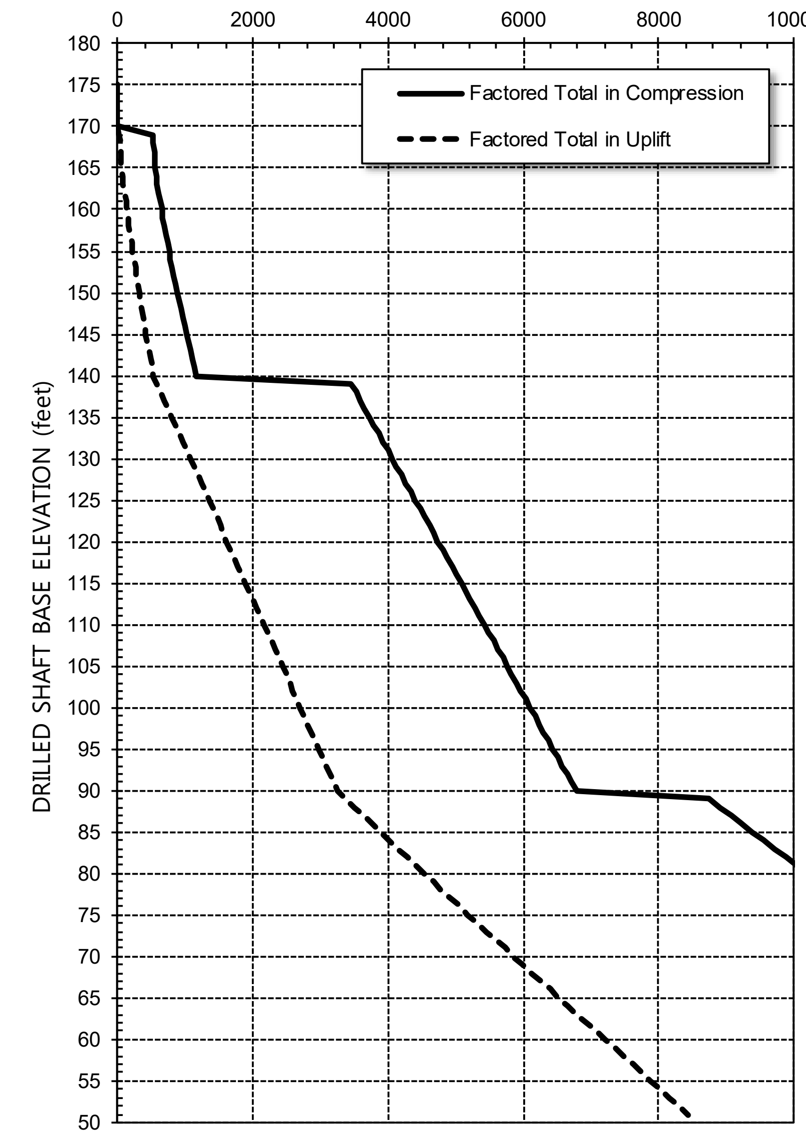


SERVICE LIMIT

STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

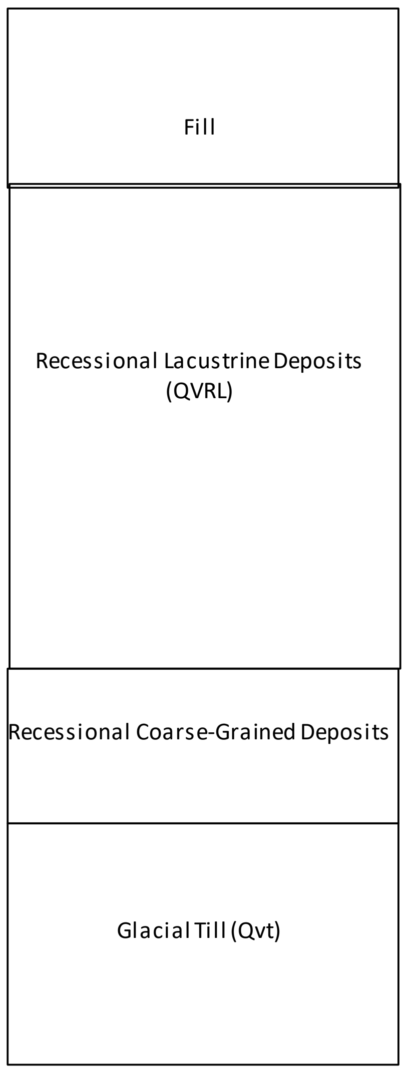
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

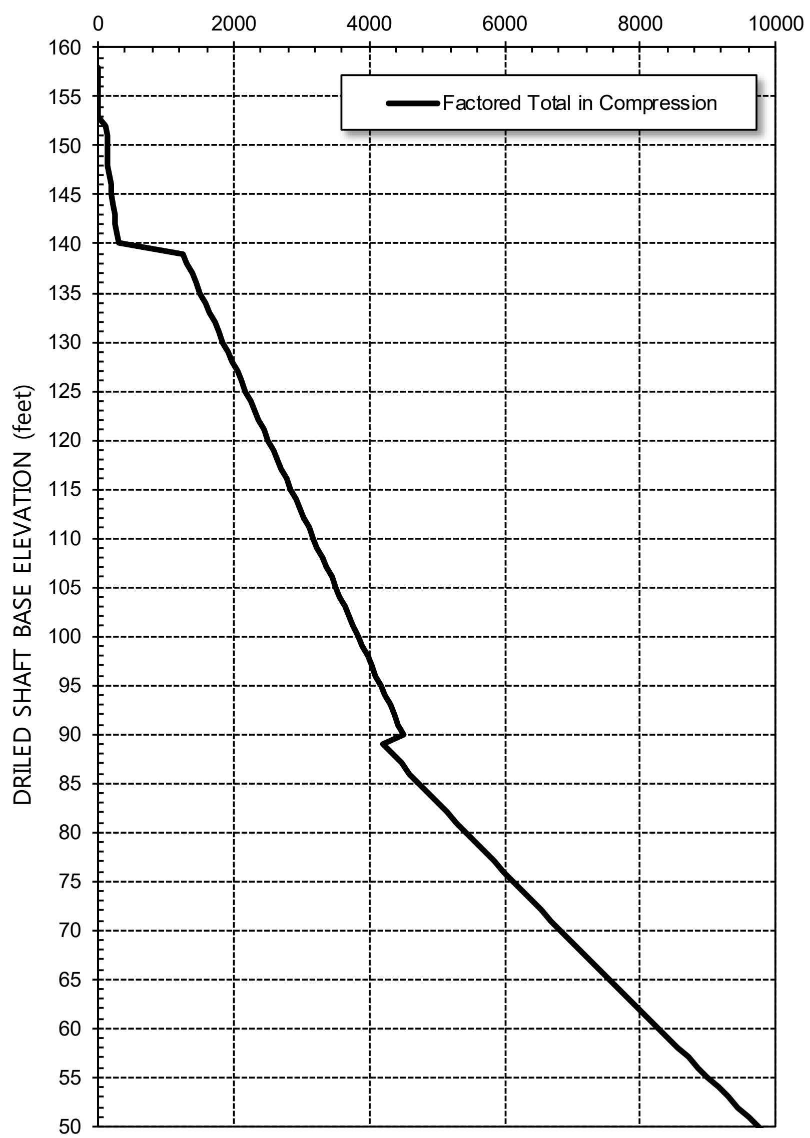
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 9
Drilled Shaft Axial Resistance Charts South Olive_East_8ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

ASSUMED SUBSURFACE PROFILE
(B-1 - West)



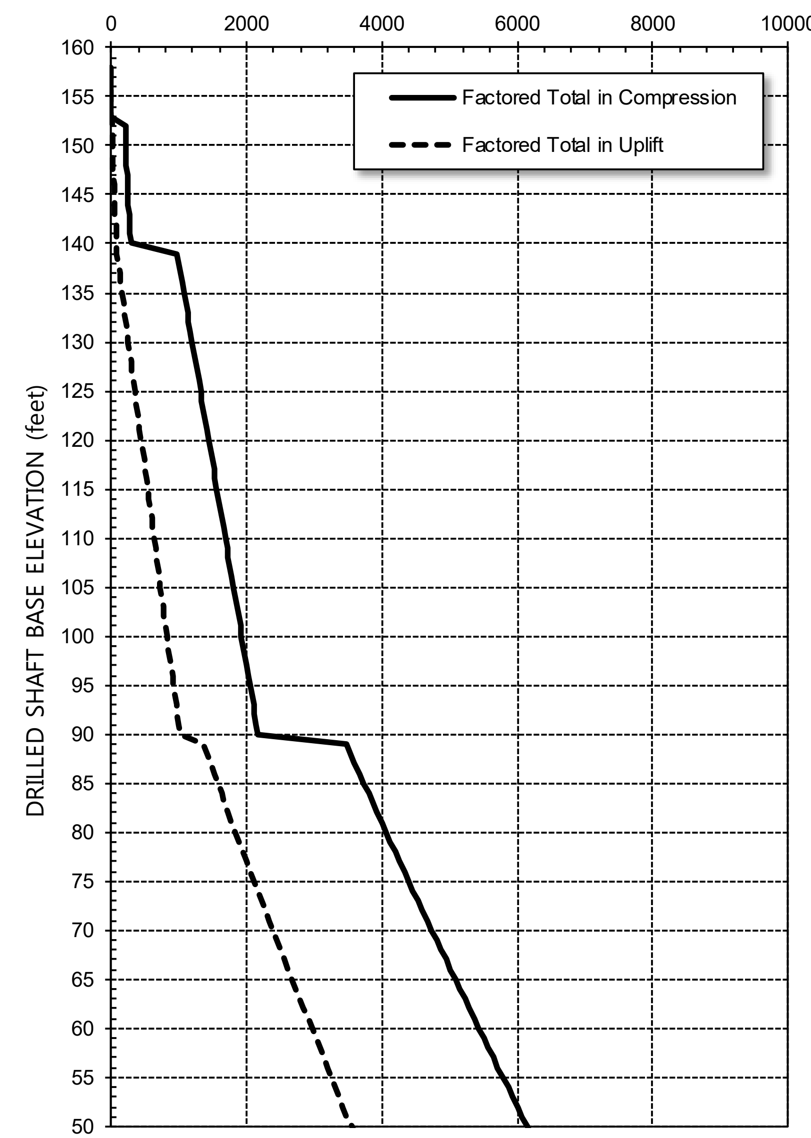
SERVICE LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

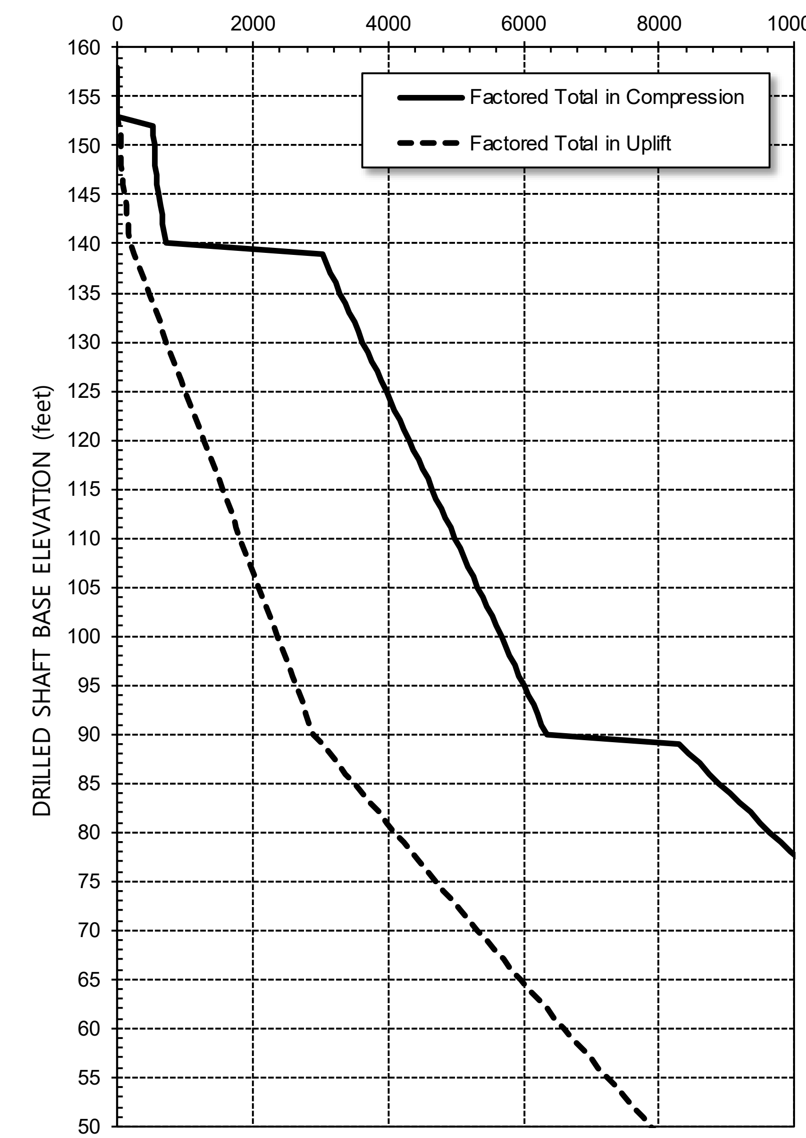
STRENGTH LIMIT



STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT



EXTREME EVENT LIMIT NOTES:

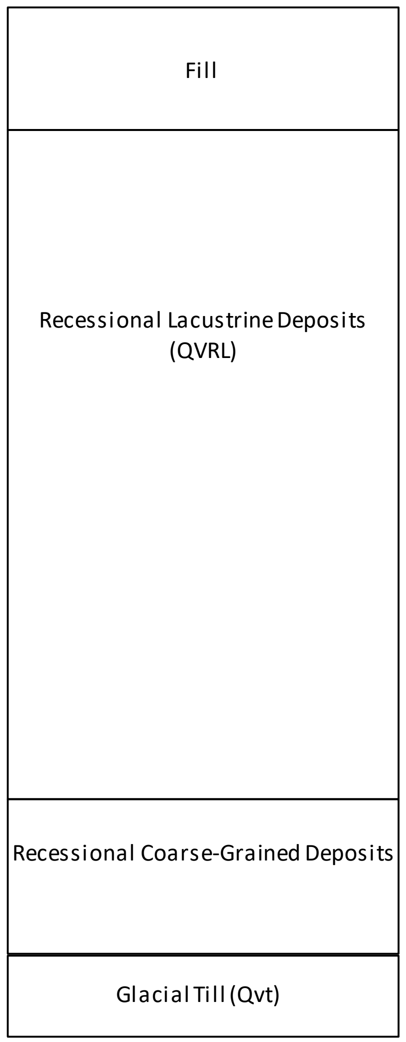
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

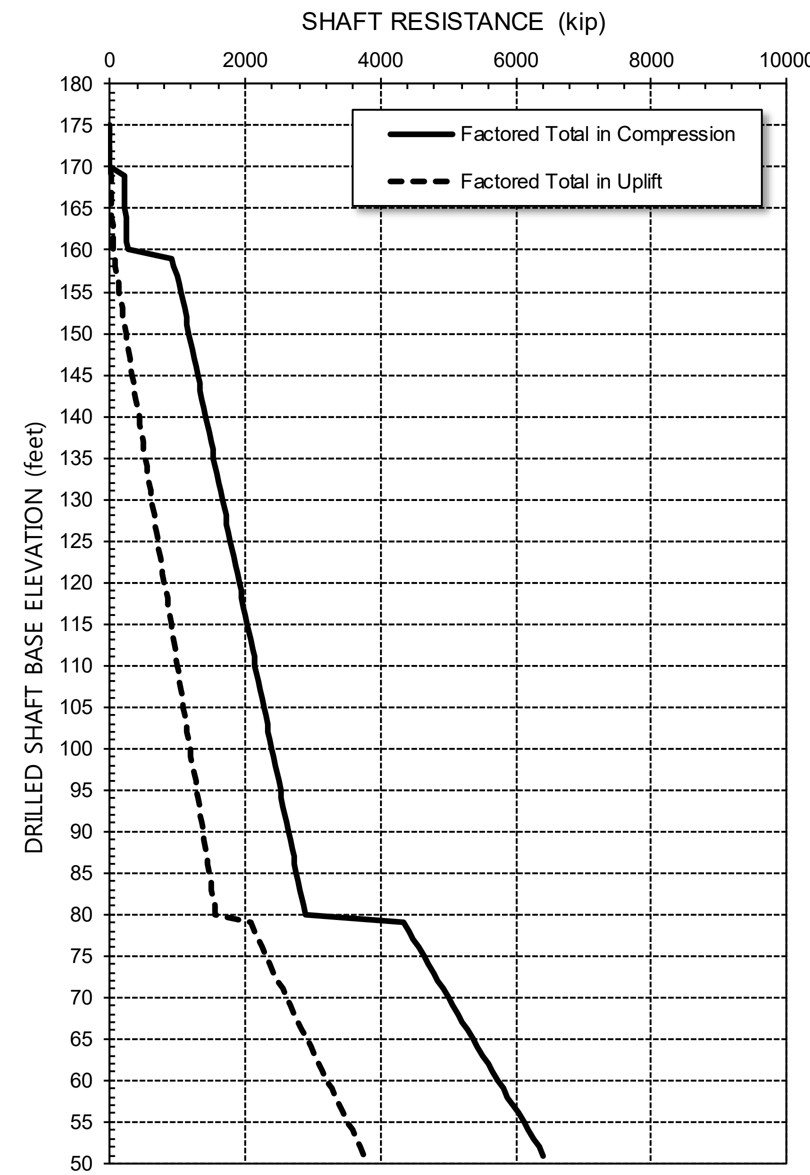
FIGURE 10
Drilled Shaft Axial Resistance Charts South Olive_West_8ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

ASSUMED SUBSURFACE PROFILE
(237 - East)

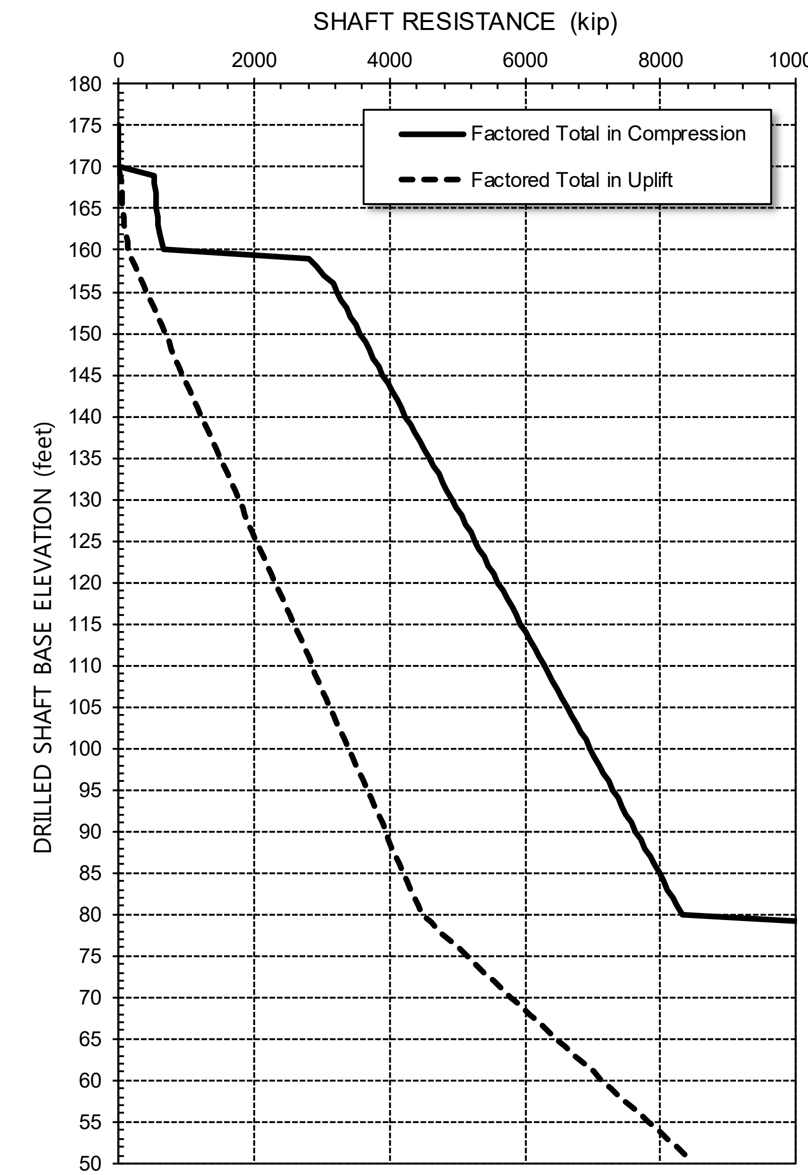


SERVICE LIMIT

STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

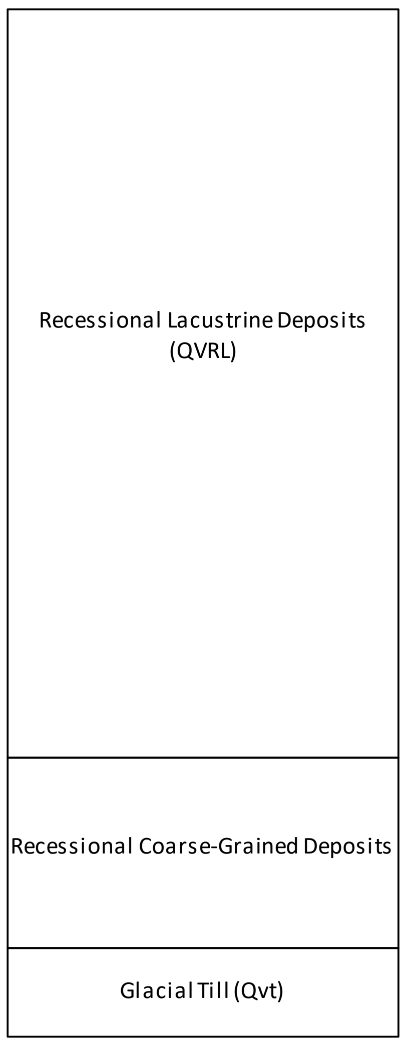
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

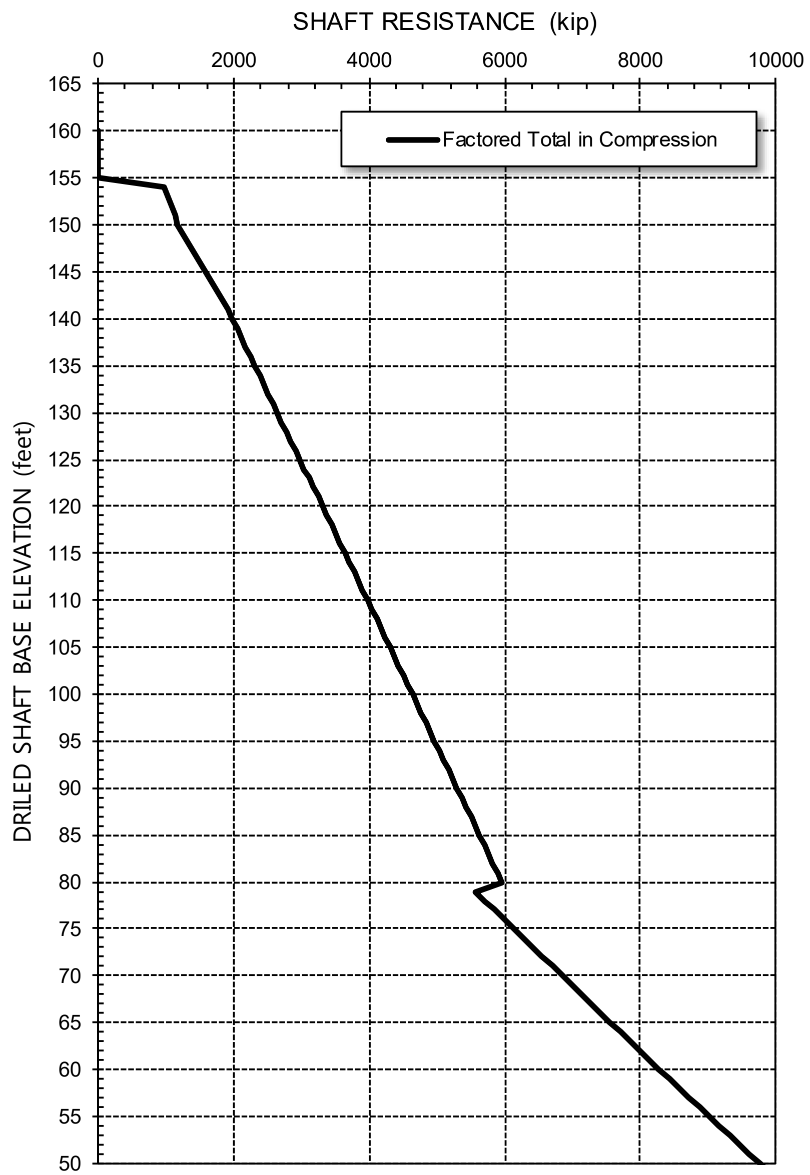
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 11
Drilled Shaft Axial Resistance Charts North Olive_East_8ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

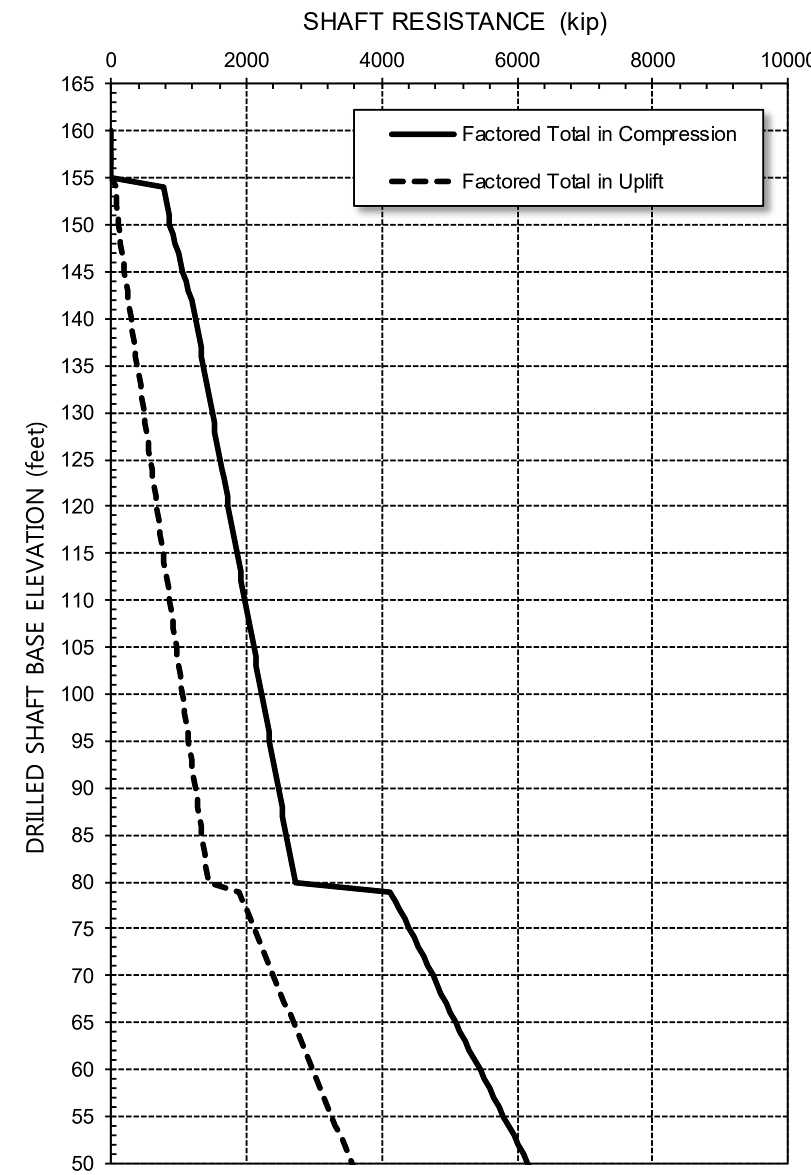
ASSUMED SUBSURFACE PROFILE
(237 - West)



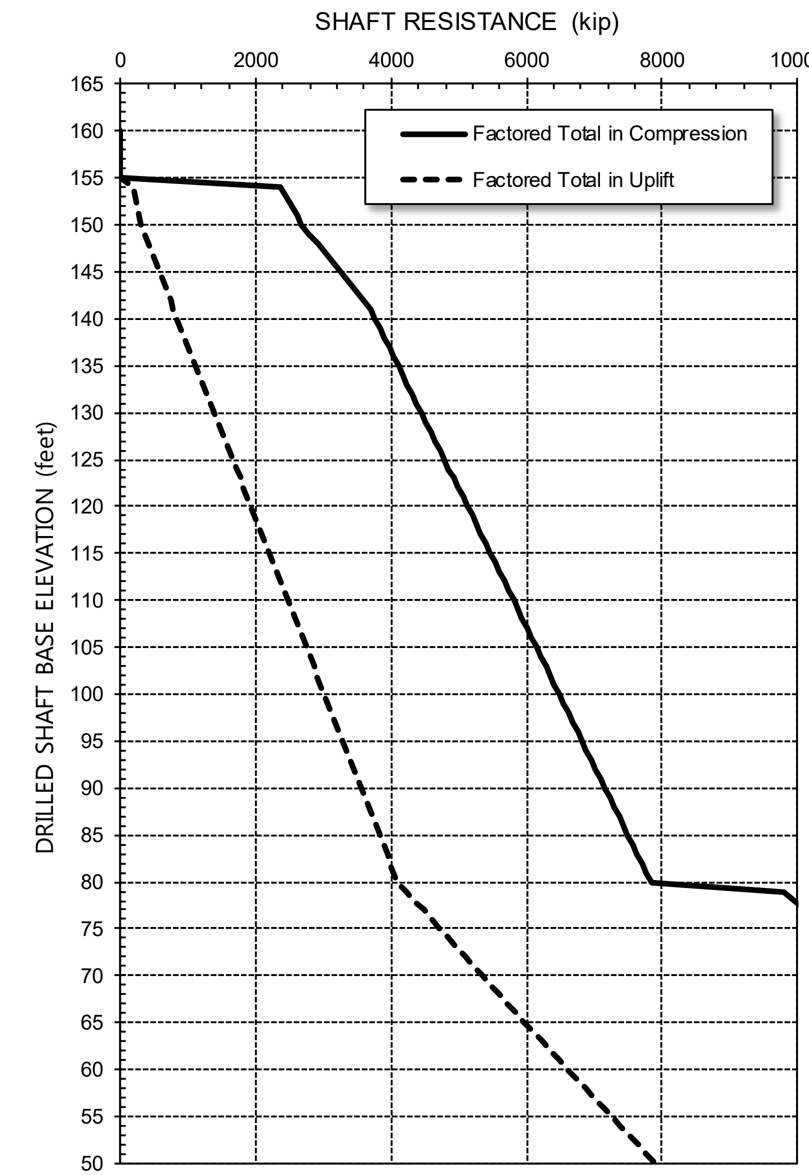
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

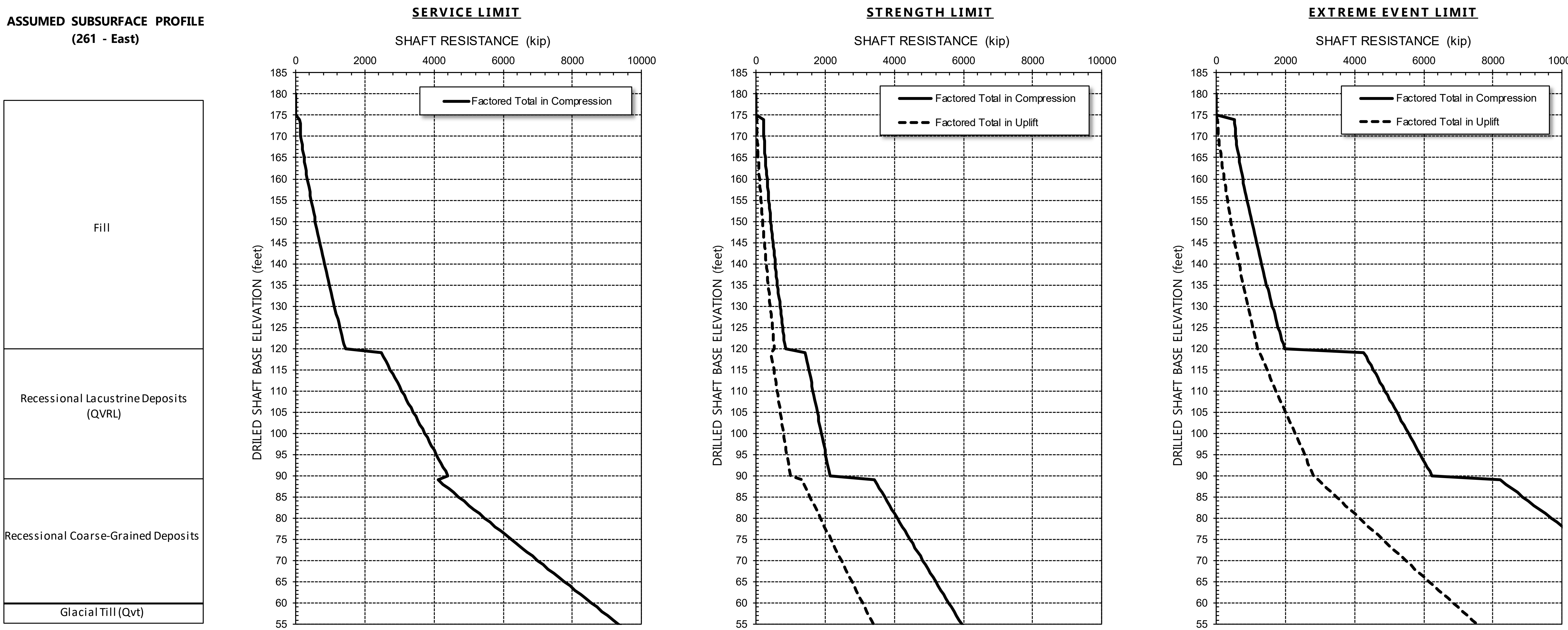
EXTREME EVENT LIMIT NOTES:

1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 12
Drilled Shaft Axial Resistance Charts North Olive_West_8ft Diameter
I-5 Lid Feasibility Study
Seattle, WA



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

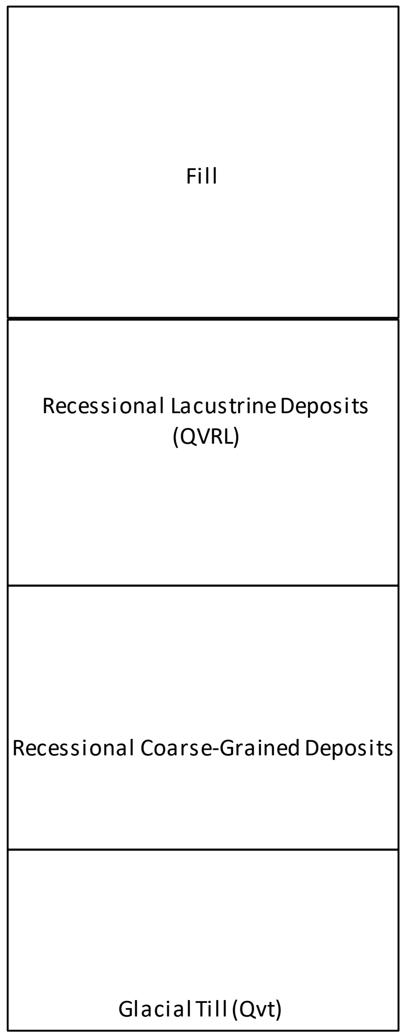
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

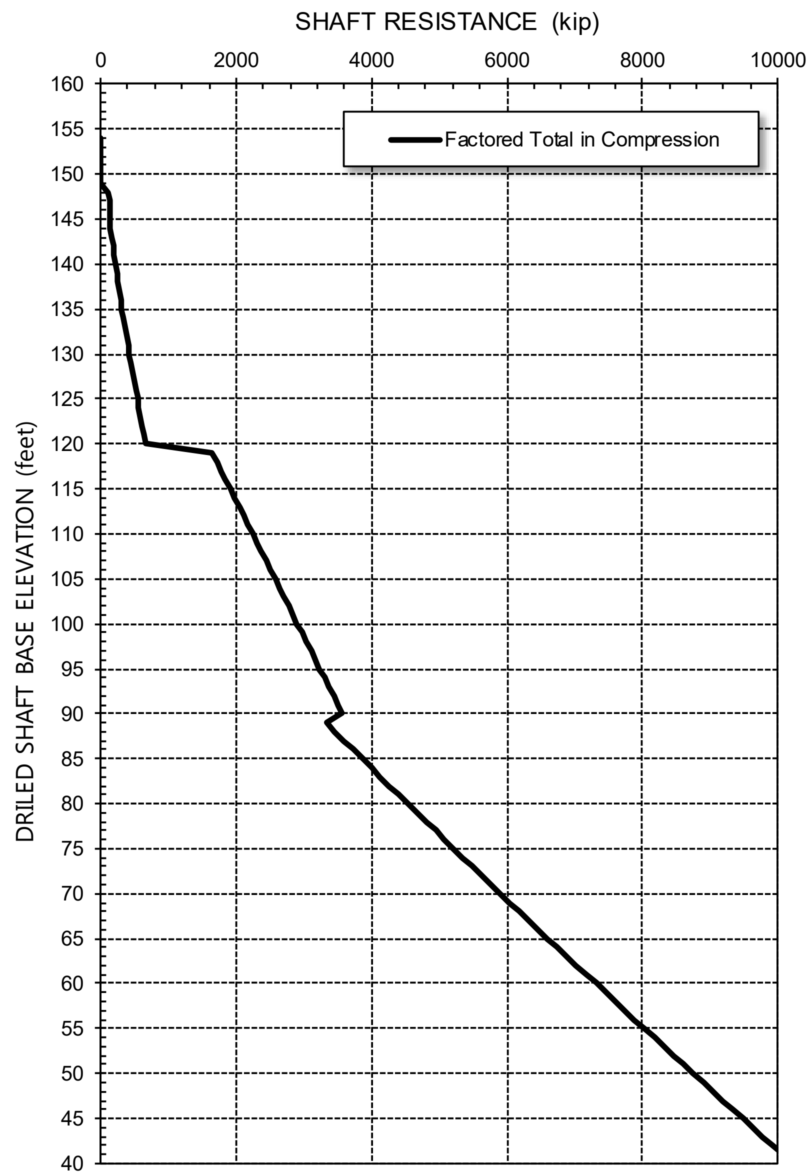
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 13
Drilled Shaft Axial Resistance Charts Denny_East_8ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

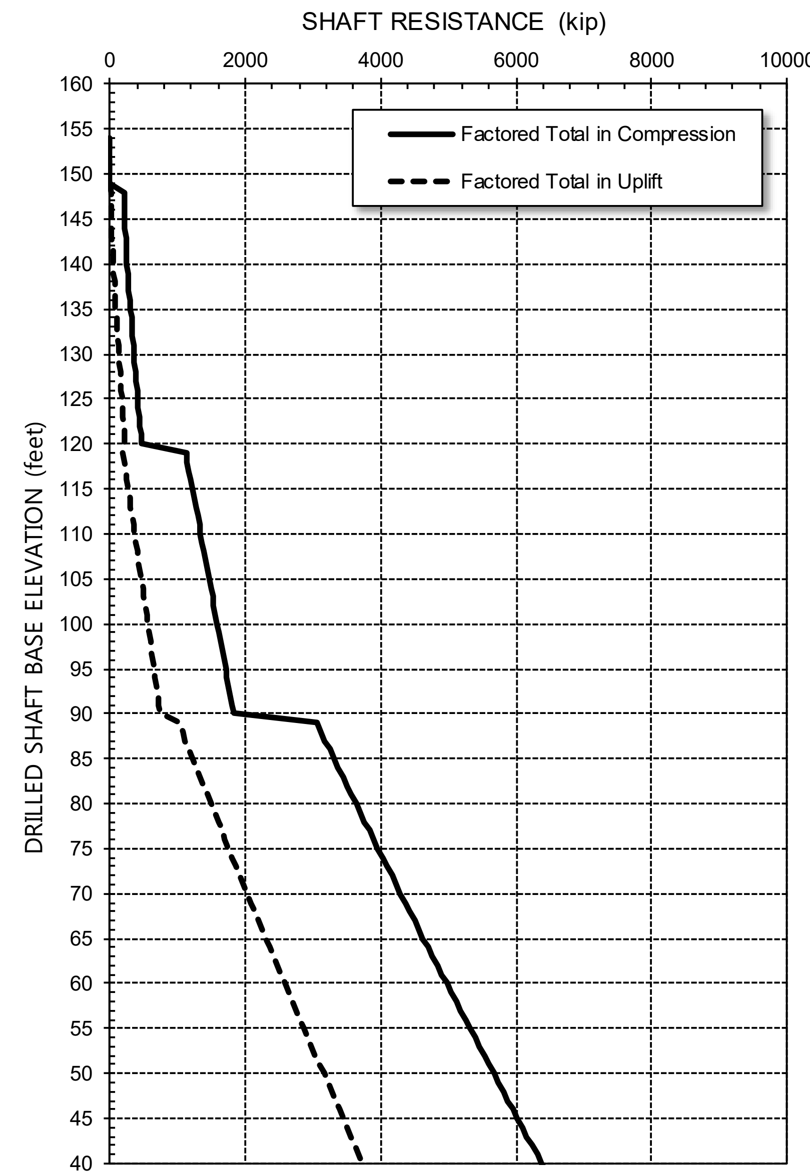
ASSUMED SUBSURFACE PROFILE
(261 - West)



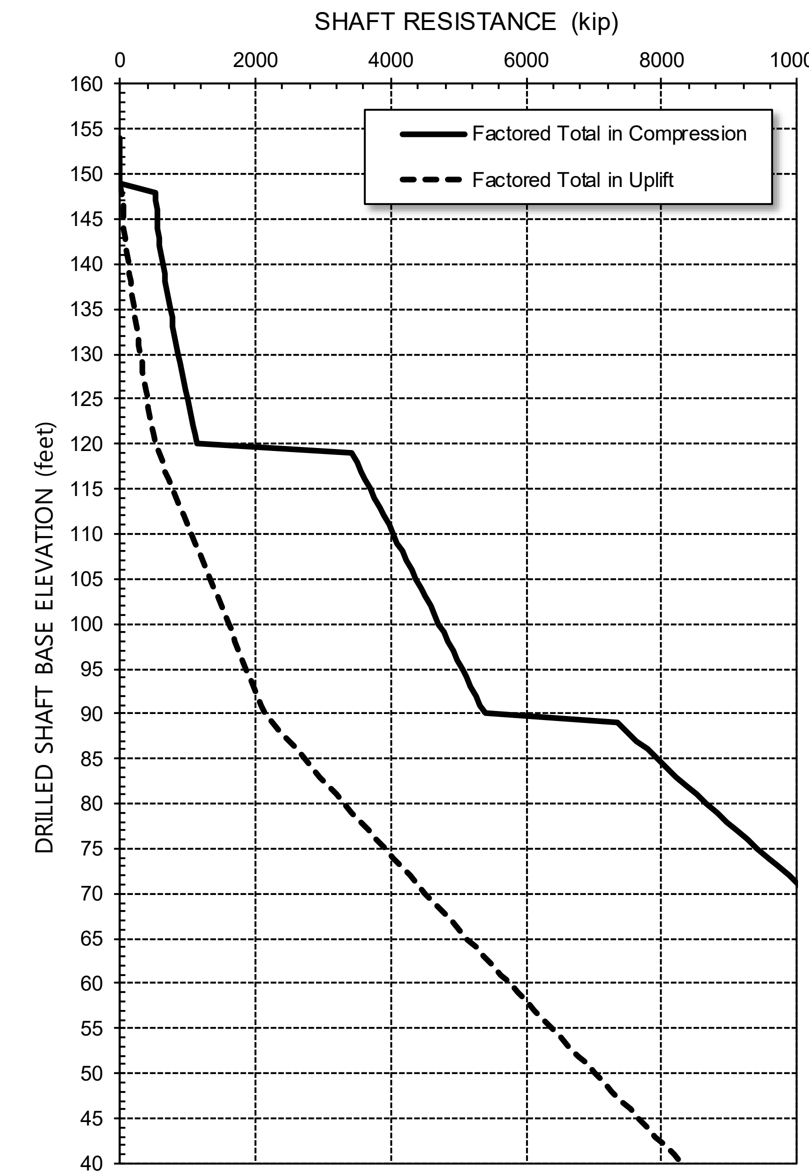
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

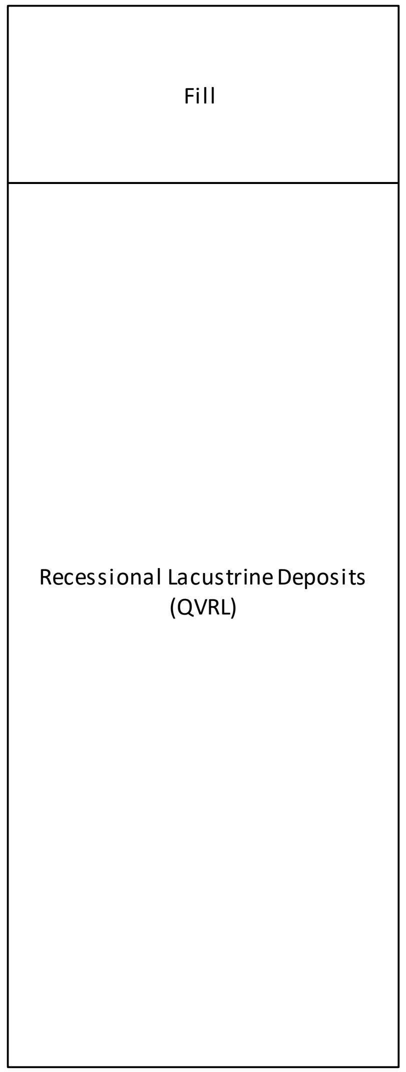
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

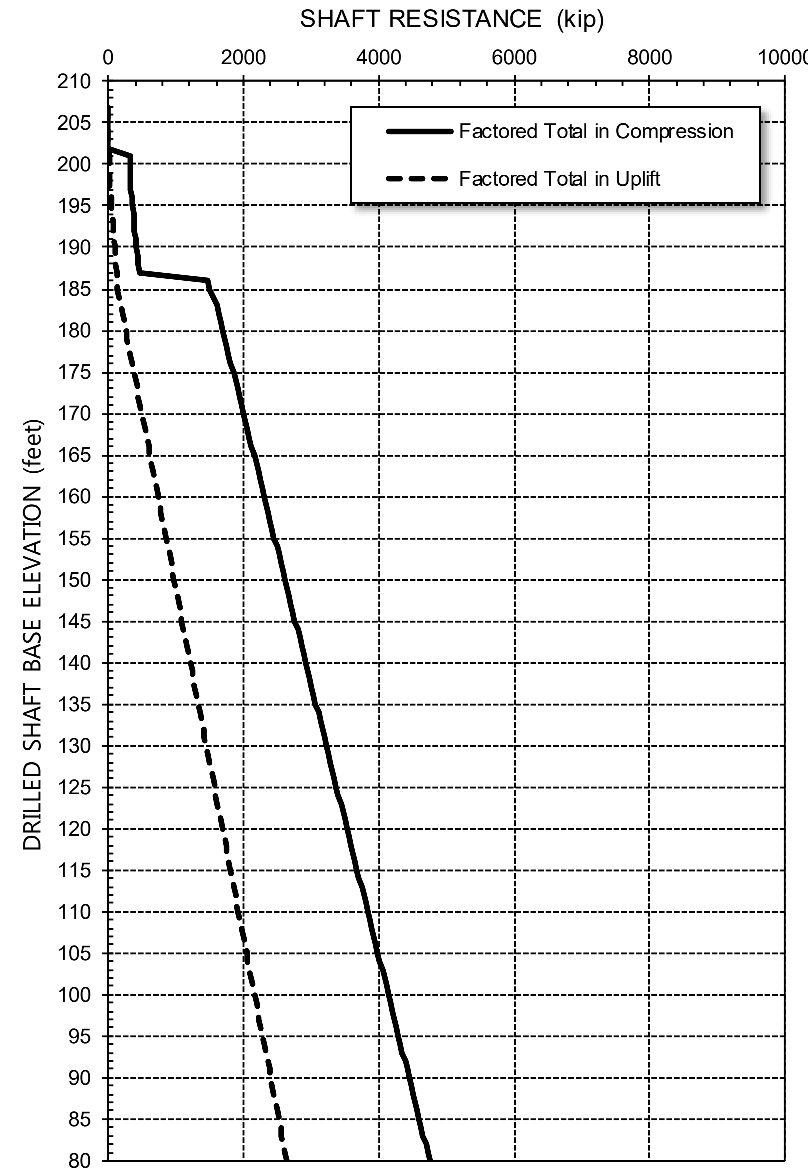
FIGURE 14
Drilled Shaft Axial Resistance Charts Denny_West_8ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

ASSUMED SUBSURFACE PROFILE
(525 - East)

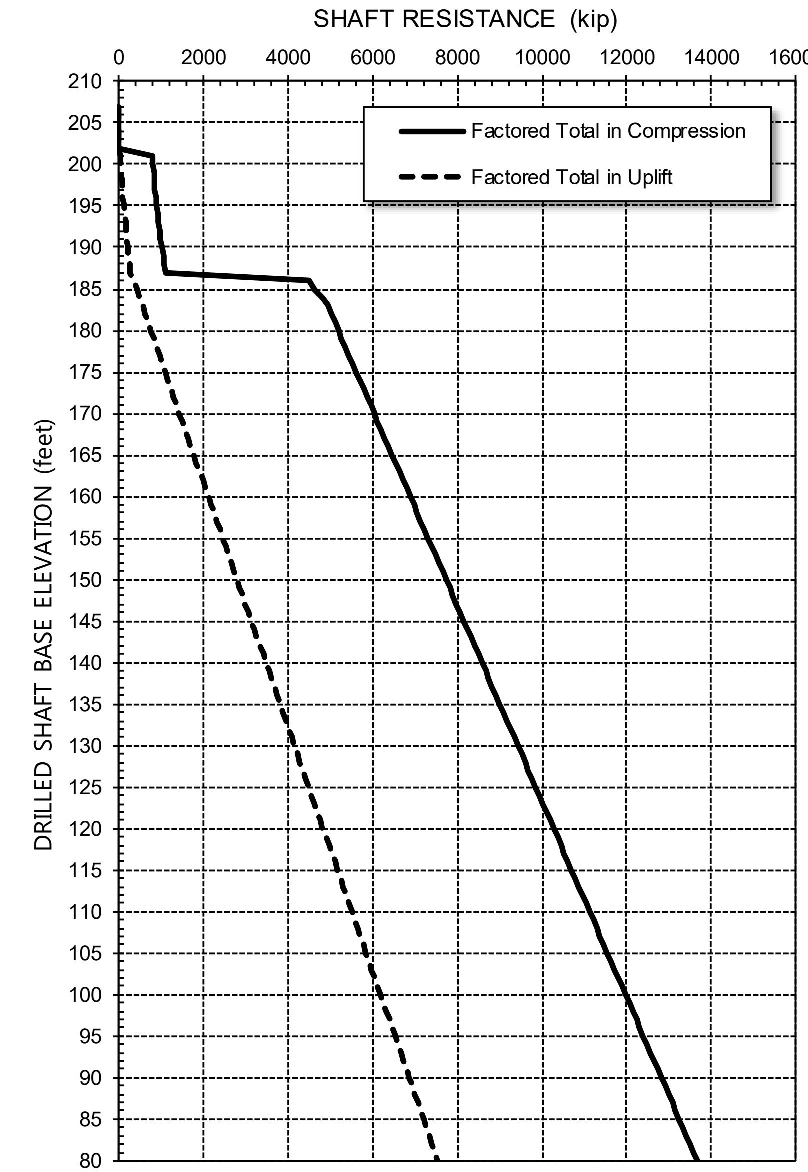


SERVICE LIMIT

STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:
1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

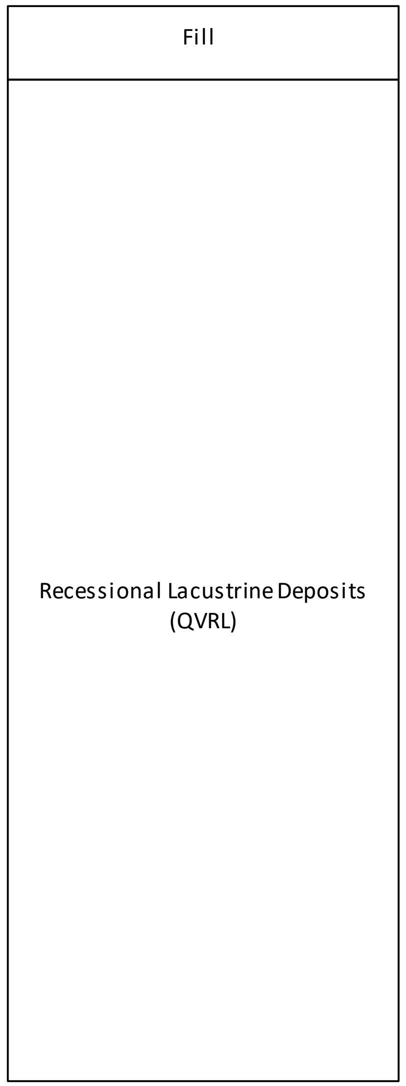
STRENGTH LIMIT NOTES:
1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

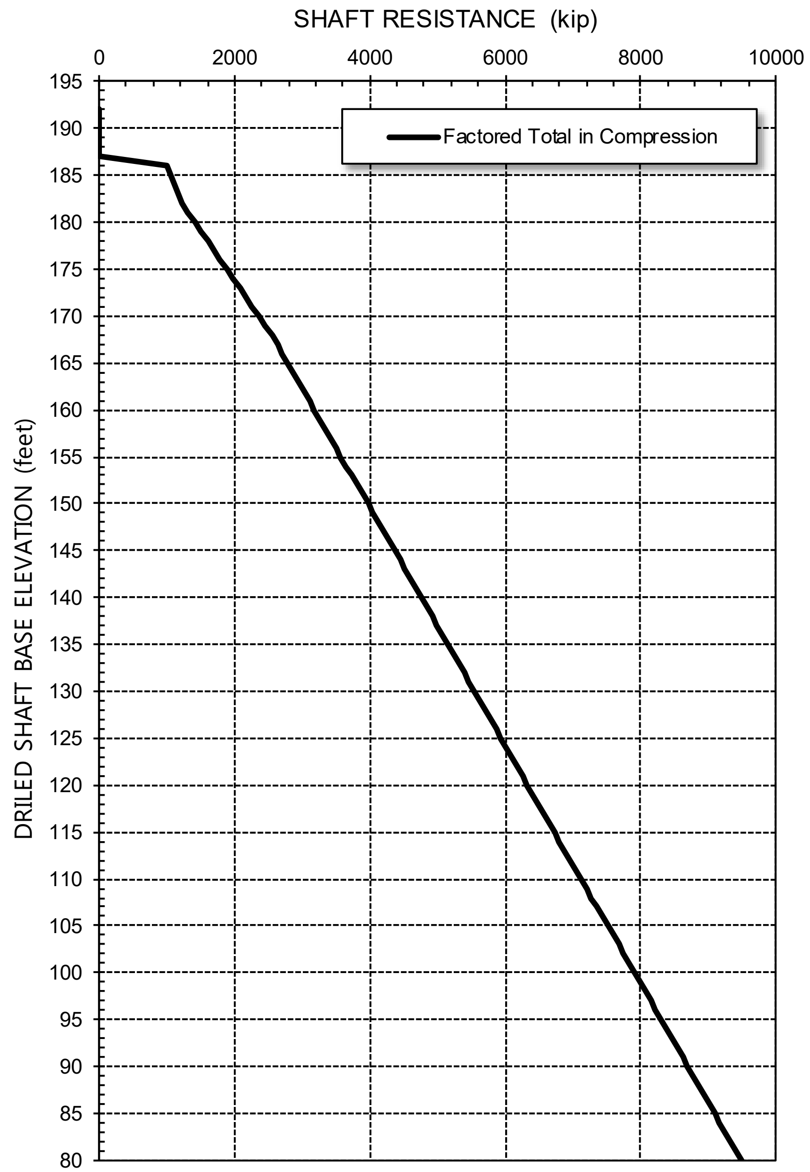
GENERAL NOTES:
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 1
Drilled Shaft Axial Resistance Charts Seneca_East_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

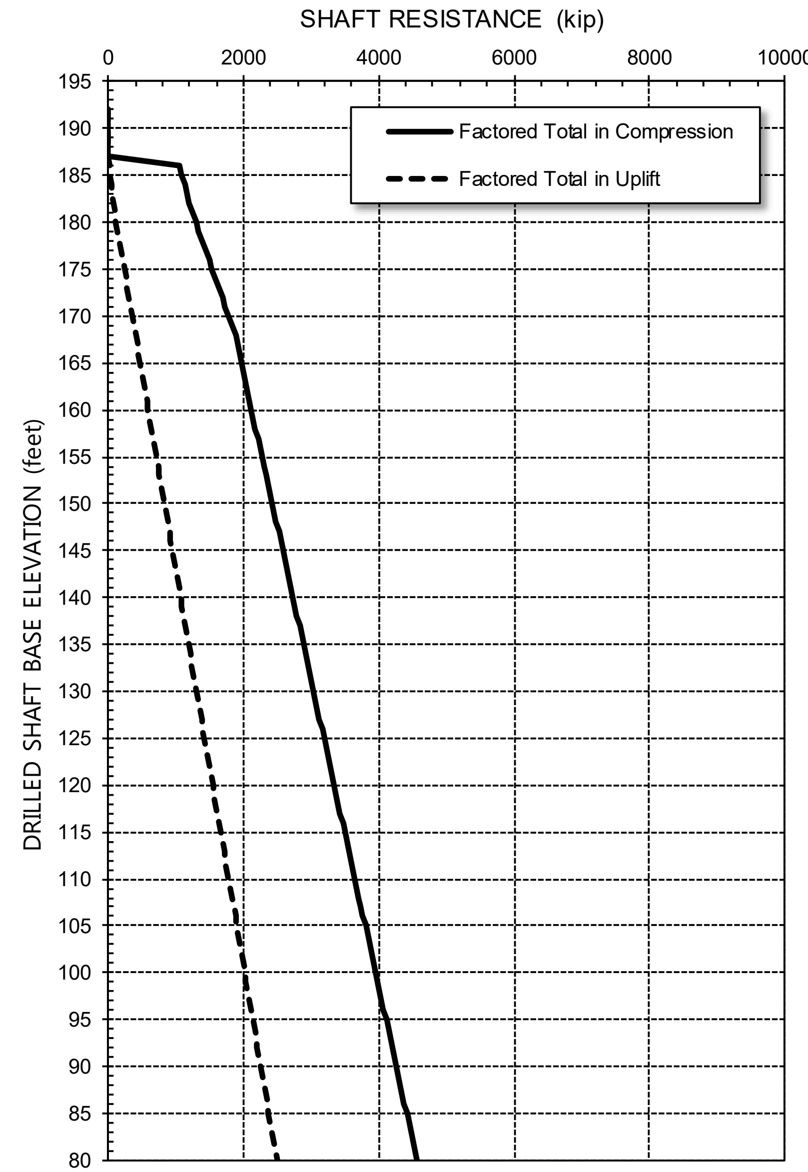
ASSUMED SUBSURFACE PROFILE
(525 - West)



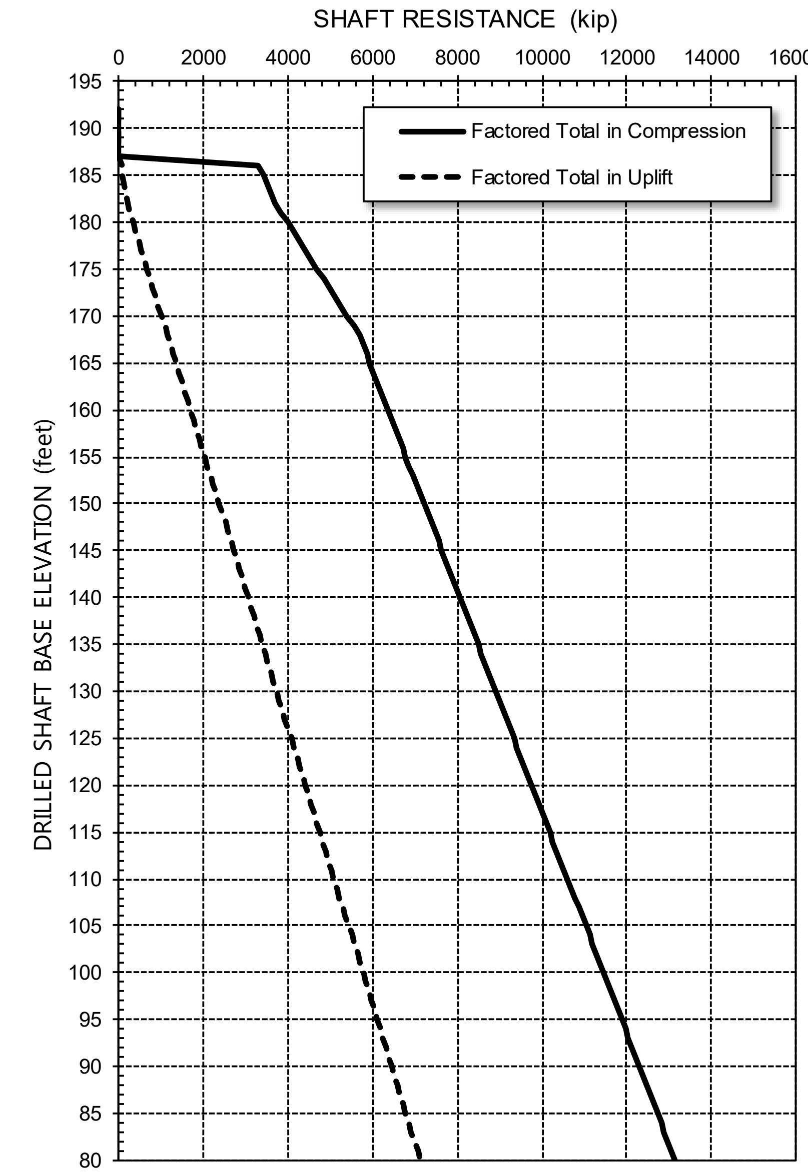
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:
1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

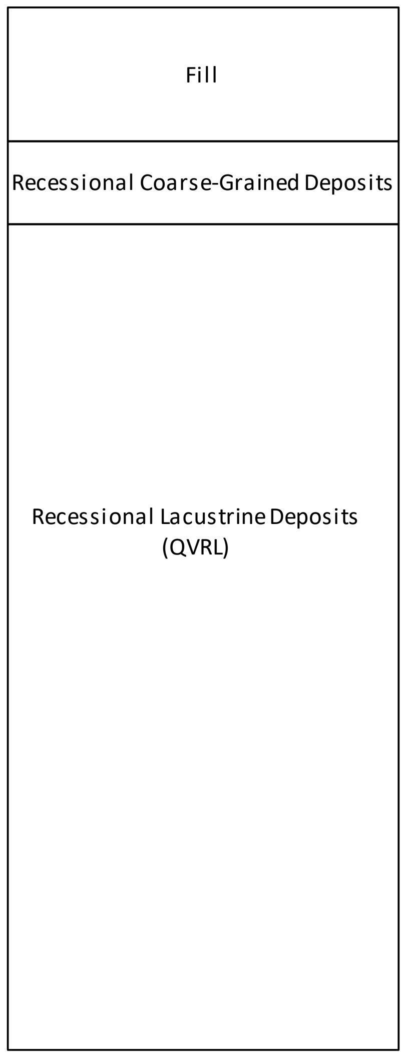
STRENGTH LIMIT NOTES:
1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

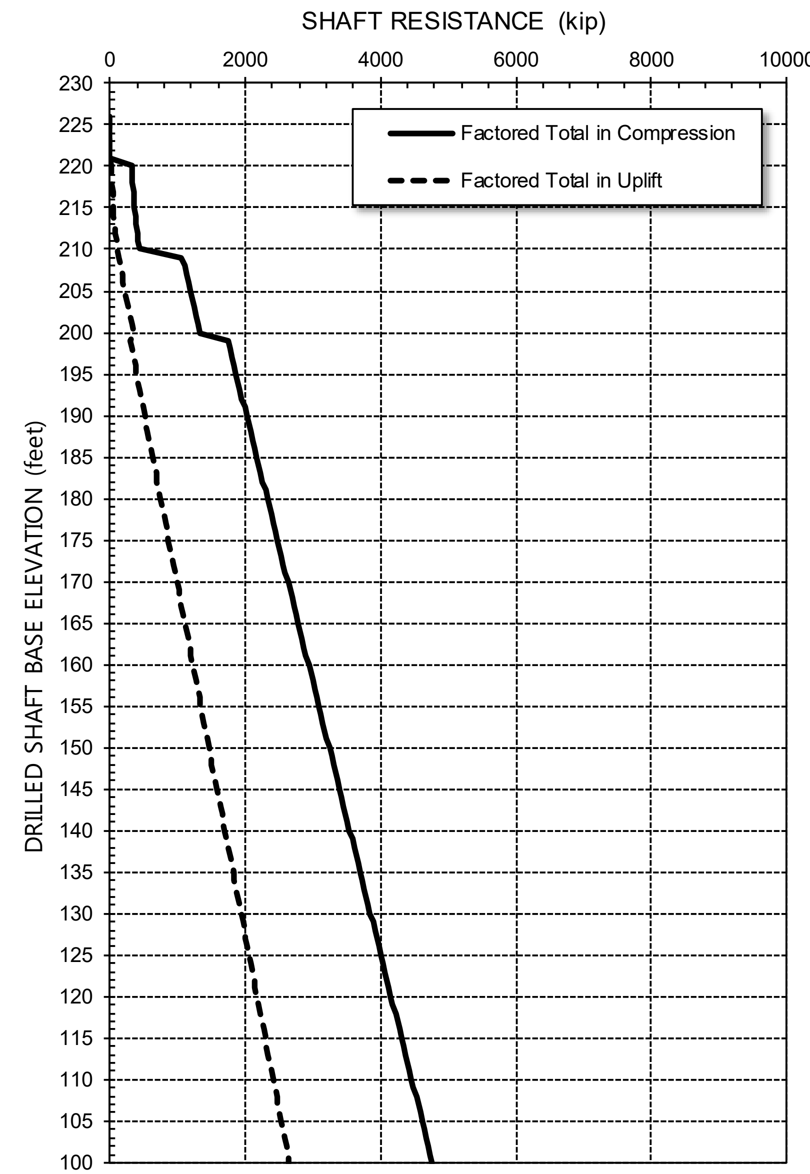
FIGURE 2
Drilled Shaft Axial Resistance Charts Seneca_West_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

ASSUMED SUBSURFACE PROFILE
(X-9 - East Side)

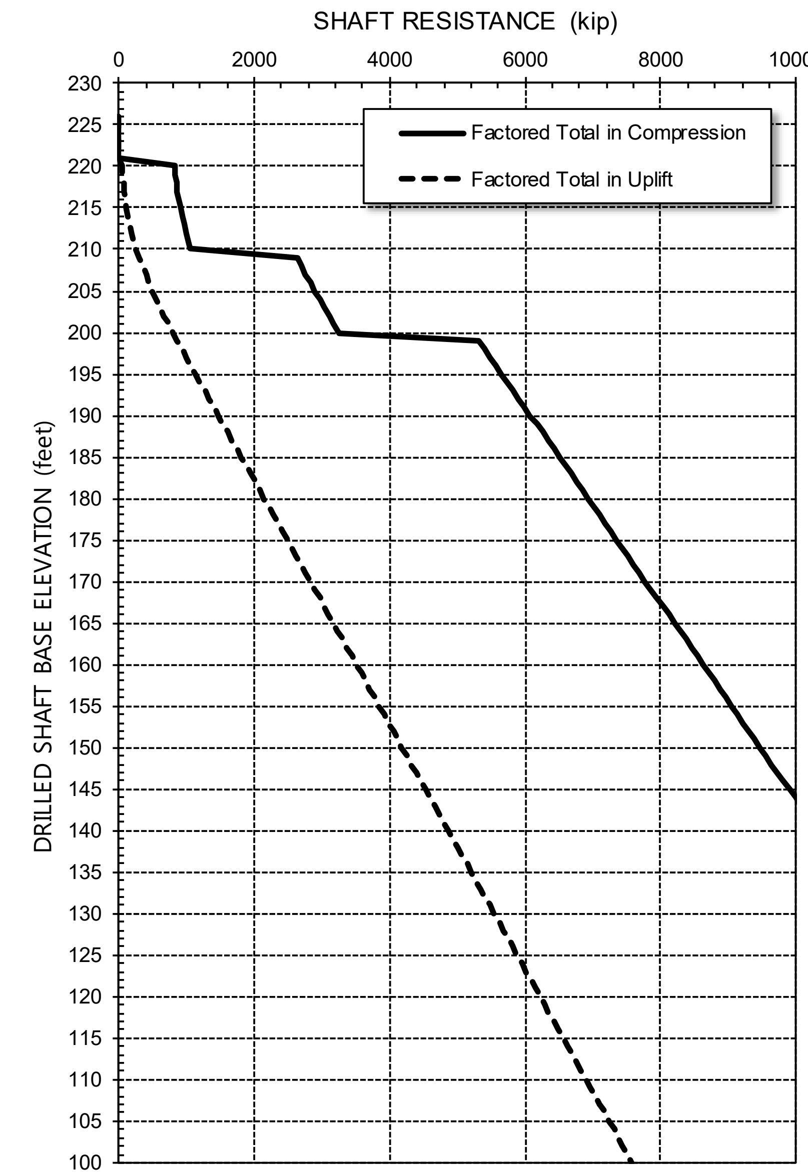


SERVICE LIMIT

STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

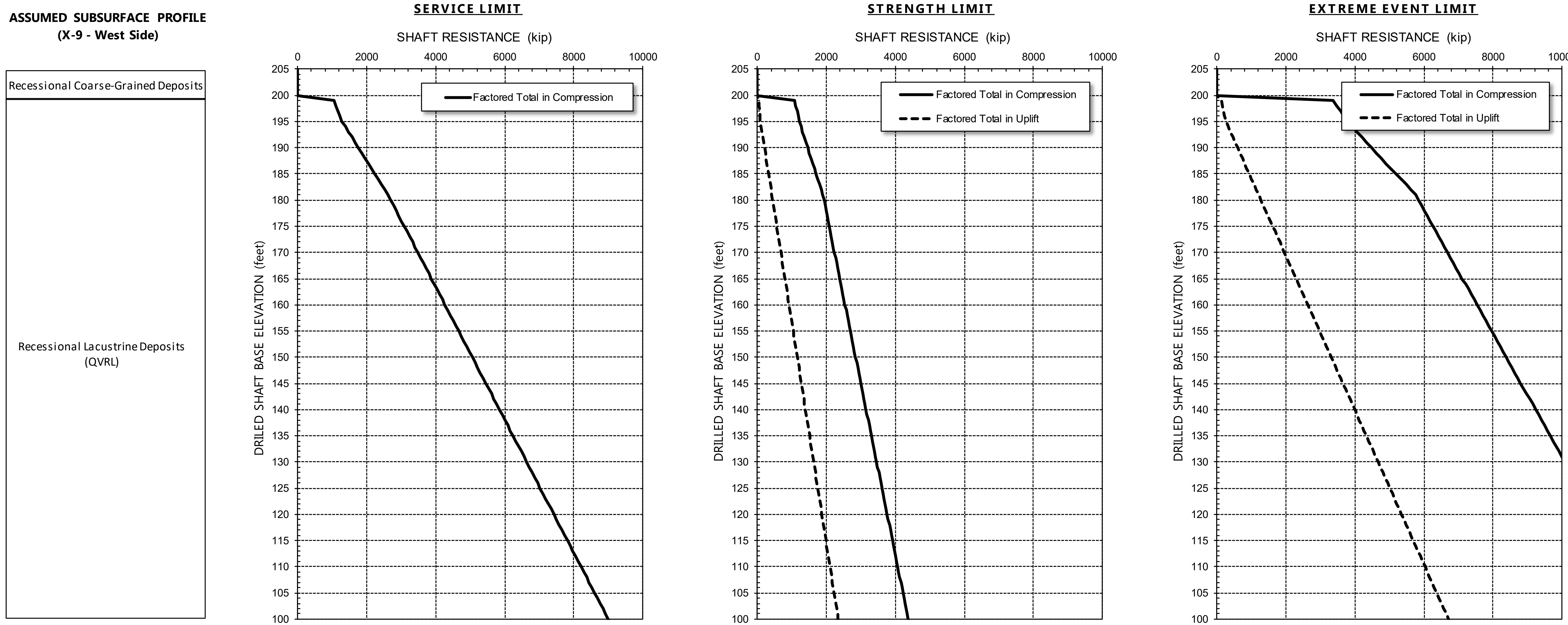
EXTREME EVENT LIMIT NOTES:

1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 3
Drilled Shaft Axial Resistance Charts Spring_East_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

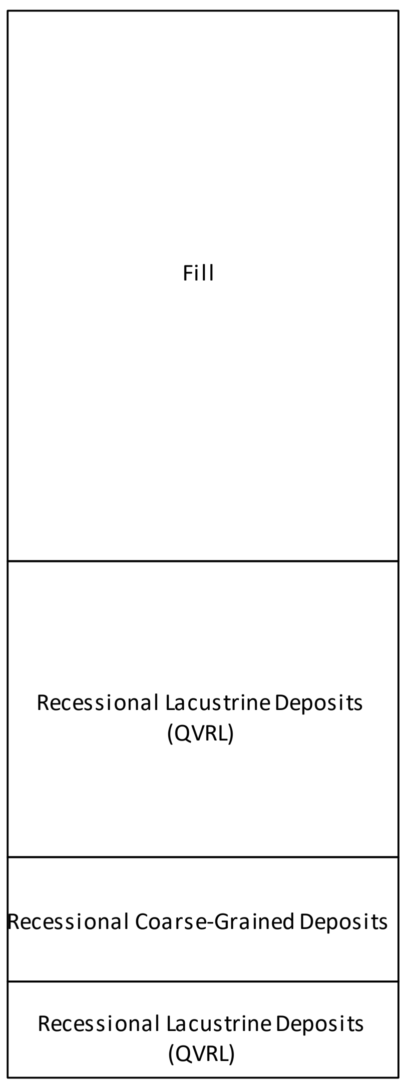
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

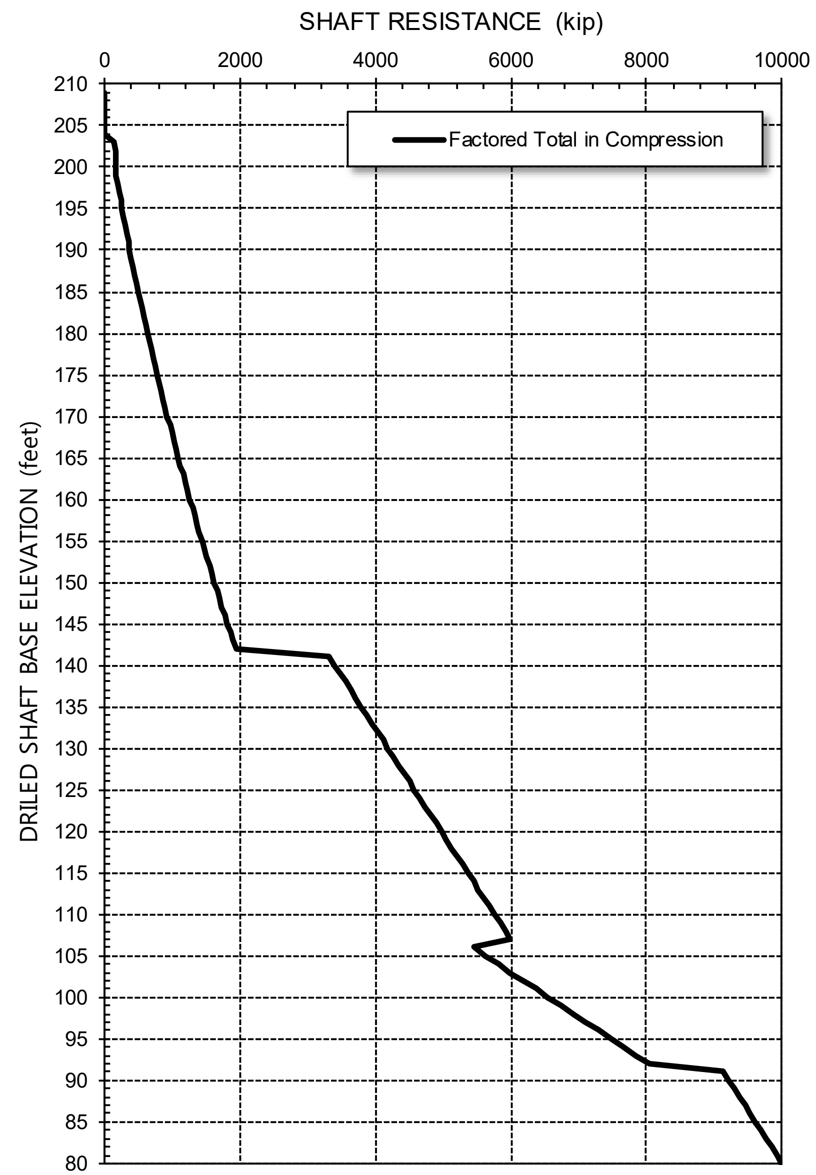
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 4
Drilled Shaft Axial Resistance Charts Spring_West_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

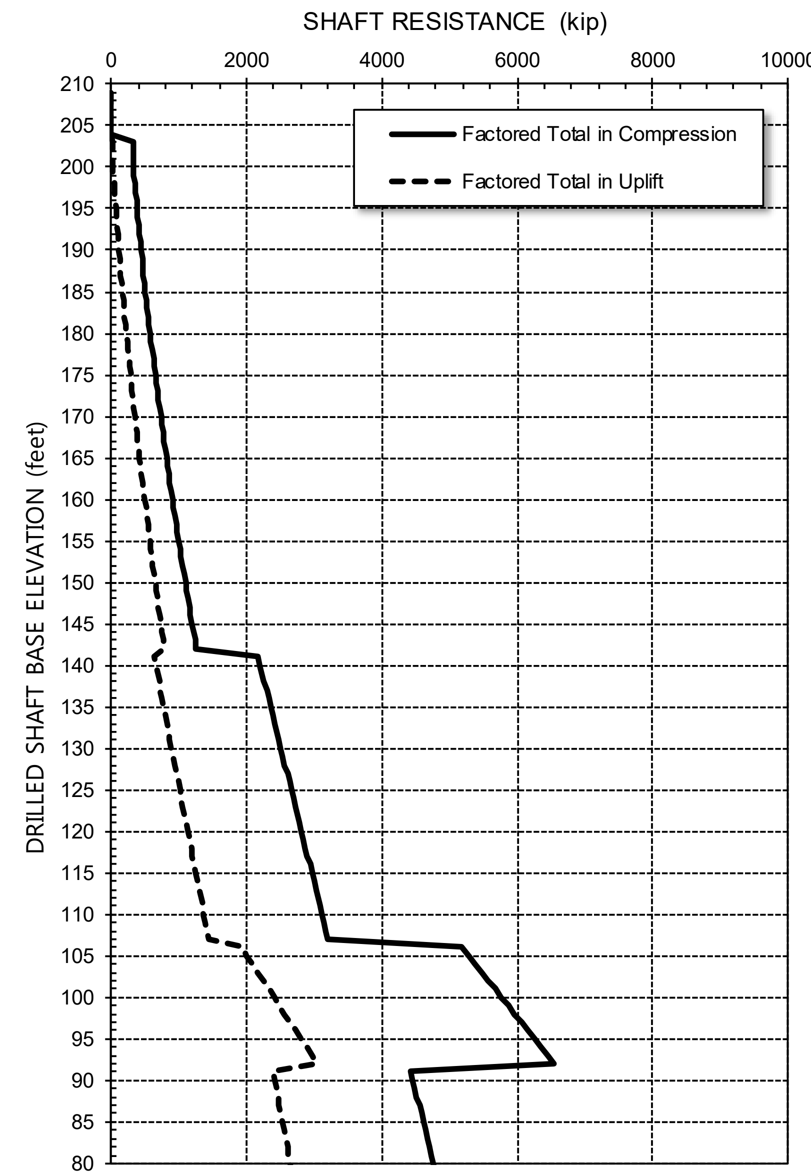
ASSUMED SUBSURFACE PROFILE
(B-19 East)



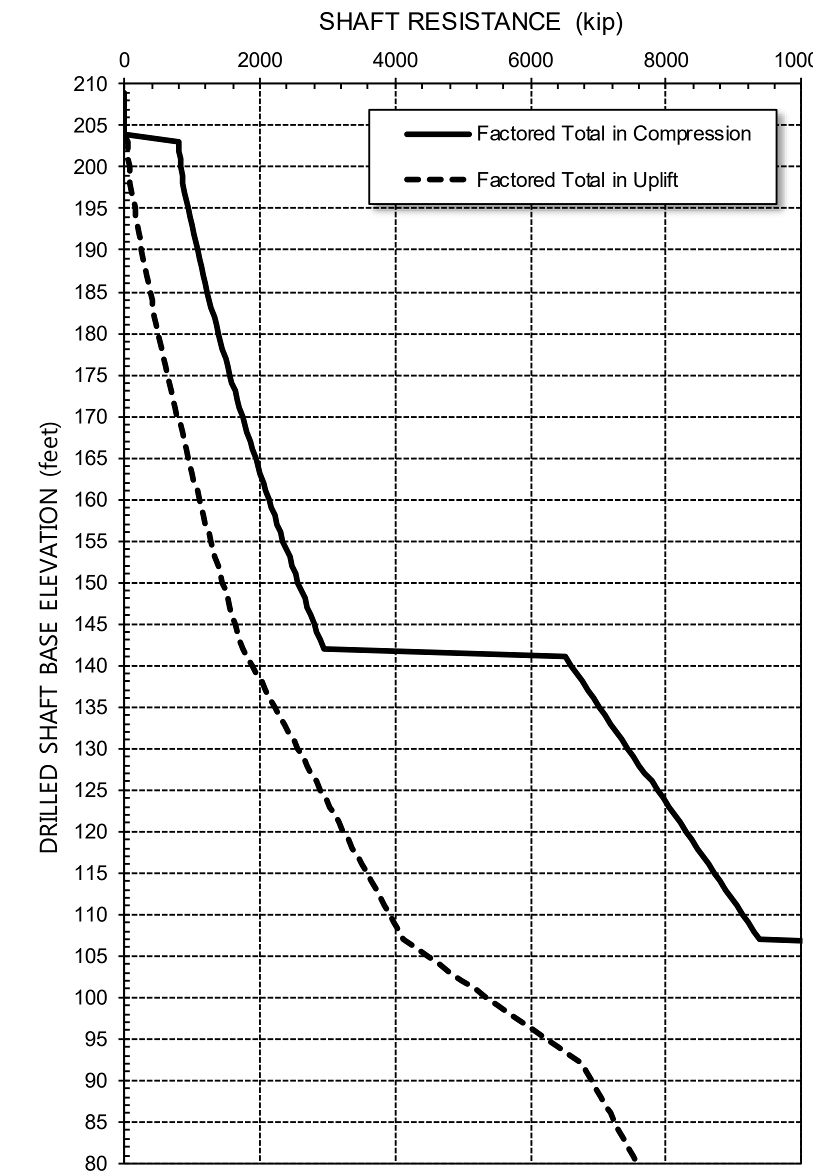
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

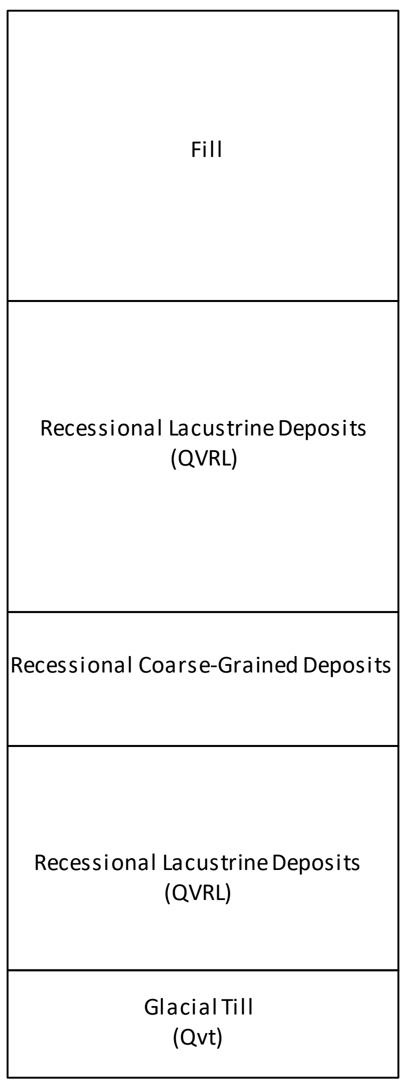
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

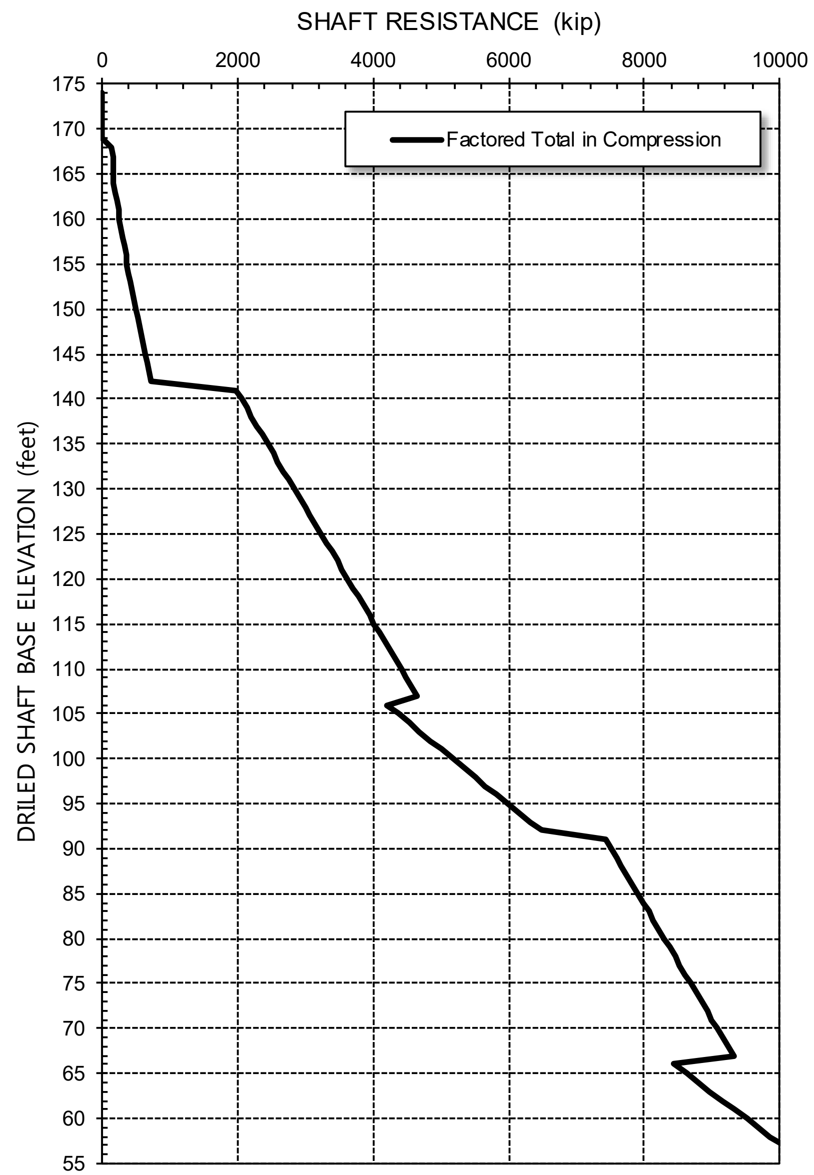
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 5
Drilled Shaft Axial Resistance Charts 8th_East_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

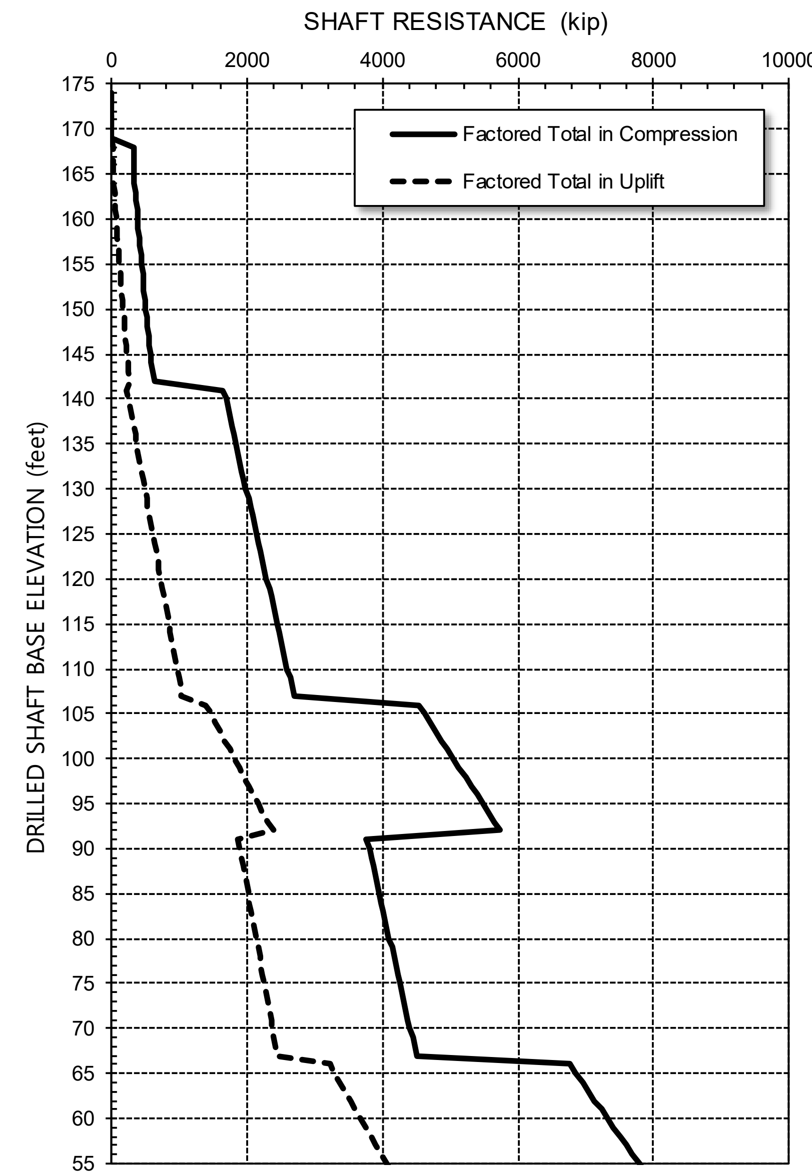
ASSUMED SUBSURFACE PROFILE
(B-19 West)



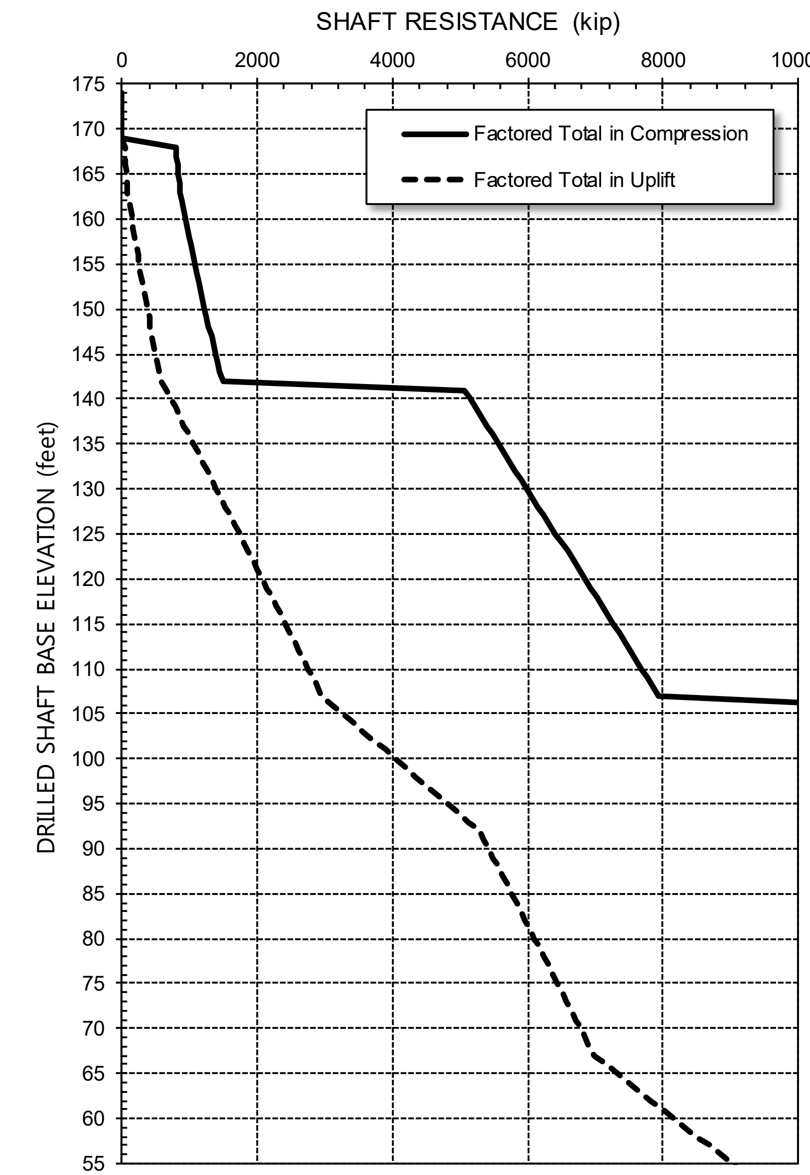
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:
1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

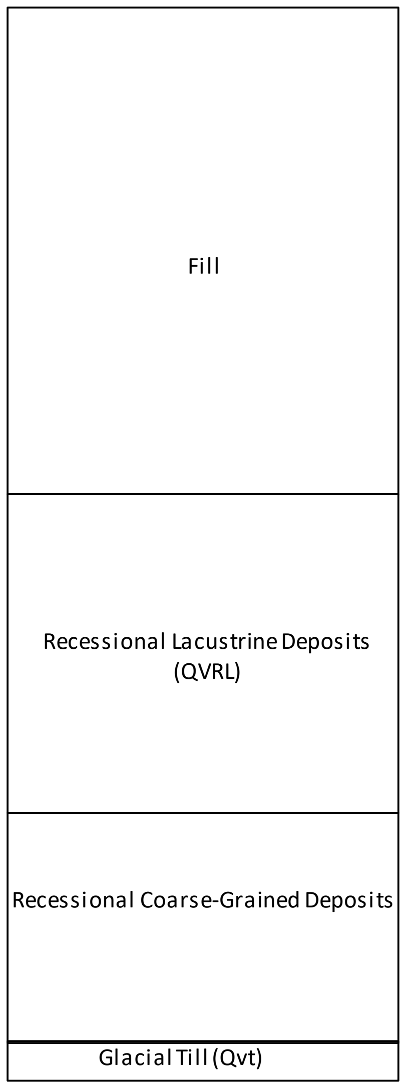
STRENGTH LIMIT NOTES:
1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

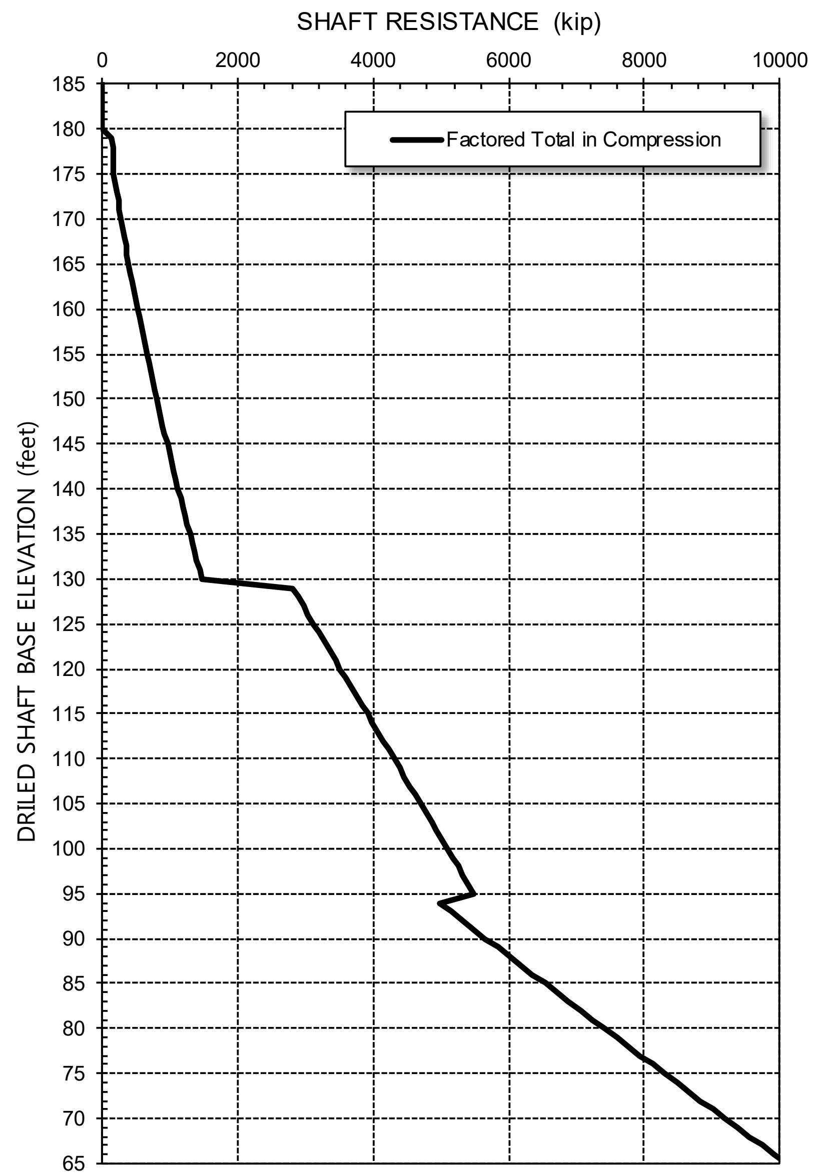
GENERAL NOTES:
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 6
Drilled Shaft Axial Resistance Charts 8th_West_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

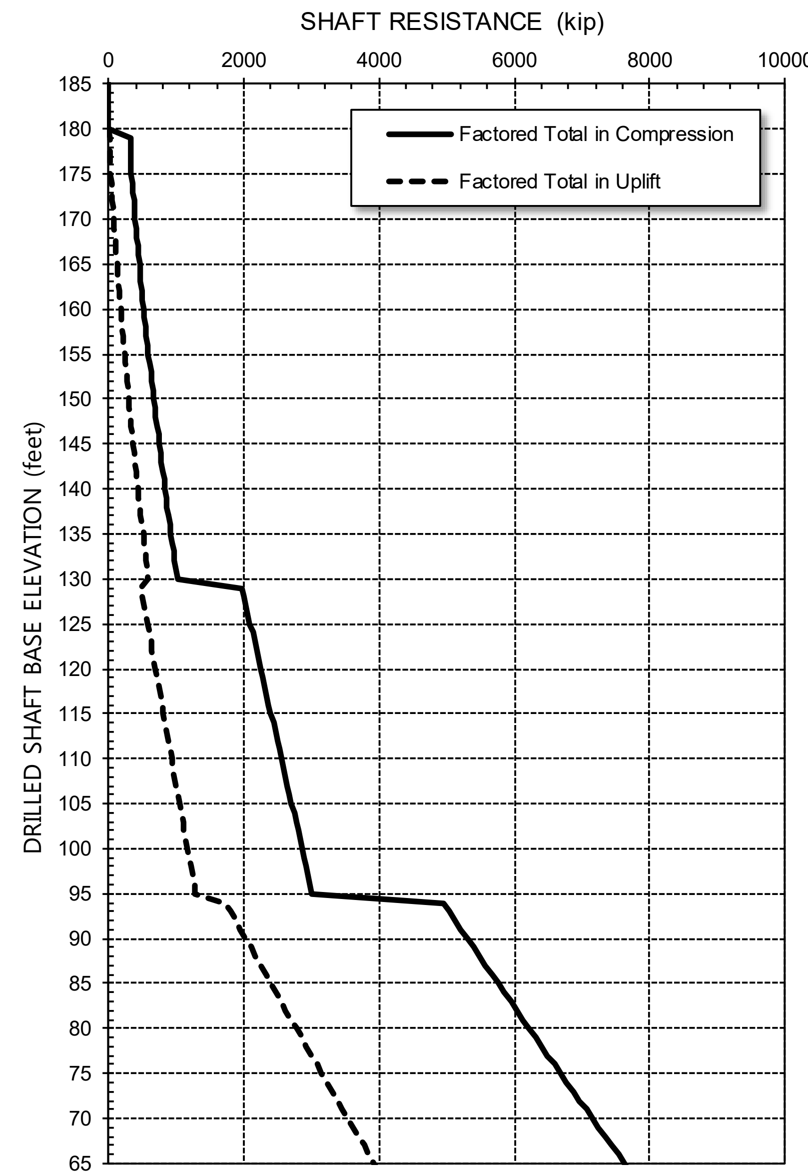
ASSUMED SUBSURFACE PROFILE
(B-9 - East)



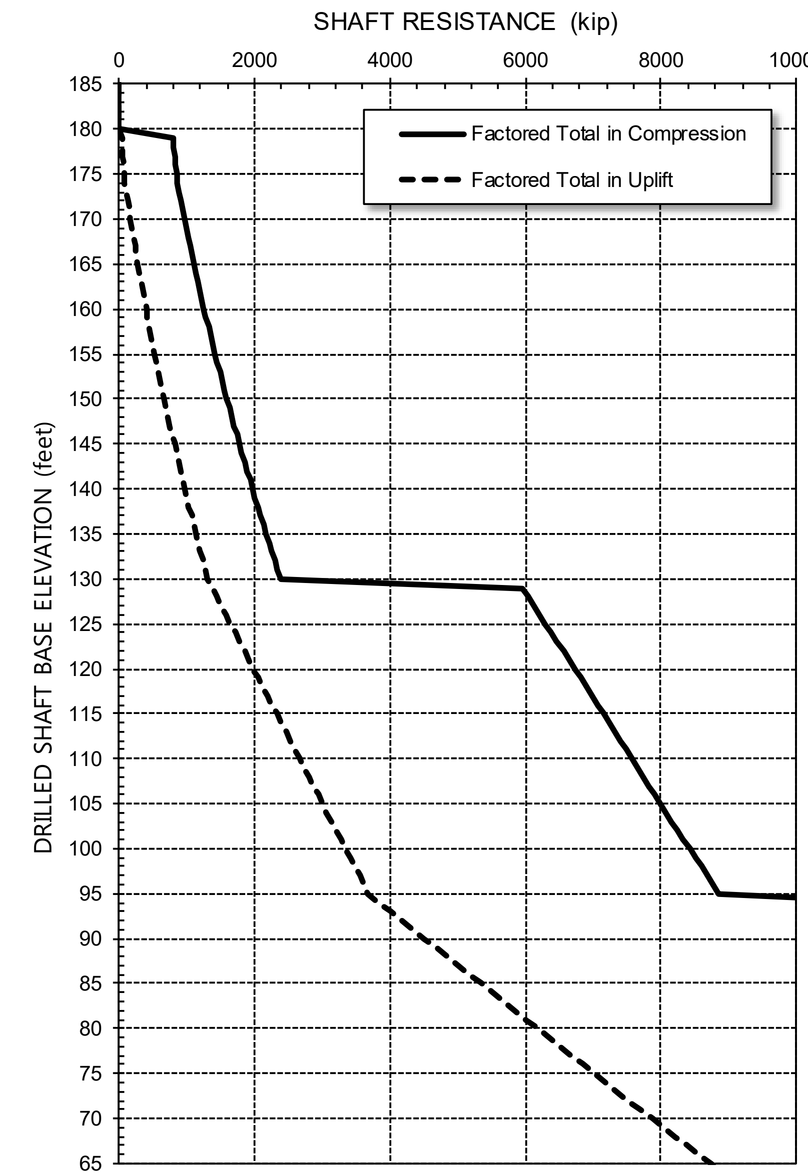
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

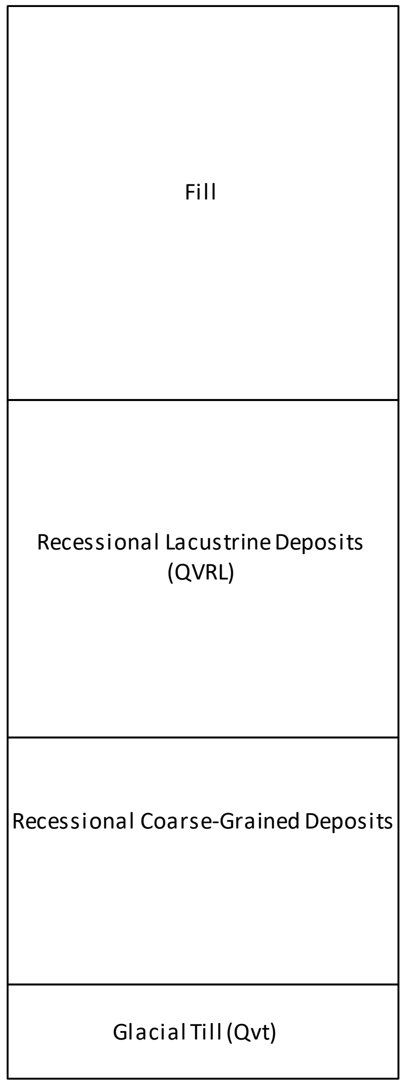
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

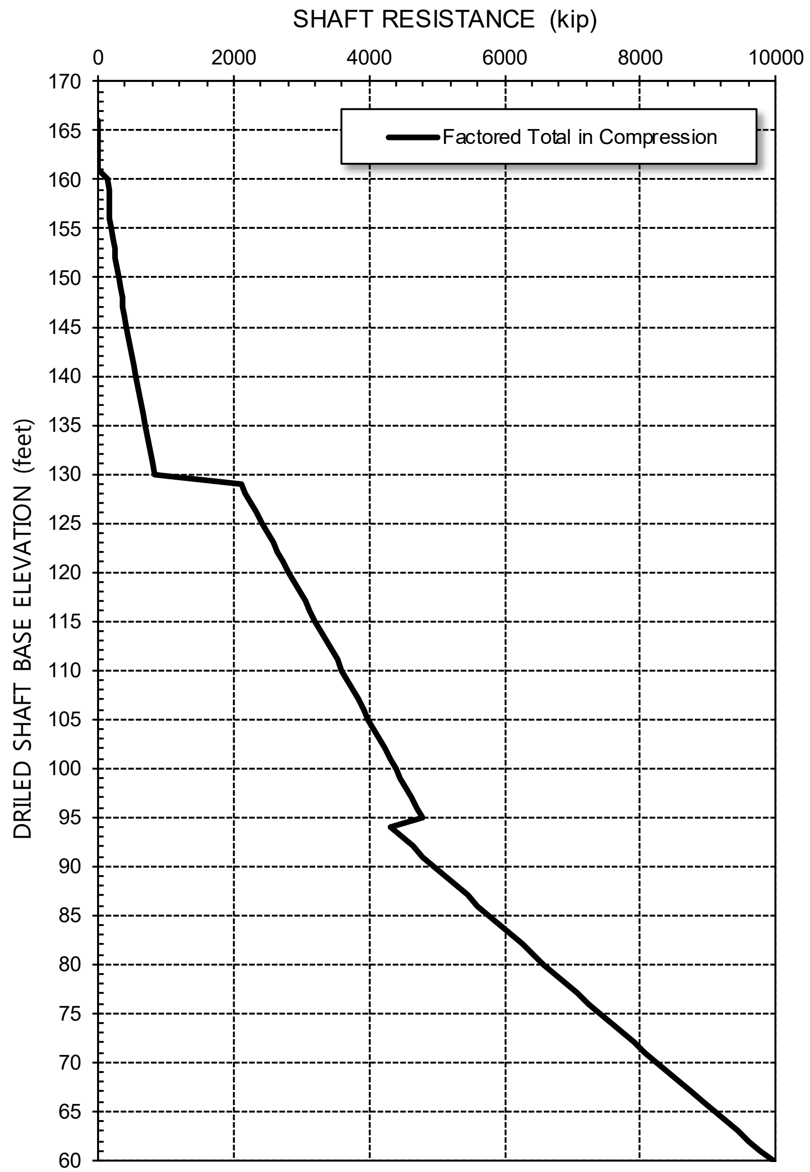
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 7
Drilled Shaft Axial Resistance Charts Pike_East_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

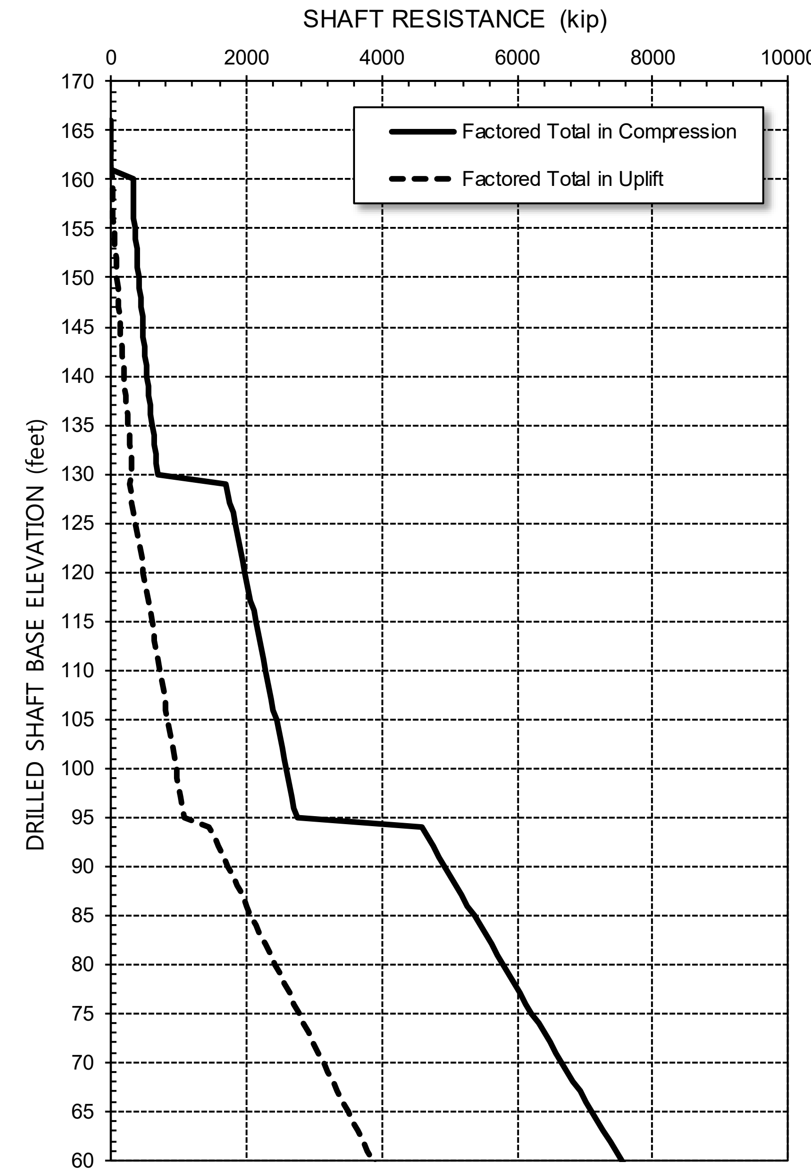
ASSUMED SUBSURFACE PROFILE
(B-9 - West)



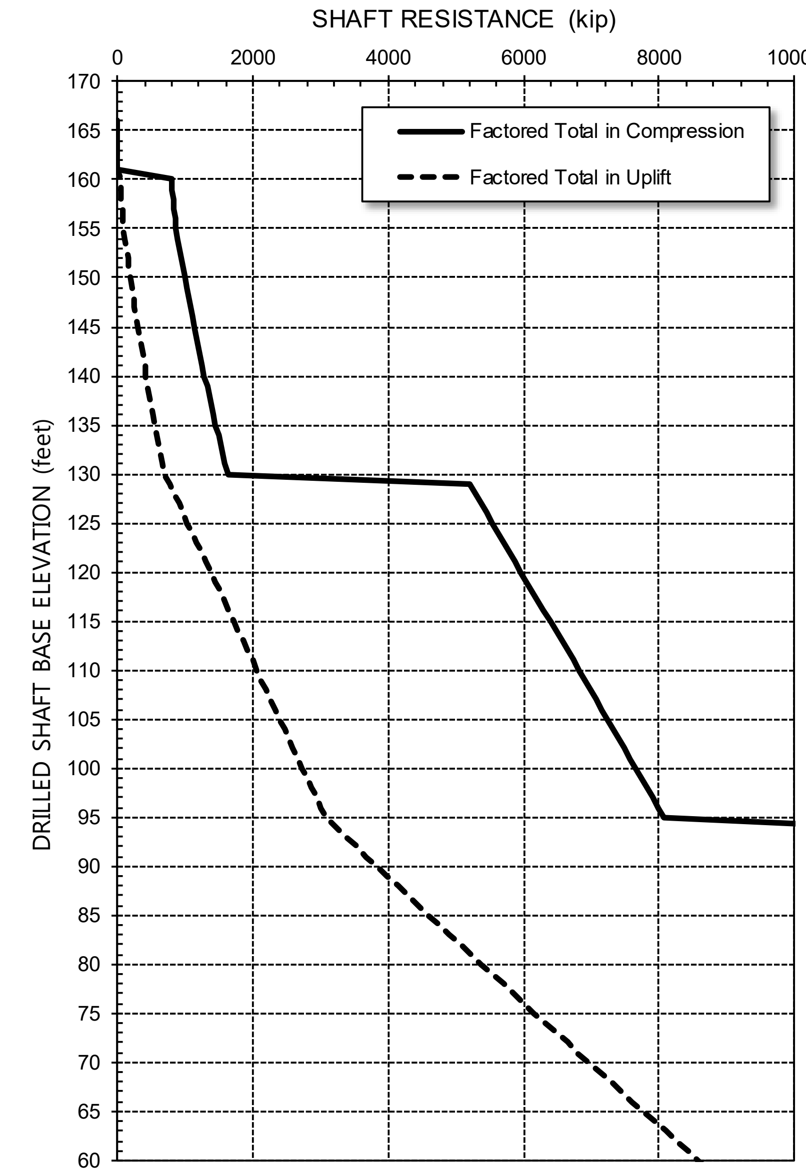
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



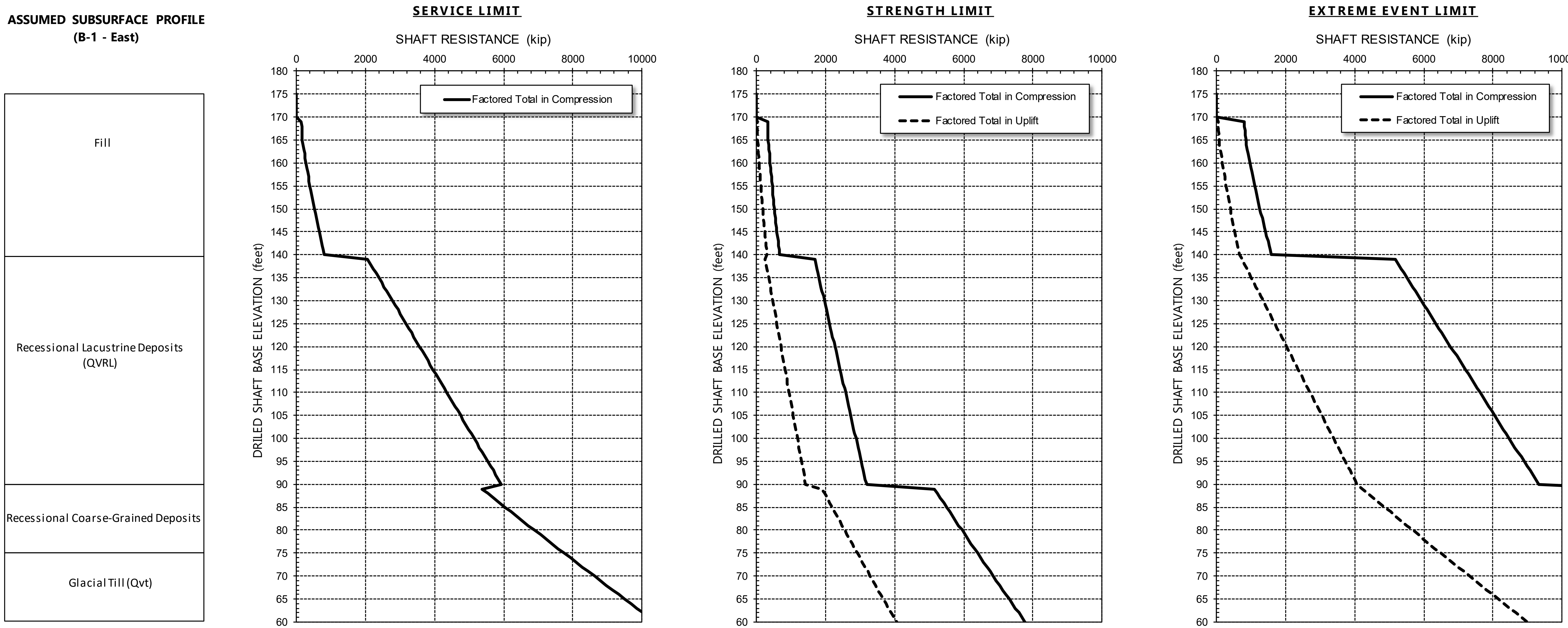
SERVICE LIMIT NOTES:
1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:
1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 8
Drilled Shaft Axial Resistance Charts Pike_West_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

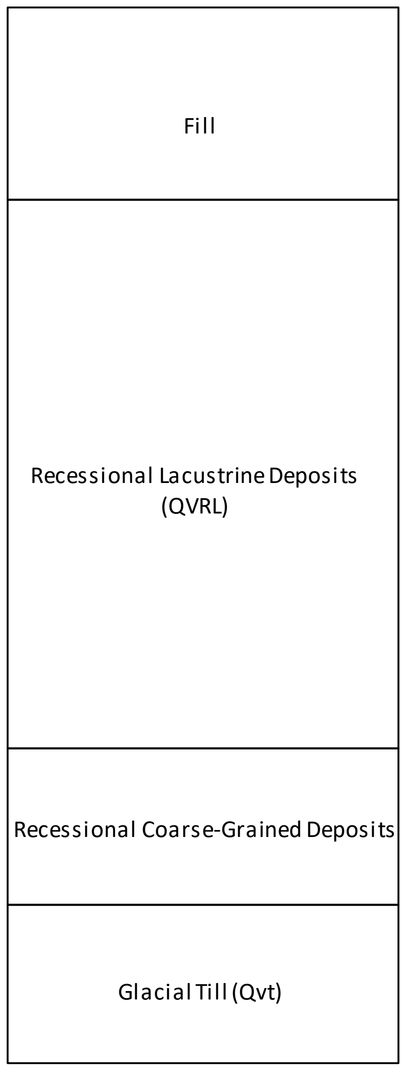
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

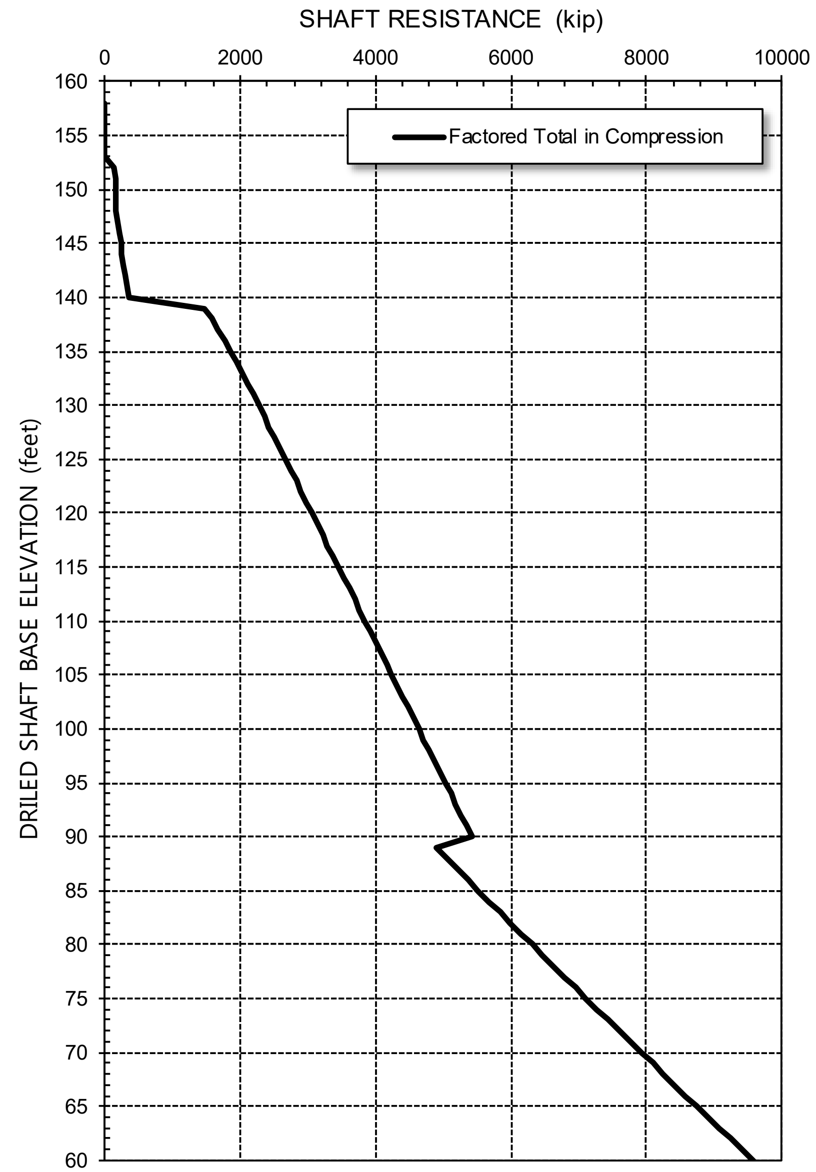
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 9
Drilled Shaft Axial Resistance Charts South Olive_East_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

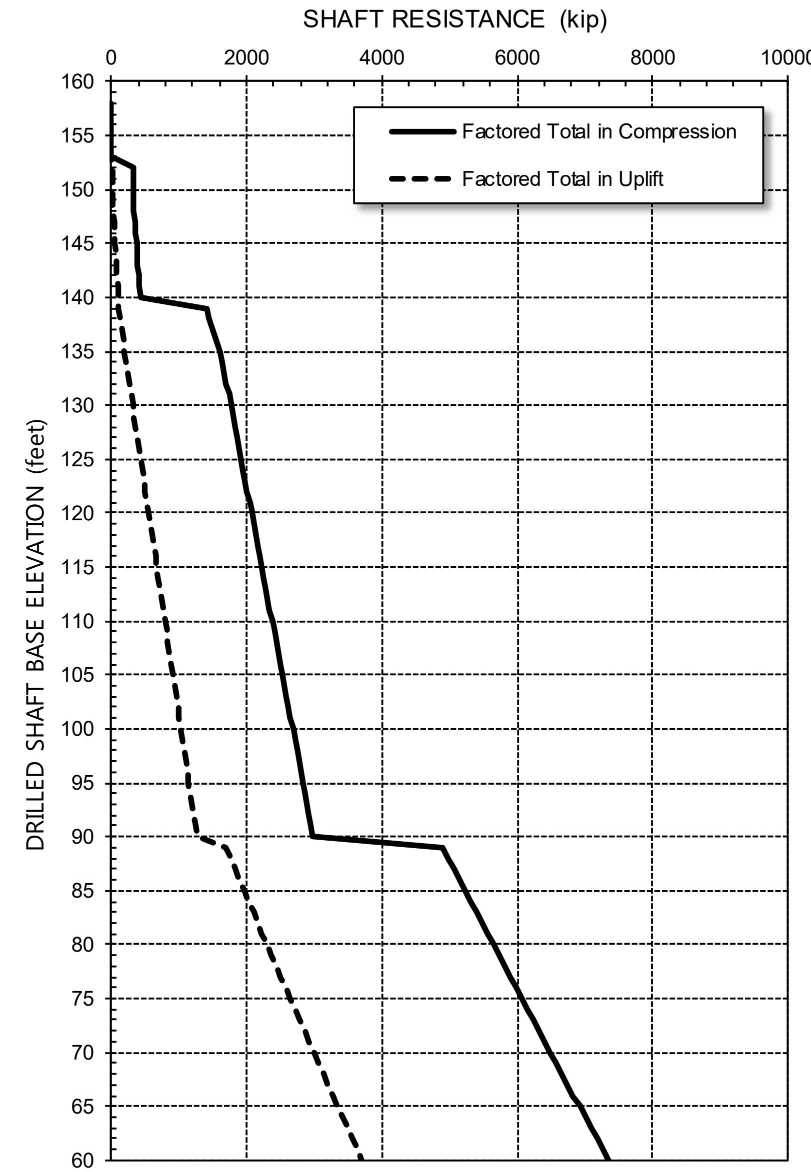
ASSUMED SUBSURFACE PROFILE
(B-1 - West)



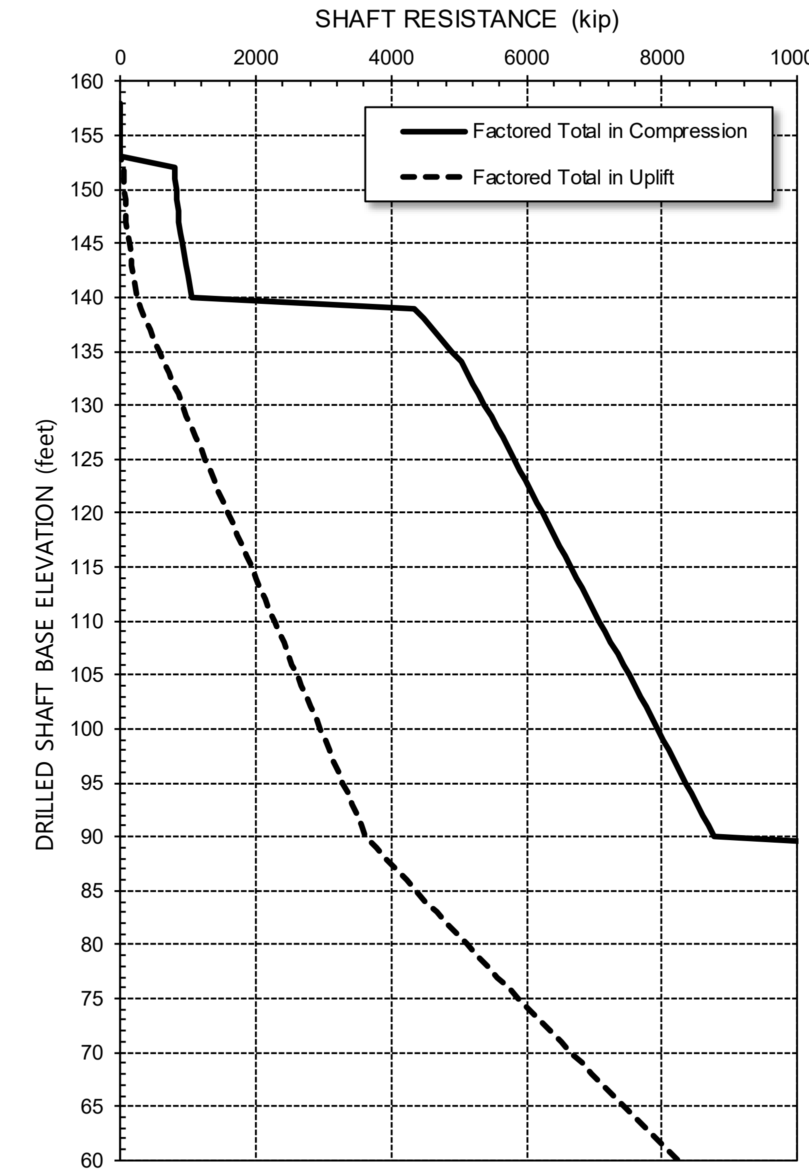
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

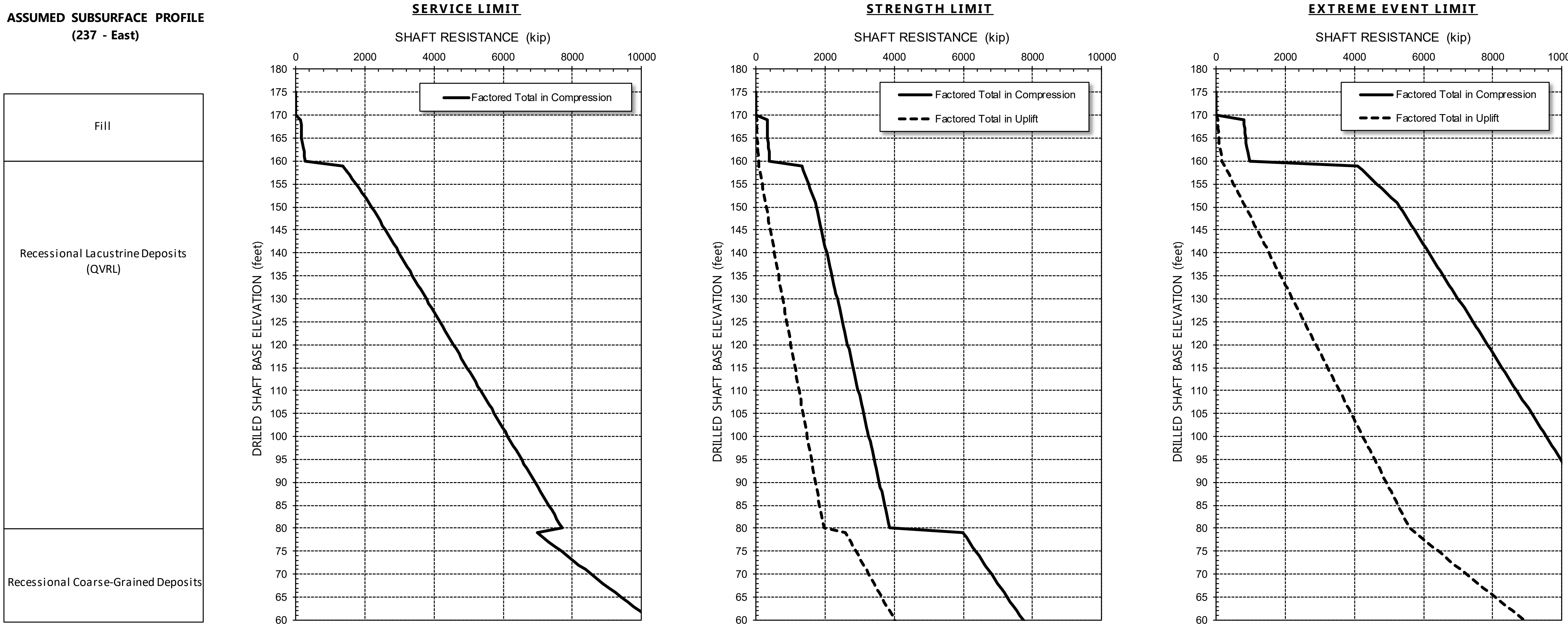
EXTREME EVENT LIMIT NOTES:

1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 10
Drilled Shaft Axial Resistance Charts South Olive_West_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

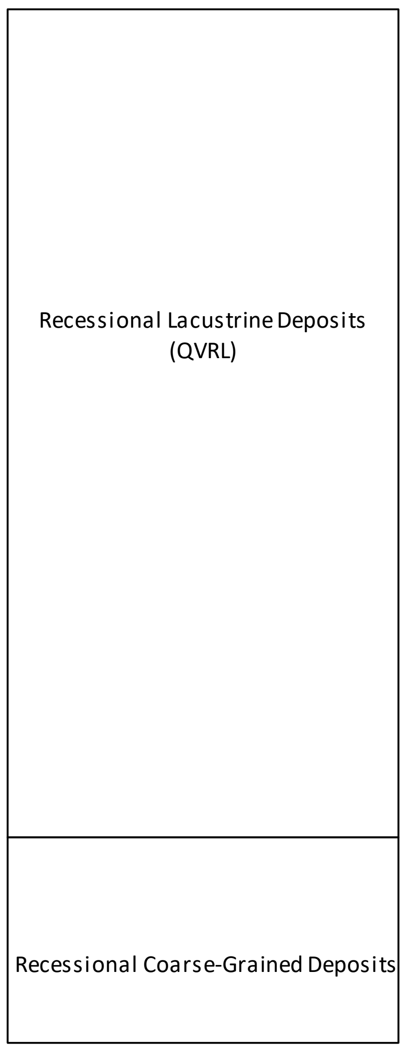
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

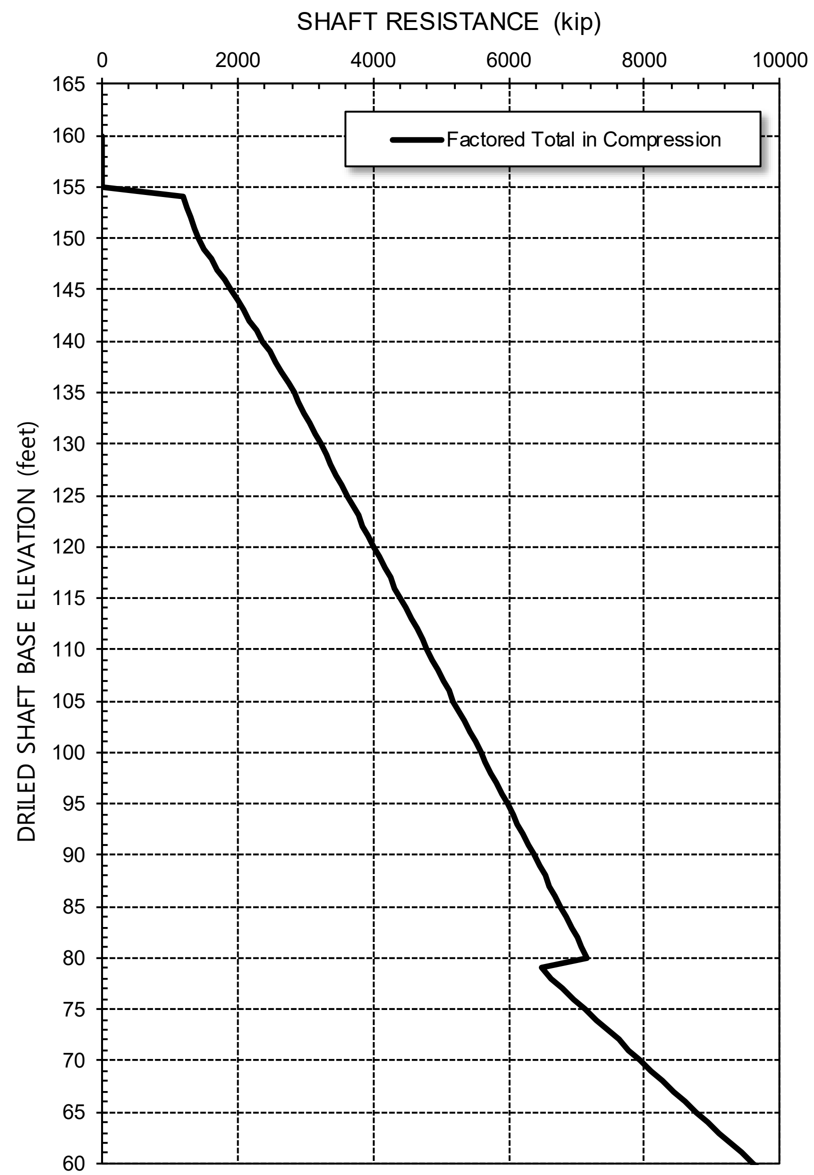
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 11
Drilled Shaft Axial Resistance Charts North Olive_East_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

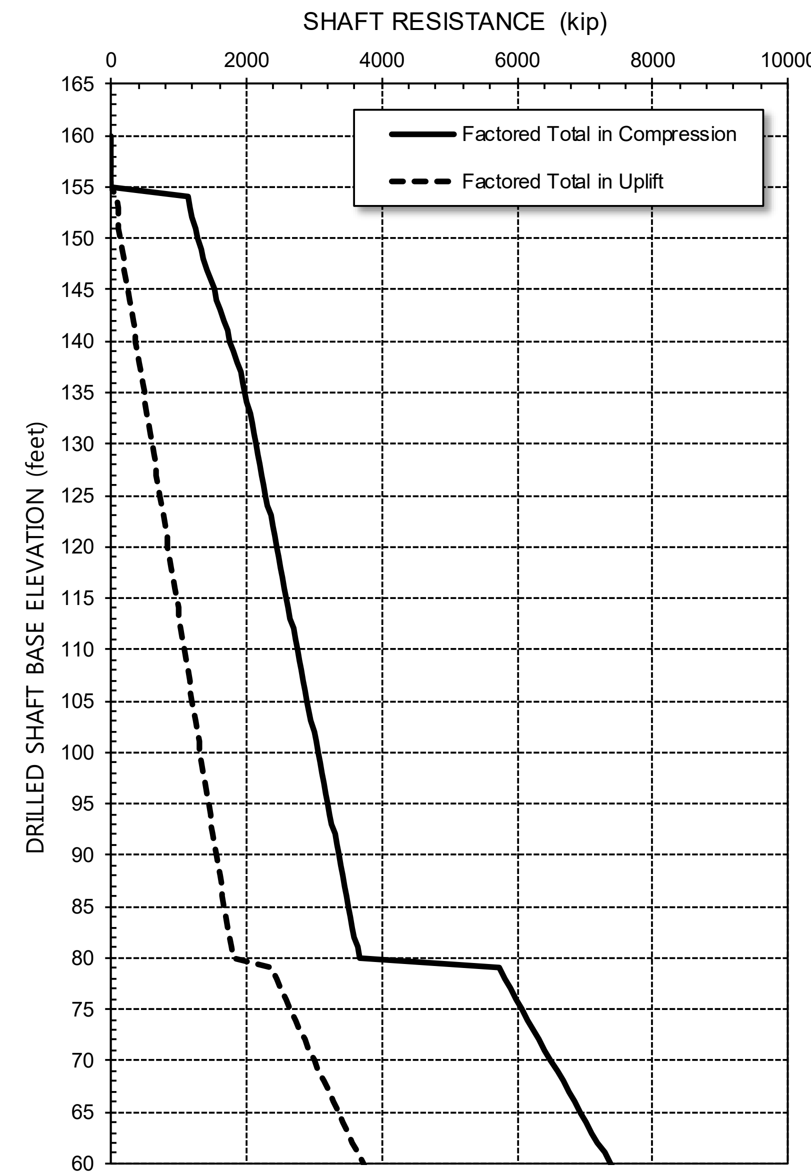
ASSUMED SUBSURFACE PROFILE
(237 - West)



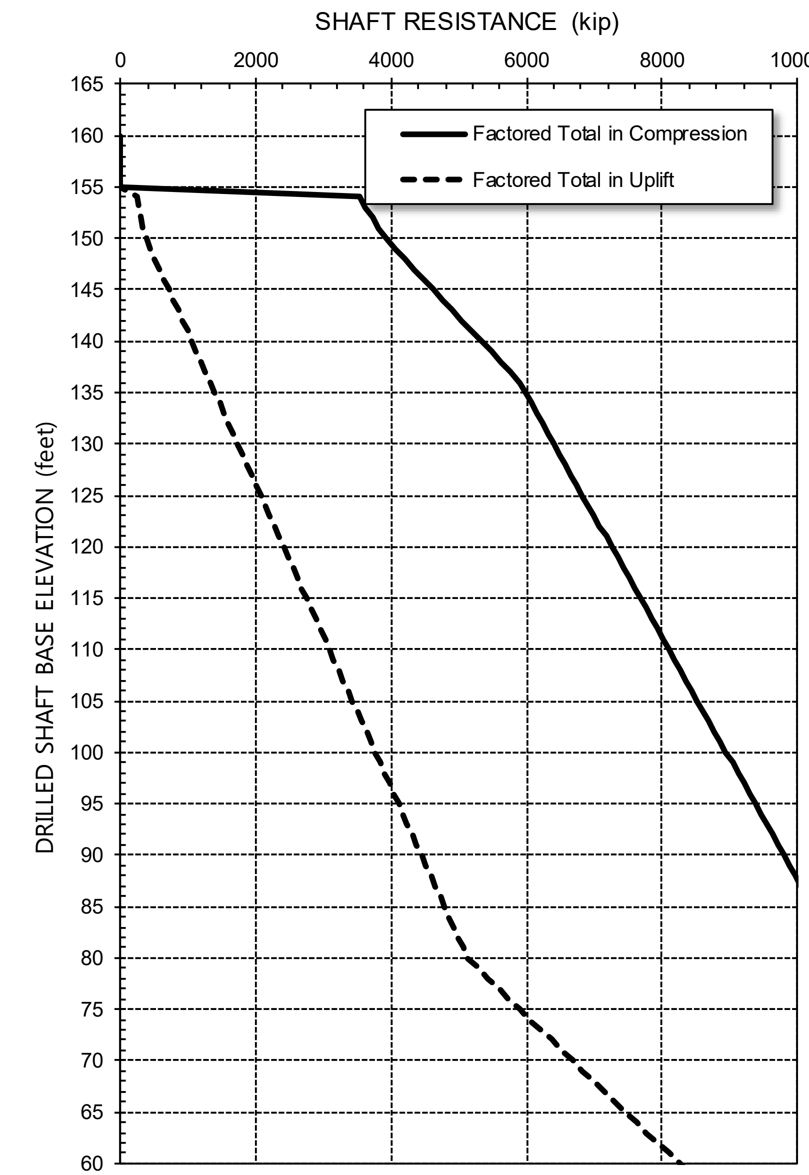
SERVICE LIMIT



STRENGTH LIMIT



EXTREME EVENT LIMIT



SERVICE LIMIT NOTES:
1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

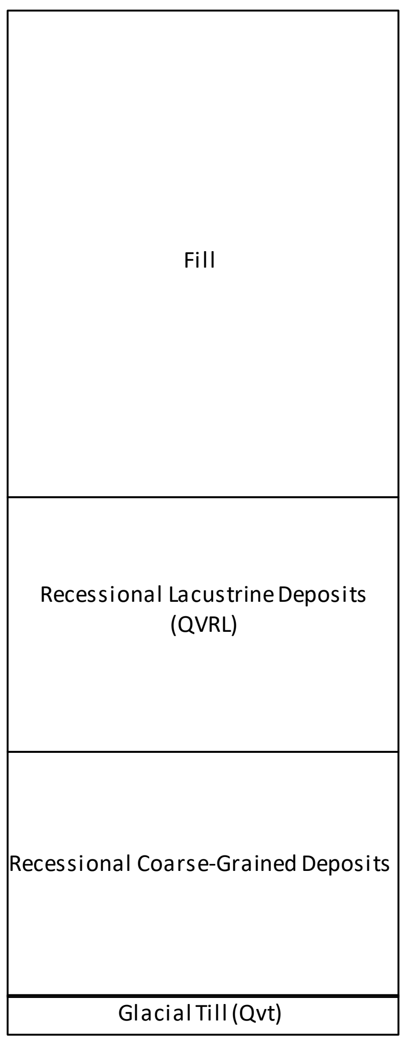
STRENGTH LIMIT NOTES:
1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

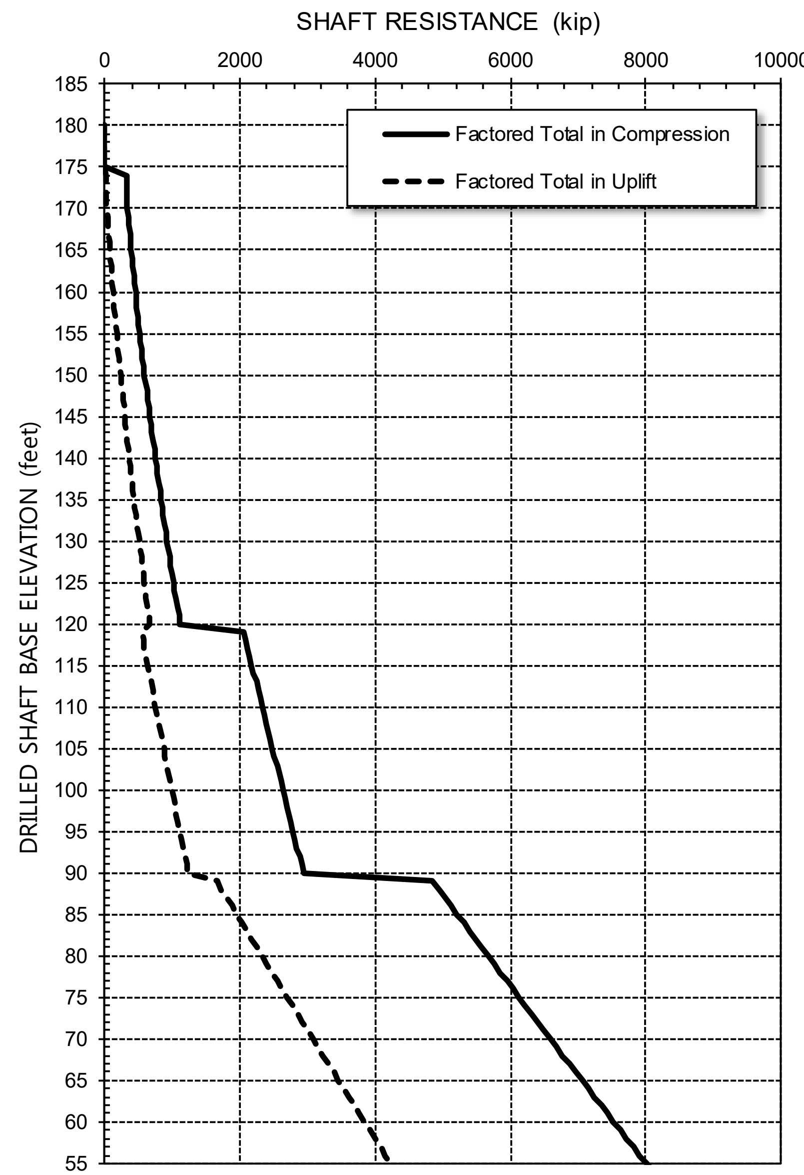
FIGURE 12
Drilled Shaft Axial Resistance Charts North Olive_West_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

ASSUMED SUBSURFACE PROFILE
(261 - East)

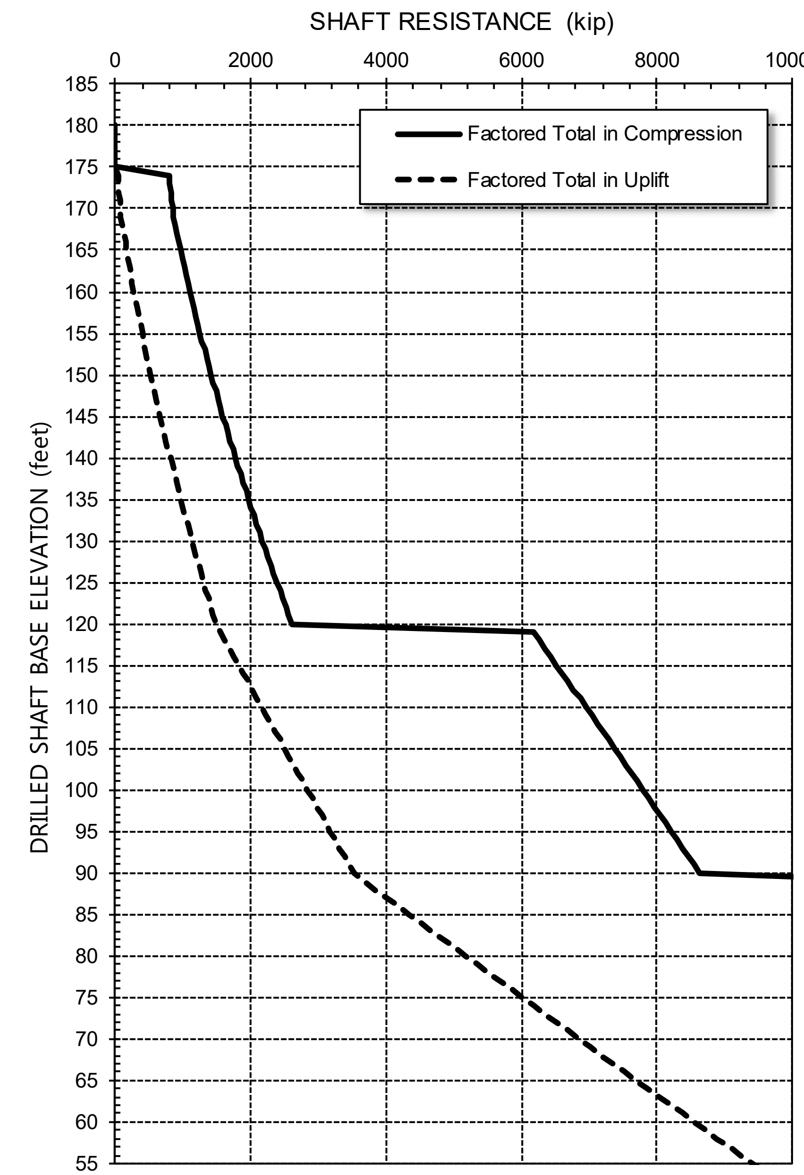


SERVICE LIMIT

STRENGTH LIMIT



EXTREME EVENT LIMIT



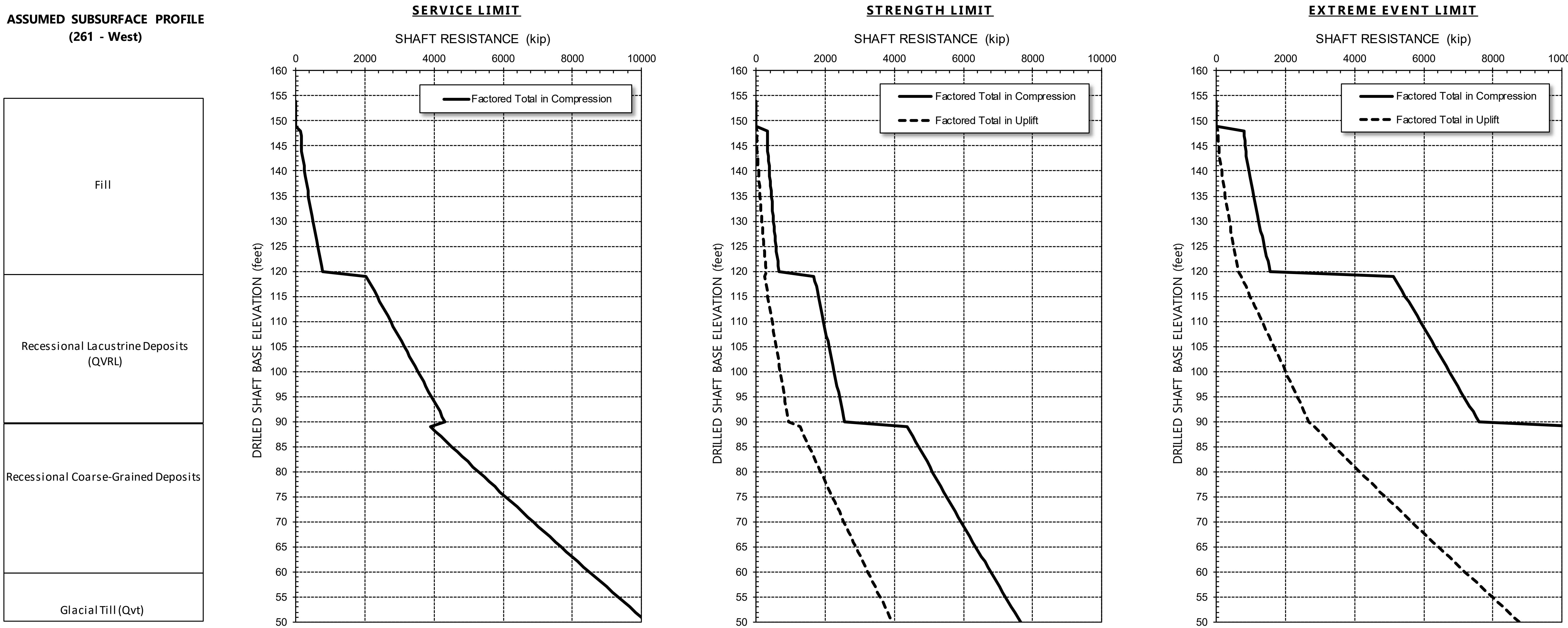
SERVICE LIMIT NOTES:
1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:
1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:
1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:
1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 13
Drilled Shaft Axial Resistance Charts Denny_East_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA



SERVICE LIMIT NOTES:

1. Resistance factors are 1.0 for both side and tip resistance
2. Service resistance was based on a shaft settlement of 0.5 inch.

STRENGTH LIMIT NOTES:

1. Resistance factors are 0.55 for side resistance and 0.5 for tip resistance.
2. Both side and tip resistances were further reduced by 20 percent to account for for the non-redundancy of the shafts (AASHTO 2014).
3. Resistance factor for uplift is 0.45.

EXTREME EVENT LIMIT NOTES:

1. Resistance factors for side and tip resistance are 1.0 for compression loading and 0.8 for uplift loading.

GENERAL NOTES:

1. The analyses were performed based on guidelines included in AASHTO LRFD Bridge Design Specifications (2014) and local experience. The analyses are based on a single shaft and do not consider group action or closely spaced shafts (i.e., closer than 3 diameters center-to-center).
2. Factored total shaft resistance shown on the plots is determined by adding factored side and tip resistances.
3. The computed axial capacities provided in the above charts do not account for the net weight of the shafts (i.e., weight of concrete minus weight of the soil removed).
4. It is assumed that a 10-ft long permanant casing was used for the drilled shaft.
5. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

FIGURE 14
Drilled Shaft Axial Resistance Charts Denny_West_10ft Diameter
I-5 Lid Feasibility Study
Seattle, WA

RECOMMENDED LPILE PARAMETERS

Soil Unit	Unit Weight (pcf)	Friction Angle	Soil Modulus, k (pci) above water/below water	Undrained Shear Strength (psf)	Strain E50
Fill	120	30	18/15		
Recessional Coarse-Grained De|	125	36	120/75		
Hard Clay-Lacustrine (QVRL)	125			6000	0.004
Glacial Till (Qvt)	135	40	260/140		

NOTE:

1. Geotechnical data is conceptual and solely intended for exploring opportunities, constraints, and technical questions that will need to be examined in more detail in future phases of work. The assumed subsurface profiles were generated from nearby completed projects and are not based on Geotechnical explorations conducted for this project. Project specific explorations and additional Geotechnical investigations will need to be performed in future phases of work.

I-5 Lid Feasibility Study

Appendix E
Cost Estimating Back-Up

Prepared for:

Seattle
Office of Planning &
Community Development

Prepared by:

wsp

OJB
Magnusson Klemencic Assoc.

EnviroIssues
Framework

HR&A Advisors
Shiels Obletz Johnsen

December 5, 2019

I-5 Lid Feasibility Study

Capital Cost Estimate Summary

Robust Lid Project Bookend

No.	Item Description		Area 1 Cost	Area 2 Cost	Area 3 Cost	Area 4 Cost	Total SAB Cost
I. CONSTRUCTION							
1.0	DEMOLITION		$ 1,711,931	$ 755,615	$ 309,365	$ 90,300	$ 2,867,211
2.0	STRUCTURES		$ 270,546,480	$ 111,625,200	$ 456,397,500	$ 416,088,600	$ 1,254,657,780
3.0	STREETSCAPE AND PARK		$ 4,922,527	$ 3,151,169	$ 10,298,484	$ 9,489,973	$ 27,862,153
4.0	CIVIL/ROADWAY		$ 3,993,508	$ 2,930,917	$ 6,243,147	$ 5,349,632	$ 18,517,204
5.0	DRAINAGE		$ 286,740	$ 665,758	$ 602,288	$ 362,814	$ 1,917,600
6.0	TRAFFIC		$ 963,934	$ 2,238,081	$ 2,024,714	$ 1,219,671	$ 6,446,400
7.0	UTILITIES		$ 2,013,279	$ 4,674,473	$ 4,228,834	$ 2,547,414	$ 13,464,000
8.0	MEP		$ 14,372,572	$ 7,588,081	$ 19,594,866	$ 22,082,741	$ 63,638,260
9.0	TRAFFIC CONTROL		$ 3,172,274	$ 7,365,452	$ 6,663,269	$ 4,013,898	$ 21,214,893
10.0	FEDERAL & STATE ASSET REPLACEMENT		$ -	$ -	$ -	$ -	$ -
11.0	VERTICAL DEVELOPMENT		$ -	$ -	$ -	$ -	$ -
	Construction without Mobilization		$ 301,983,245	$ 140,994,746	$ 506,362,467	$ 461,245,043	$ 1,410,585,501
	Mobilization	0%	$ -	$ -	$ -	$ -	$ -
	Construction including Mobilization		$ 301,983,245	$ 140,994,746	$ 506,362,467	$ 461,245,043	$ 1,410,585,501
	Contingency	20%	$ 60,396,649	$ 28,198,949	$ 101,272,493	$ 92,249,009	$ 282,117,100
		Subtotal	$ 362,379,894	$ 169,193,695	$ 607,634,960	$ 553,494,052	$ 1,692,702,601
	Risk	30%	$ 108,713,968	$ 50,758,109	$ 182,290,488	$ 166,048,215	$ 507,810,780
		Subtotal	$ 471,093,862	$ 219,951,804	$ 789,925,449	$ 719,542,267	$ 2,200,513,382
	Sales Tax	0.00%	$ -	$ -	$ -	$ -	$ -
		Subtotal	$ 471,093,862	$ 219,951,804	$ 789,925,449	$ 719,542,267	$ 2,200,513,382
	Inflation (Assume Construction in 2019)	0.0%	$ -	$ -	$ -	$ -	$ -
		Construction Subtotal	$ 471,093,862	$ 219,951,804	$ 789,925,449	$ 719,542,267	$ 2,200,513,382
CONSTRUCTION TOTAL			**$ 471,094,000**	**$ 219,952,000**	**$ 789,926,000**	**$ 719,543,000**	**$ 2,200,515,000**

No.	Item Description	Area 1 Cost	Area 2 Cost	Area 3 Cost	Area 4 Cost	Total SAB Cost
II. RIGHT OF WAY						
1.0	TEMPORARY EASEMENT	$ -	$ -	$ -	$ -	$ -
2.0	AERIAL EASEMENT	$ -	$ -	$ -	$ -	$ -
3.0	PERMANENT AQUISITION	$ -	$ -	$ -	$ -	$ -
4.0		$ -	$ -	$ -	$ -	$ -
5.0		$ -	$ -	$ -	$ -	$ -
RIGHT OF WAY TOTAL		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**

No.	Item Description		Area 1 Cost	Area 2 Cost	Area 3 Cost	Area 4 Cost	Total SAB Cost
III. OTHER VARIABLE							
	Construction Total		$ 471,094,000	$ 219,952,000	$ 789,926,000	$ 719,543,000	$ 2,200,515,000
	Other Variable	30%	$ 141,328,200	$ 65,985,600	$ 236,977,800	$ 215,862,900	$ 660,154,500
OTHER VARIABLE TOTAL			**$ 141,329,000**	**$ 65,986,000**	**$ 236,978,000**	**$ 215,863,000**	**$ 660,156,000**

Build Case Notes & Assumptions:

- Structural Assessment Boundary (SAB) is the total of Area 1 - 4
- Maximum square feet of developable land within SAB

CONSTRUCTION TOTAL - SAB	$ 2,200,515,000
RIGHT OF WAY TOTAL - SAB	$ -
OTHER VARIABLE TOTAL - SAB	$ 660,156,000

I-5 Lid Feasibility Study

Capital Cost Estimate Summary

Leanest Lid Project Bookend

No.	Item Description		Area 1 Cost	Area 2 Cost	Area 3 Cost	Area 4 Cost	Total SAB Cost
I. CONSTRUCTION							
1.0	DEMOLITION		$ 397,731	$ -	$ 116,515	$ 49,583	$ 563,829
2.0	STRUCTURES		$ 41,918,760	$ 860,000	$ 183,732,920	$ 182,949,760	$ 409,461,440
3.0	STREETSCAPE AND PARK		$ 2,504,328	$ -	$ 7,952,926	$ 8,032,781	$ 18,490,035
4.0	CIVIL/ROADWAY		$ 2,661,627	$ 2,305,996	$ 5,275,101	$ 5,037,392	$ 15,280,116
5.0	DRAINAGE		$ 286,740	$ 665,758	$ 602,288	$ 362,814	$ 1,917,600
6.0	TRAFFIC		$ 963,934	$ 2,238,081	$ 2,024,714	$ 1,219,671	$ 6,446,400
7.0	UTILITIES		$ 2,013,279	$ 4,674,473	$ 4,228,834	$ 2,547,414	$ 13,464,000
8.0	MEP		$ 11,710,473	$ 2,285,476	$ 20,116,399	$ 24,144,033	$ 58,256,381
9.0	TRAFFIC CONTROL		$ 3,172,274	$ 7,365,452	$ 6,663,269	$ 4,013,898	$ 21,214,893
10.0	FEDERAL & STATE ASSET REPLACEMENT		$ -	$ -	$ -	$ -	$ -
11.0	VERTICAL DEVELOPMENT		$ -	$ -	$ -	$ -	$ -
	Construction without Mobilization		$ 65,629,146	$ 20,395,236	$ 230,712,966	$ 228,357,346	$ 545,094,694
	Mobilization	0%	$ -	$ -	$ -	$ -	$ -
	Construction including Mobilization		$ 65,629,146	$ 20,395,236	$ 230,712,966	$ 228,357,346	$ 545,094,694
	Contingency	20%	$ 13,125,829	$ 4,079,047	$ 46,142,593	$ 45,671,469	$ 109,018,939
		Subtotal	$ 78,754,975	$ 24,474,283	$ 276,855,559	$ 274,028,815	$ 654,113,633
	Risk	0%	$ -	$ -	$ -	$ -	$ -
		Subtotal	$ 78,754,975	$ 24,474,283	$ 276,855,559	$ 274,028,815	$ 654,113,633
	Sales Tax	0.00%	$ -	$ -	$ -	$ -	$ -
		Subtotal	$ 78,754,975	$ 24,474,283	$ 276,855,559	$ 274,028,815	$ 654,113,633
	Inflation (Assume Construction in 2019)	0.0%	$ -	$ -	$ -	$ -	$ -
		Construction Subtotal	$ 78,754,975	$ 24,474,283	$ 276,855,559	$ 274,028,815	$ 654,113,633
CONSTRUCTION TOTAL			**$ 78,755,000**	**$ 24,475,000**	**$ 276,856,000**	**$ 274,029,000**	**$ 654,115,000**

No.	Item Description	Area 1 Cost	Area 2 Cost	Area 3 Cost	Area 4 Cost	Total SAB Cost
II. RIGHT OF WAY						
1.0	TEMPORARY EASEMENT	$ -	$ -	$ -	$ -	$ -
2.0	AERIAL EASEMENT	$ -	$ -	$ -	$ -	$ -
3.0	PERMANENT AQUISITION	$ -	$ -	$ -	$ -	$ -
4.0		$ -	$ -	$ -	$ -	$ -
5.0		$ -	$ -	$ -	$ -	$ -
RIGHT OF WAY TOTAL		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**

No.	Item Description		Area 1 Cost	Area 2 Cost	Area 3 Cost	Area 4 Cost	Total SAB Cost
III. OTHER VARIABLE							
	Construction Total		$ 78,755,000	$ 24,475,000	$ 276,856,000	$ 274,029,000	$ 654,115,000
	Other Variable	30%	$ 23,626,500	$ 7,342,500	$ 83,056,800	$ 82,208,700	$ 196,234,500
OTHER VARIABLE TOTAL			**$ 23,627,000**	**$ 7,343,000**	**$ 83,057,000**	**$ 82,209,000**	**$ 196,236,000**

Build Case Notes & Assumptions:
- Structural Assessment Boundary (SAB) is the total of Area 1 - 4
- Minimum square feet of developable land within SAB

CONSTRUCTION TOTAL - SAB	$ 654,115,000
RIGHT OF WAY TOTAL - SAB	$ -
OTHER VARIABLE TOTAL - SAB	$ 196,236,000