Appendix I. Structural Alternatives Study

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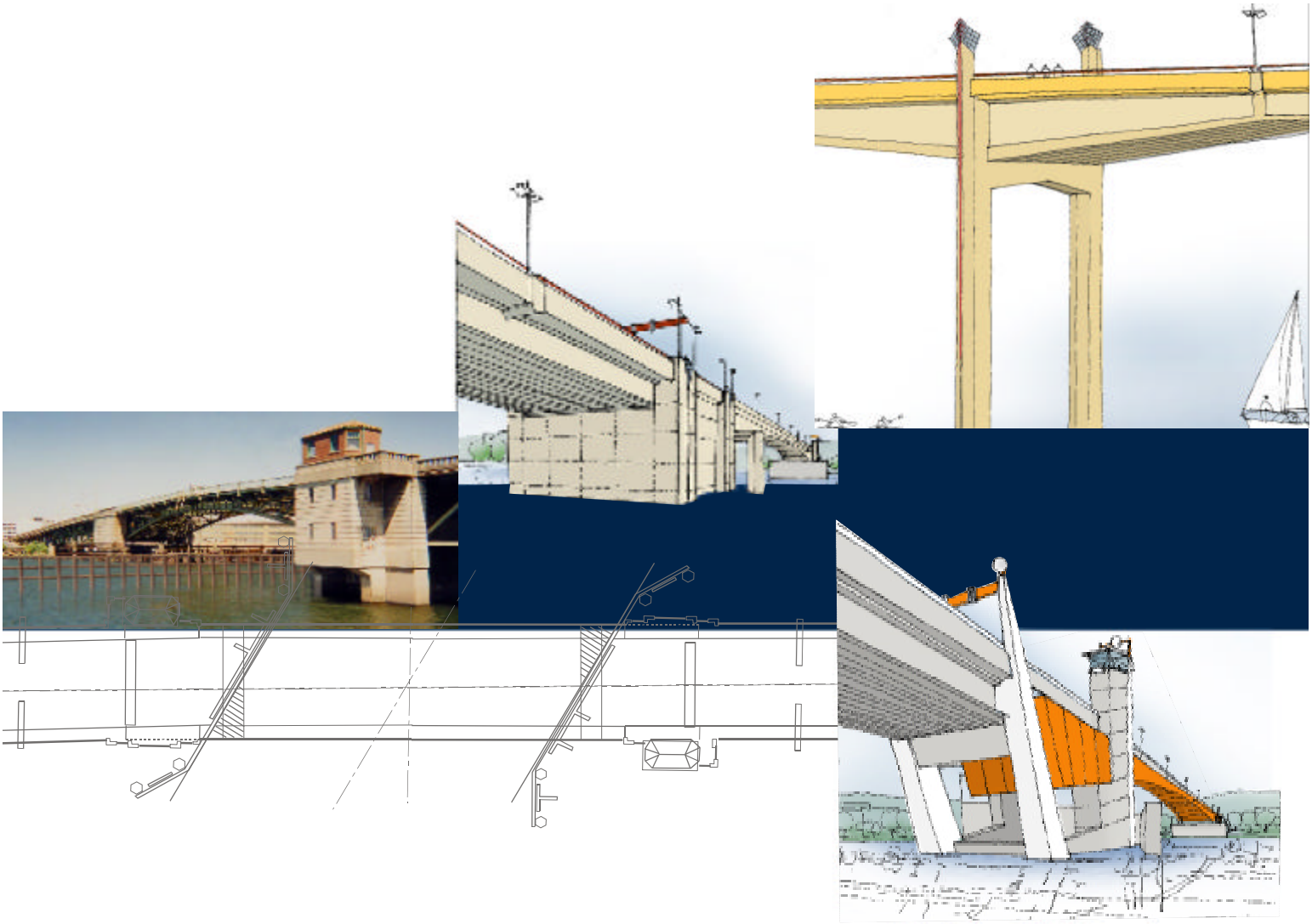
SOUTH PARK BRIDGE

Structural Alternatives Study

prepared for:
King County Department of Transportation

prepared by:
Parsons Brinckerhoff

November 2003



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SOUTH PARK BRIDGE PROJECT

Structural Alternatives Study

Prepared for the

King County
Department of Transportation

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Seattle, Washington 98104

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November 2003

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SUMMARY

The purpose of this study is to develop conceptual-level engineering designs and cost estimates for the structural alternatives (except the No Action Alternative) recommended by King County [Refs. 8 and 9], based on the *South Park Bridge Project Summary Technical Report: Alternatives Development and Screening* prepared by Parsons Brinckerhoff, Inc. on September 6, 2002 [Ref. 1]. The structural alternatives that King County has recommended for further study include:

- No Action (No Build) Alternative
- Retrofit Alternative
- Fixed-Span High-Level Bridge Alternative
- Fixed-Span Mid-Level Bridge Alternative
- New Movable Bridge Alternative

For the four build alternatives listed above, conceptual designs were prepared that include structure layouts, typical cross sections, preferred superstructure and substructure types, and possible foundation types and sizes. Several architectural sketches of the four build alternatives, based on conceptual engineering, are included in this report (see Section 10).

Conceptual-level construction costs were estimated for the build alternatives. In order to compare the cost of constructing and maintaining different types of bridges, life-cycle cost estimates were also developed. A summary of construction and life-cycle costs for each build alternative is presented in the Appendix.

1. Introduction

1.1. PROJECT GOAL

The purpose of the South Park Bridge project is to find the most feasible long-term solution that addresses the bridge's deteriorated condition and increasing seismic vulnerability, and maintains a vital transportation linkage for cars, trucks, buses, bicyclists and pedestrians across the Duwamish River [Ref. 1]. Figure 1 on the following page shows the project vicinity.

1.2 PURPOSE OF THE STRUCTURAL ALTERNATIVES STUDY

The purpose of this study is to develop conceptual-level engineering designs and cost estimates for the structural alternatives (except the No Action Alternative) recommended by King County [Refs. 8 and 9], based on the *South Park Bridge Project Summary Technical Report: Alternatives Development and Screening* prepared by Parsons Brinckerhoff, Inc. on September 6, 2002 [Ref. 1]. The structural alternatives that King County has recommended for further study include:

- No Action (No Build) Alternative:
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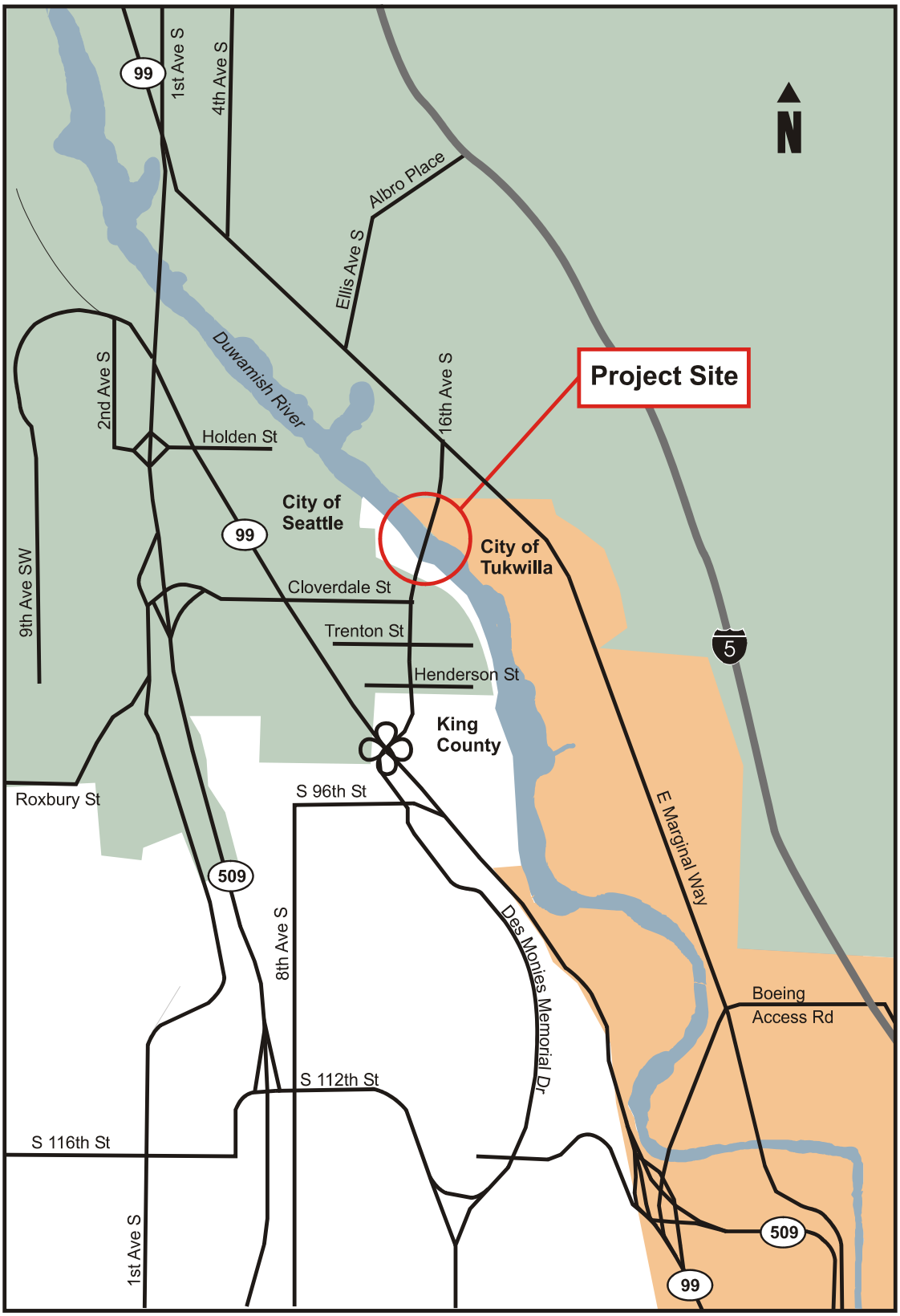


Figure 1
Vicinity Map

2. Existing Conditions of the South Park Bridge

2.1. EXISTING BRIDGE

The South Park Bridge is a double-leaf bascule bridge built in 1931. Its existing main span is a Scherzer rolling-lift double-leaf bascule span. Because it is the only operational example of a Scherzer rolling-lift bascule bridge in the state of Washington, the bridge is listed on the National Historic Register [Refs. 2, 3]. See Photo 1. Two steel-truss spans and twelve concrete-slab approach spans connect to the main bascule span from each side. The overall length of the bridge is 1,045 feet (see Figure 2). The double-leaf bascule movable span has a center-to-center distance between the front bearings of 190 feet. The approach spans are symmetrical to each side of the main span. Twelve concrete spans totaling approximately 240 feet lead up to a two-span steel truss approach of approximately 87 feet and 79 feet in length. The existing bridge deck consists of a four-lane, 38-foot-wide roadway, and 6-foot sidewalks on each side. See the existing bridge drawing (Figure 3).

The South Park Bridge spans the navigable waterway of the Duwamish River. This river is used for industrial, commercial and recreational purposes. According to the U.S. Coast Guard permit [Ref. 4], the existing bridge's vertical clearance at the center of the bascule span is limited to 34 feet at the Mean High Water (MHW) level when closed. The existing navigable horizontal clearance is 118 feet at the waterline between the pier protections, and narrows to approximately 92 feet between the opposing tips of the two open bascule leaves. Figures 4a and 4b are the two drawings supplied by King County for the U.S. Coast Guard permit in September 8, 1998. The U.S. Coast Guard has accepted these drawings as a legitimate revision of the permit drawings for the original approval document of 1929 [Ref. 4].

2.2. EXISTING CONDITION AND DEFICIENCIES

Despite substantial ongoing maintenance and repairs, the South Park Bridge has suffered significant deterioration over the past 75 years. Its existing problems worsened significantly following the Nisqually Earthquake in February 2001, and the bridge remains vulnerable to future seismic events according to the Washington State Bridge Inspection (WSBIS) rating system. This rating places the bridge in the "Structurally Deficient" category.

A recent bridge inspection conducted by King County resulted in an existing condition rating of 6.0 out of a possible score of 100 (based on Federal Highway Administration criteria). This is among the lowest ratings given any bridge structure in the State of Washington.

More detailed descriptions of the existing bridge condition can be found in the *South Park Bridge Project Rehabilitation Feasibility Study Technical Memorandum* prepared by Parsons Brinckerhoff, Inc. in June 2003 [Ref. 5].

Photo 1
Existing South Park Bridge

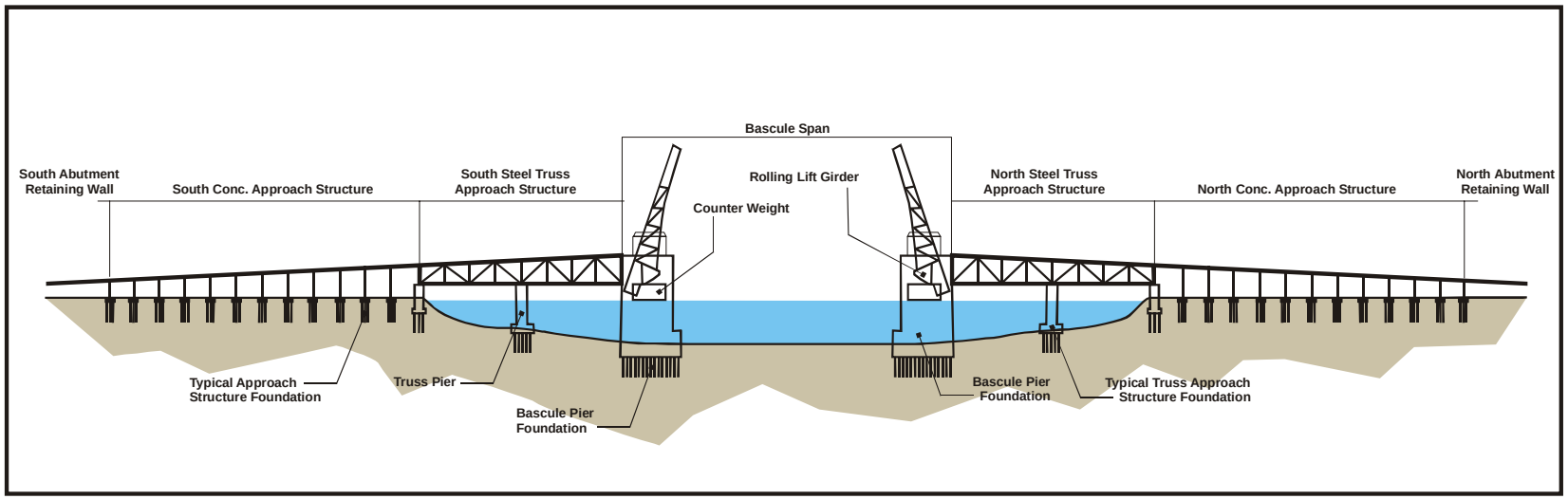


Figure 2
Existing South Park Bridge, Built in 1931

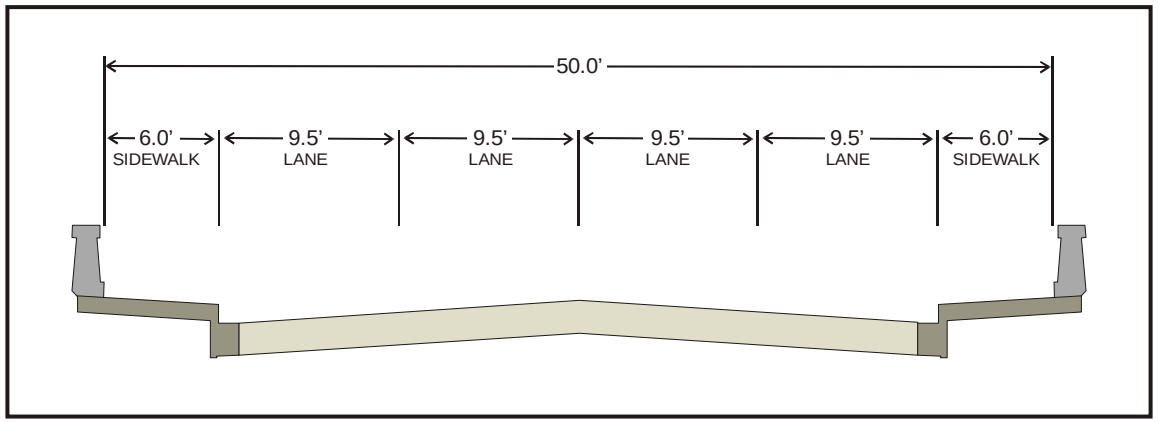


Figure 3
Width and Lane Configuration of the Existing South Park Bridge

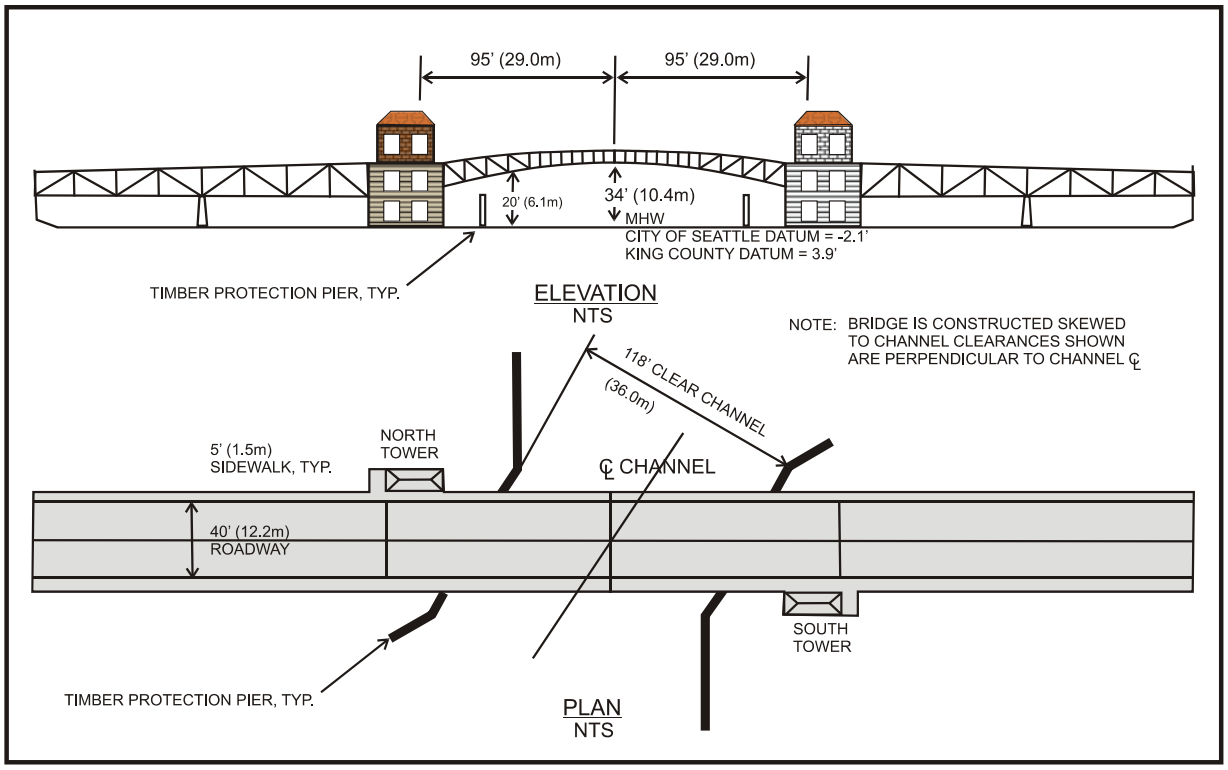


Figure 4a
Existing Horizontal Navigable Clearance as Permitted by the U.S. Coast Guard [Ref. 4]

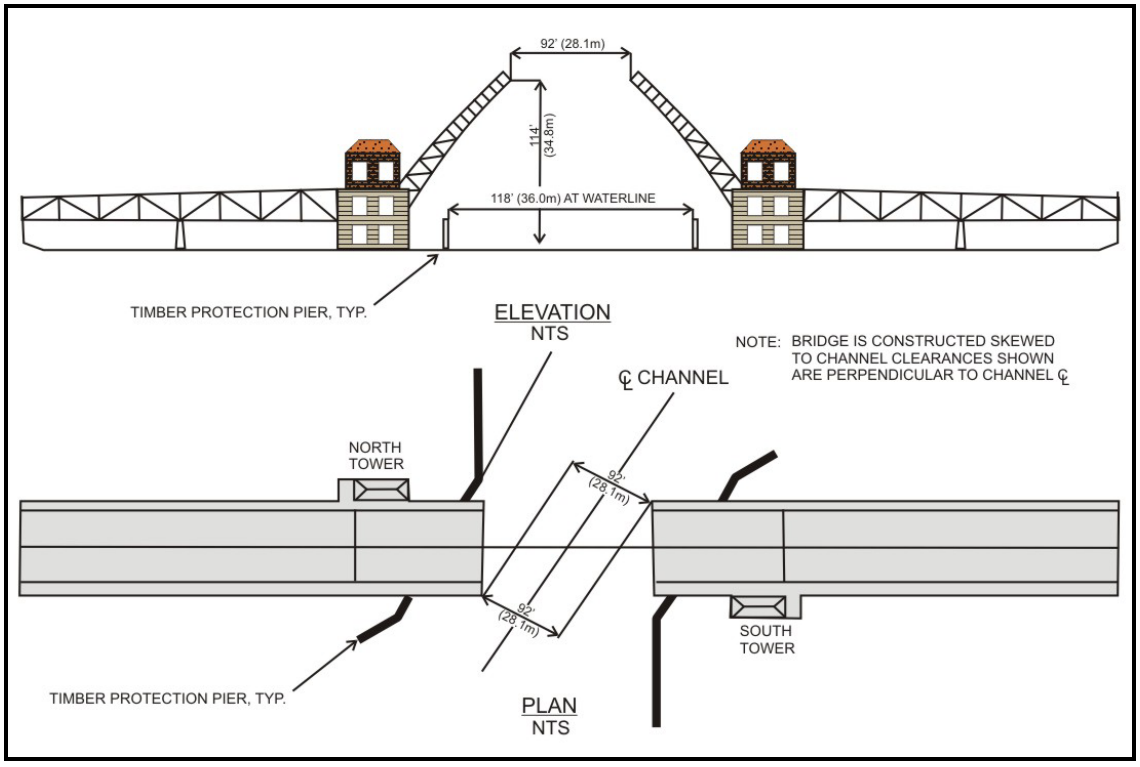


Figure 4b
Existing Vertical Navigable Clearance as Permitted by the U.S. Coast Guard [Ref. 4]

3. Proposed Structural Design Parameters

The design of the South Park Bridge rehabilitation or replacement will follow the specifications and standards listed below.

3.1. DESIGN SPECIFICATIONS

- AASHTO LRFD Bridge Design Specifications, 2nd Edition, 1998, with interim revisions up to 2002.
- WSDOT Bridge Design Manual (BDM), with interim revisions up to August 2002.
- AASHTO/AWS-D1.5M/D1.5: 2002 An American National Standard, "Bridge Welding Code".
- AASHTO LRFD Movable Highway Bridge Design Specifications, 1st Edition, 2001, with interim revisions up to 2002. (If Movable Bridge or Rehabilitation alternatives are selected.)
- AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals, 4th Edition, 2003
- AASHTO Guide Specification and Commentary for Vessel Collision Design of Highway Bridges, February 1991.
- WSDOT Standard Specifications for Road, Bridge, and Municipal Construction, 2002.
- WSDOT Standard Plans for Road, Bridge, and Municipal Construction, with interim revisions up to August 2002.

3.2. MEASUREMENT AND UNITS

- Contract documents shall be presented in the English system of measurement.
- Plan dimensions are taken to be correct at 64°F.

3.3. DESIGN METHODS

- Design of structural elements shall be based on Load Resistance Factor Design (LRFD).
- Foundation design (bearing capacity, lateral resistance capacities, etc.) shall be based on Allowable Stress Design.
- The structure shall be designed for earthquake effects, in accordance with AASHTO *LRFD Bridge Design Specifications*, Articles 3.10 and 4.7.4.

3.4. DESIGN LOADS

3.4.1 Dead Loads (in mass units)

Plain concrete without reinforcing steel	145 pcf (pounds per cubic foot)
Prestressed and reinforced concrete density	160 pcf
Structural steel	490 pcf
Soil	120 pcf
Utilities	as applicable

3.4.2 Live Loads

- Vehicular live load shall be HL-93, consisting of a combination of the HS-20 design truck or design tandem of 25-kip axles spaced 4 feet apart, and 0.64 kip/ft design-lane load.
- Load on sidewalks shall be applied per AASHTO LRFD Article 3.6.1.6.

3.4.3 Wind Loads

- Wind loads shall be computed in accordance with AASHTO LRFD.

3.4.4 Thermal Loads

Concrete: per WSDOT Bridge Design Manual Section 6.4.2-H.

Coefficient of thermal expansion: 5×10^{-6} °F

Elastic modulus of concrete column may be reduced by 50% for longitudinal analysis in thermal load case.

Steel: Temperature Range 0°F to +120°F.

Coefficient of thermal expansion: 6.5×10^{-6} °F

Assuming temperature at 64°F when steel is fabricated.

3.5. EARTHQUAKE LOADS

All seismic parameters are in accordance with the geotechnical report for this project, prepared by Shannon and Wilson, Inc. [Ref. 6]

3.6. MATERIALS

3.6.1 Classes of Concrete

Class 3000 (3,000 pounds per square inch (psi))	Sidewalks, curbs gutters, luminary bases
Class 4000 (4,000 psi)	Columns, barriers, retaining walls
Class 4000P (4,000 psi)	Drilled shafts, footings
Class 4000D (4,000 psi)	Bridge decks
Class 7000 (7,000 psi)	Precast prestressed concrete girders
Class 5000 (5,000 psi)	Closure placement

3.6.2 Structural Steel

Modulus of Elasticity	29,000 ksi (kilo-pounds per square inch)
Secondary Members	AASHTO M 270 Grade 36 (36 psi)
Main Members	AASHTO M 270 Grade 50 or 50W (50 psi)

3.6.3 Welds

Weld Electrodes	Tables 4.1 and 4.2 of ANSI/AASHTO/AWS D1.5

3.6.4 Bolts

High-Strength Bolts	AASHTO M 164 (ASTM A 325). Galvanized in accordance with AASHTO M 232. Bolted connection shall be friction type. Design is based on Class B coating on fraying surfaces.
Anchor Bolts	ASTM A 449 Galvanized per ASTM A 143

3.6.5 Reinforcing Steel

Modulus of Elasticity	29,000 ksi
Deformed Steel Bar	AASHTO M 31 (ASTM A 615), Grade 60 (60 ksi) Where ductility is to be assured or welding is required: ASTM A 706

3.6.6 Prestressing Reinforcement

Prestressing Strand	AASHTO M 203 (ASTM A416), Grade 270, low relaxation strand. Modulus of elasticity is 28,500 ksi.
Prestressing Bar	AASHTO M 275 (ASTM A722), tensile strength 150 ksi. Modulus of elasticity is 30,000 ksi.

3.6.7 Minimum Concrete Cover

2.5 inch	Top of deck slab
1.0 inch	Bottom of deck slab
2.5 inch	Web of post-tensioned girder
1.5 inch	Spiral and tie-in column
3.0 inch	Footing
6.0 inch	Drilled shaft > 5-foot diameter

3.6.8 Bearings and Expansion Joints

Concrete	Temperature range 0°F to +100°F
Steel	Temperature range 0°F to +120°F, assuming temperature at 64 °F when steel is fabricated

Center bearings at 50 °F.

4. Structural Alternatives Studied

The following five structural alternatives were recommended by King County [Refs. 8 and 9] for further study:

- No Action Alternative
- Rehabilitation Alternative
- High-Level Fixed-Span Bridge Alternative
- Mid-Level Fixed-Span Bridge Alternative
- Bascule Bridge Alternative

The No Action Alternative assumes the existing South Park Bridge will be closed to vehicle and pedestrian traffic in the future, and the bridge will be demolished and removed.

5. Rehabilitation of Existing Bridge

The objective of the Rehabilitation Alternative is: 1) To provide a rehabilitated structure that will meet the requirements of the current standards and 2) to extend the bridge's service life to approximately 75 years or longer.

Under the Rehabilitation Alternative, the existing substructures would be significantly re-built in their current alignment, including the bascule piers and foundations, steel approach piers, and concrete approach structures. The bascule leaves and approach trusses would be temporarily removed, refurbished and reinstalled during construction.

5.1. PROPOSED BRIDGE CROSS SECTION

The width of existing sidewalks would be increased from 6 feet to 7.5 feet at each side of the bridge deck. The vehicle traffic lanes would be re-stripped from four 9.5-foot lanes to three lanes, to meet AASHTO design standards. Figure 5 shows the typical bridge deck section for the Rehabilitation Alternative and for comparison also shows the roadway section of the existing bridge.

5.2. CONCRETE APPROACH

In the Rehabilitation Alternative, either a four-span prestressed girder concrete bridge or a 12-span structure would replace the existing deteriorating concrete approach. The spans would cover the entire 240 feet. The bridge would keep its overall width of 50 feet, but would carry three lanes instead of four. Two 7.5-foot sidewalks, two 12-foot lanes and one 11-foot center lane would comprise the 50-foot width. The bridge deck would be carried by six W42G girders.

5.3. STEEL APPROACH

The two steel approach spans would be temporarily removed during construction of the Rehabilitation Alternative. The foundations and piers would be demolished and rebuilt at the current location. The steel truss span is in fair condition according to the NBIS inspection reports, and would be removed, cleaned and repainted. Individual members would be replaced on an as-needed basis. The trusses would then be reinstalled on the reconstructed piers.

5.4. MAIN SPAN

Because the superstructure is in adequate condition (per inspection reports), it is envisioned that the truss superstructure could be reconditioned, painted and re-used. After thorough inspection, any deficient members could be replaced or strengthened.

More detailed descriptions of the Rehabilitation Alternative can be found in *South Park Bridge Project Rehabilitation Feasibility Study, Technical Memorandum* prepared by Parsons Brinckerhoff, Inc. in June 2003 [Ref. 5].

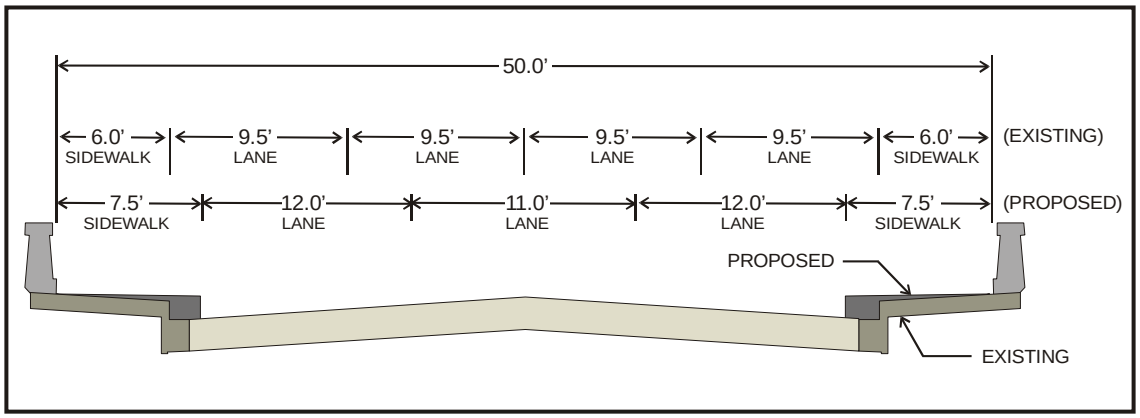


Figure 5: Rehabilitation Alternative: Typical Bridge Deck Section

6. Fixed-Span Bridge Replacement Alternatives

Several fixed-span bridge replacement alternatives were studied as potential long-term solutions for the South Park Bridge.

6.1. SUPERSTRUCTURE STUDIES

This section describes several superstructure configurations that were considered and evaluated for the mid-level and high-level fixed-span bridge alternatives.

6.1.1 Standard WSDOT Prestressed Concrete Girders

This is the most common bridge type used in Washington State. The superstructure is composed of a cast-in-place concrete deck on top of precast prestressed girders. The concrete deck provides the roadway surface. The top layer of deck reinforcing is epoxy-coated for corrosion protection.

Number of Girder Lines

First, a parametric study was performed to evaluate the optimal number of girders per span. The WSDOT standard prestressed girder W83G was used for this study, and two girder layouts were compared for cost. Eight girders were spaced at 8'-0" and six girders spaced at 12'-0". The cost differential determined for these two girder layouts is shown in Table 1.

Table 1
Comparison of Six and Eight Girder Lines

Assume Average Span Length = 155 feet
Deck Area = 155 x 64.3 = 9967 SF

WSDOT Standard W83G Girders	(A) 6 Girders	(B) 8 Girders	Approx. Cost Difference (A-B) per SF of Bridge
Superstructure			
Girder Spacing	12'-0"	8'-0"	
Deck Thickness	8"	7.5"	$0.77
Deck Reinforcing, top and bottom	#6 @ 5.75"	#5 @ 6"	
Reinforcing per SF @ $0.65/ lb	6.27 lb	4.17 lb	$1.37
Additional Girder at $130/ LF		$40,300	-$4.04
Superstructure Cost Difference per SF			-$1.91
Substructure			
Maximum Span Length	135'	155'	
Substructure Cost Ratio (Drilled Shafts)	1.15	1	
Substructure Cost Difference per SF	$553,407	$482,000	$7.16
Total Cost Difference per SF			$5.26
Cost Difference per Average Span			$52,403

As expected, the parametric study determined that the superstructure would be approximate $1.90/SF less expensive if two lines of girders were eliminated. However, with fewer girders the span length would need to be reduced by about 15%, resulting in additional substructure costs of approximately $7.16/SF. As the cost comparison shows, the eight-girder line arrangement would cost approximately $52,000 less per span than the six-girder line arrangement.

An additional consideration is that pier construction will determine the pace of construction, and closer-spaced girders with longer spans result in faster construction. This advantage outweighs any minor cost difference that a more detailed analysis may show. Therefore, the use of the eight-girder arrangement is

recommended. Although this evaluation has been made for one girder type, the recommendation applies to other similar girders.

Size of Standard Pre-Cast Prestressed Concrete Girder

WSDOT standard girders W58G, W74G and W83G were investigated. Table 2 shows the characteristics of each girder type and the cost per square foot. Detailed cost estimates for the high-level bridge are included in Tables 2a, 2b and 2c. Because the mid-level bridge's span length would be similar to the high-level, these comparative cost estimates would also apply to the mid-level alternative.

Figure 6 shows a typical cross section with WSDOT standard W83G prestressed girders.

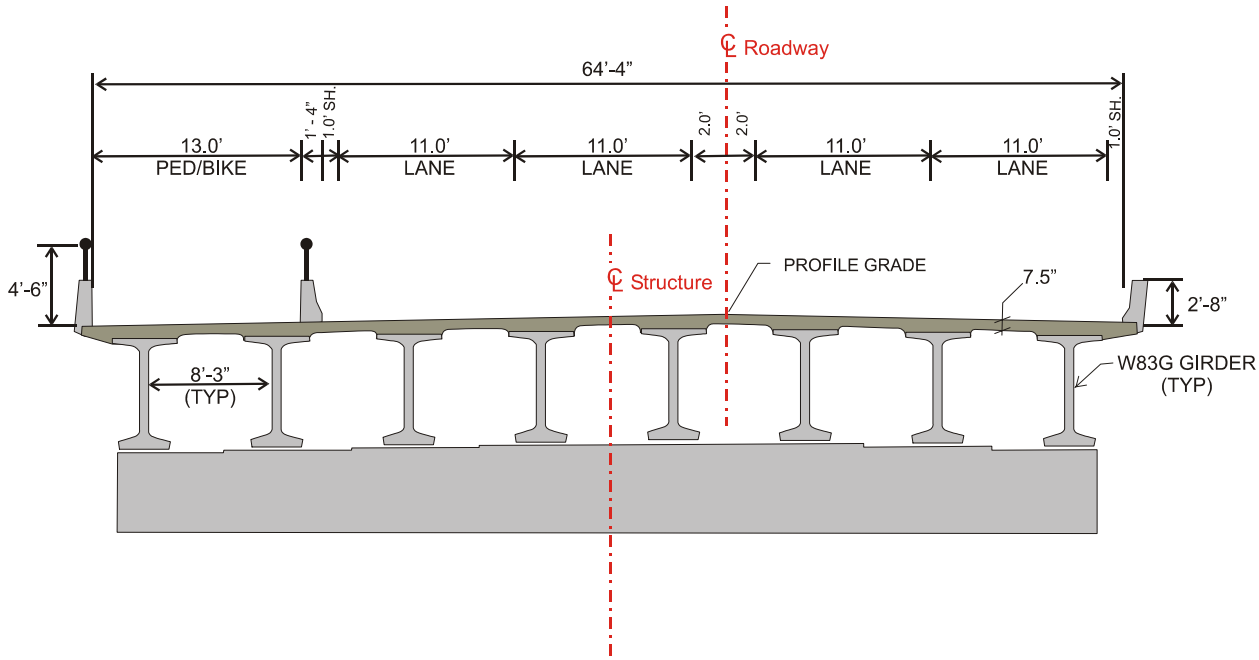


Figure 6
Typical Cross Section with W83G Prestressed Girders

Table 2
Standard Precast Prestressed Concrete Girders

Girder Size	**W58G**	**W74G**	**W83G**
Span length	100 feet	135 feet	155 feet
Number of girders and spacing	8 at 8'-3"	8 at 8'-3"	8 at 8'-3"
Girder depth	58"	73 1/2"	83"
Concrete deck	7 1/2 inches	7 1/2 inches	7 1/2 inches
Structural depth	6.1 feet	7.5 feet	8.5 feet
Superstructure cost per square foot	$34.50	$35.80	$38.20
Substructure cost per square foot	$71.10	$65.20	$48.10
Combined costs per square foot	$105.60	$101.00	$86.30

Table 2a
W58G Girder Alternative

Maximum span = 100 ft
Deck Area = 2332 ft x 66 ft = 153932 ft^2

Item Description	Unit	Quantity	Unit Cost	Cost
W58G Prestressed Concrete Girder	ft	18,656	100.00	$1,865,600
Steel Reinforced Bars in Deck	lbs	1,211,502	0.65	$787,476
Conc. Class 4000D - Deck	yd^3	3,563	500.00	$1,781,620
Exp. Joint System - Superstructure	ft	396	100.00	$39,600
Traffic Barrier	ft	6,996	63.00	$440,748
Metal Railing Type BP	ft	4,664	45	$209,880
Bearings	each	64	3000	$192,000
Superstructure Cost	ft^2			$34.54
Substructure Cost	ft^2	23	482,000	$71.14
Combined Cost	ft^2			$105.68

Table 2b
W74G Girder Alternative

Maximum span = 135 ft
Deck Area = 2332 ft x 66 ft= 153932 ft^2

Item Description	Unit	Quantity	Unit Cost	Cost
W74G Prestressed Concrete Girder	ft	18,656	110.00	$2,052,160
Steel Reinforced Bars in Deck	lbs	1,211,502	0.65	$787,476
Conc. Class 4000D - Deck	yd^3	3,563	500.00	$1,781,620
Exp. Joint System - Superstructure	ft	396	100.00	$39,600
Traffic Barrier	ft	6,996	63.00	$440,748
Metal Railing Type BP	ft	4,664	45	$209,880
Bearings	each	64	3000	$192,000
Superstructure Cost	ft^2			$35.8
Substructure Cost	ft^2	21	482,000	$65.2
Combined Cost	ft^2			$101.0

Table 2c
W83G Girder Alternative

Maximum span = 135 ft
Deck Area = 2332 ft x 66 ft= 153932 ft^2

Item Description	Unit	Quantity	Unit Cost	Cost
W83G Prestressed Concrete Girder	ft	18,656	130.00	$2,425,280
Steel Reinforced Bars in Deck	lbs	1,211,502	0.65	$787,476
Conc. Class 4000D - Deck	yd^3	3,563	500.00	$1,781,620
Exp. Joint System - Superstructure	ft	396	100.00	$39,600
Traffic Barrier	ft	6,996	63.00	$440,748
Metal Railing Type BP	ft	4,664	45	$209,880
Bearings	each	64	3000	$192,000
Superstructure Cost	ft^2			$38.2
Substructure Cost	ft^2	15	482,000	$48.1
Combined Cost	ft^2			$86.3

As expected, the superstructure costs are lower for shorter spans. However, the substructure cost would be lower for longer spans because fewer piers would be required. When combined with the substructure, the longer-span W83G girder is more cost effective than the shorter W58G and W74G girders, although the deeper W83G girder would slightly raise the roadway profile, thus making longer approaches necessary.

WSDOT standard precast girders are the most common bridge type currently being built in Washington State. Because fabricators and contractors are familiar with this type of bridge construction, minimal surprises would be anticipated during project construction.

6.1.2 High Performance Concrete (HPC) Precast Girders

WSDOT recently introduced the use of high-performance concrete (HPC) for bridge girders. These girders are the same shape as the standard WSDOT prestressed concrete girders, but have higher strength concrete and higher prestress forces. With these girders, the span lengths can be increased.

Span and girder configuration data for WSDOT standard and HPC precast girders are shown in Table 3. A detailed cost estimate for HPC W83G girder options is included in Table 3a.

Table 3
High-Performance Concrete (HPC) vs Standard Concrete

	Standard W83G	HPC W83G
Span Length	155	170
Number of Girders and Spacing	8 at 8'-3"	8 at 8'-3"
Concrete Deck Thickness	7.5"	7.5"
Girder Depth	83"	83"
Structural Depth	8.2 ft	8.2 ft
Estimated Cost per SF	$86.3	$83.2

Table 3a
W83G High Performance Concrete Girder Alternative

Maximum span = 170 ft
Deck Area = 2332 ft x 66 ft= 153932 ft^2

Item Description	Unit	Quantity	Unit Cost	Cost
W83G Prestressed HPConcrete Girder	ft	18,656	135.00	$2,518,560
Steel Reinforced Bars in Deck	lbs	1,211,502	0.65	$787,476
Conc. Class 4000D - Deck	yd^3	3,563	500.00	$1,781,620
Exp. Joint System - Superstructure	ft	396	100.00	$39,600
Traffic Barrier	ft	6,996	63.00	$440,748
Metal Railing Type BP	ft	4,664	45	$209,880
Bearings	each	64	3000	$192,000
Superstructure Cost	ft^2			$38.8
Substructure Cost	ft^2	14	482,000	$44.4
Combined Cost	ft^2			$83.2

The cost for HPC girders is about $5 more per linear foot (lf) of deck than standard W83G girders. With HPC girders, the span length can be extended from 155 to 170 feet. This results in substructure savings of about $3.70 per square foot (sf), and total structural savings of about $3.1 per sf. Therefore, considering the total structure, the use of HPC girders is cost effective.

HPC concrete mix contains micro-silica and flyash, which results in denser concrete that is stronger and more durable. This is an additional advantage. These girders have been fabricated successfully in western Washington.

6.1.3 Structural Steel Girders

Compared to prestressed concrete girders, steel girders are lightweight and easily transported, and construction is faster. To minimize the cost of steel girders, the girder layouts utilize six welded plate girders at 11'-6"spacing, with a 9-inch cast-in-place concrete deck. Table 4 shows the investigation results. The cost estimate is based on the use of unpainted weathering steel. Figure 7 shows the typical cross section.

For the 170-foot span, the cost of the steel superstructure is considerably higher than the W83G, at approximately $30 more per square foot. Even with the potential savings of the substructure, due to the lighter superstructure the structural steel is not as cost effective as the concrete girders.

Table 4
Steel Girder Alternative (Grade 50W)

Maximum span = 170 ft
Deck Area = 2332 ft x 66 ft= 153932 ft^2

Item Description	Unit	Quantity	Unit Cost	Cost
Structural Steel, Grade 50W	lbs	7,079,952	1.10	$7,787,947
Steel Reinforced Bars in Deck	lbs	1,211,502	0.65	$787,476
Conc. Class 4000D - Deck	yd^3	3,563	500.00	$1,781,620
Exp. Joint System - Superstructure	ft	396	100.00	$39,600
Traffic Barrier	ft	6,996	63.00	$440,748
Metal Railing Type BP	ft	4,664	45	$209,880
Bearings	each	64	3000	$192,000
Superstructure Cost	ft^2			$73.0
Substructure Cost	ft^2	14	482,000	$44.4
Combined Cost	ft^2			$117.4

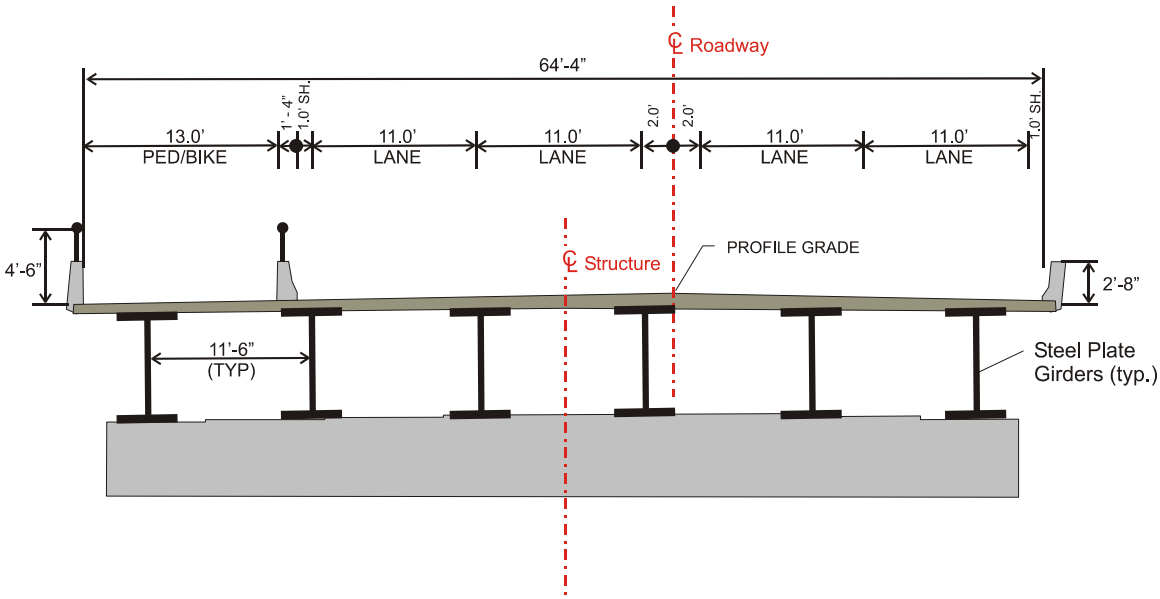


Figure 7
Structural Steel Girders: Typical Cross-Section

6.1.4 Prestressed Concrete Bulb Tee Girders

Decked Bulb Tee Girders

Decked bulb tee girders are precast prestressed girders, and also include the deck as part of the precast elements. These girders are placed side-by-side and connected to each other with weld tabs at approximately 8-foot intervals. A membrane waterproofing topped with a 2-inch asphalt concrete overlay serves as road surface. The typical cross section for the decked bulb tee girders is shown in Figure 8. Span and girder configuration data and a cost estimate are included in Tables 5 and 5a.

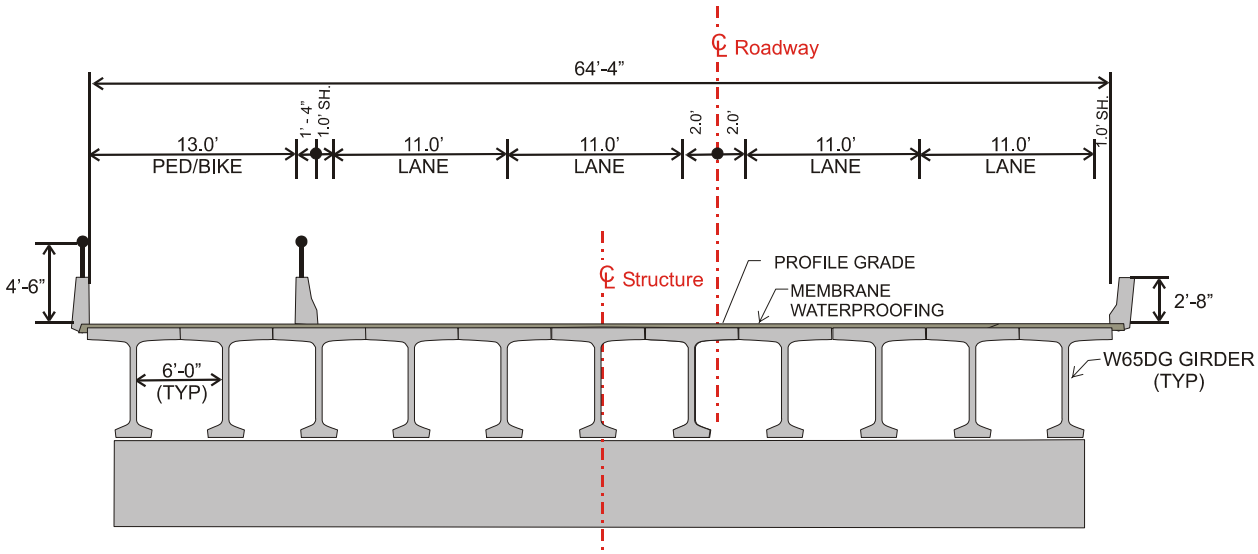


Figure 8
Decked Bulb Tee Girders: Typical Cross-Section

Table 5
W65DG Decked Bulb Tee Girders

Span Length	170
Number of Girders and Spacing	11 at 6'-0"
AC Deck Overlay Thickness	2"
Girder Depth	65"
Structural Depth	6 ft
Estimated Cost per SF	$80.8

Table 5a
W65DG Girder Alternative

Maximum span = 170 ft
Deck Area = 2332 ft x 66 ft= 153932 ft^2

Item Description	Unit	Quantity	Unit Cost	Cost
W65DG Prestressed Concrete Girder	ft	25,652	180.00	$4,617,360
Membrane Water Proofing	ft^2	2,332	1.50	$3,498
Concrete Overlay	lbs	3,078,640	0.03	$92,359
Exp. Joint System - Superstructure	ft	396	100.00	$39,600
Traffic Barrier	ft	6,996	63.00	$440,748
Metal Railing Type BP	ft	4,664	45	$209,880
Bearings	each	64	3000	$192,000
Superstructure Cost	ft^2			$36.4
Substructure Cost	ft^2	14	482,000	$44.4
Combined Cost	ft^2			$80.8

Although the decked bulb tee girders cost less than similar girders with cast-in-place decks, we do not recommend decked bulb tee girders because the connection between the deck panels consists of weld tabs every 8 feet and a grouted key. This can cause these deck connections to break up under traffic, which is a special concern on this bridge due to heavy truck traffic. Therefore, long-term maintenance problems are more likely with these girders than with cast-in-place decks.

Thin-Flanged Bulb Tee Girders with Cast-in-Place Concrete Deck

The 73.5" thin-flanged bulb tee girders with cast-in-place deck is an alternative to the WSDOT W74G girders. The top flange of these girders serves as formwork for the deck concrete, and because they have a cast-in-place concrete deck they do not have the drawbacks mentioned above for the decked bulb tee girders.

The typical cross section for the thin-flanged bulb tee girders is shown in Figure 9.

Span and girder configuration data and the cost estimate are shown in Table 6 and 6a.

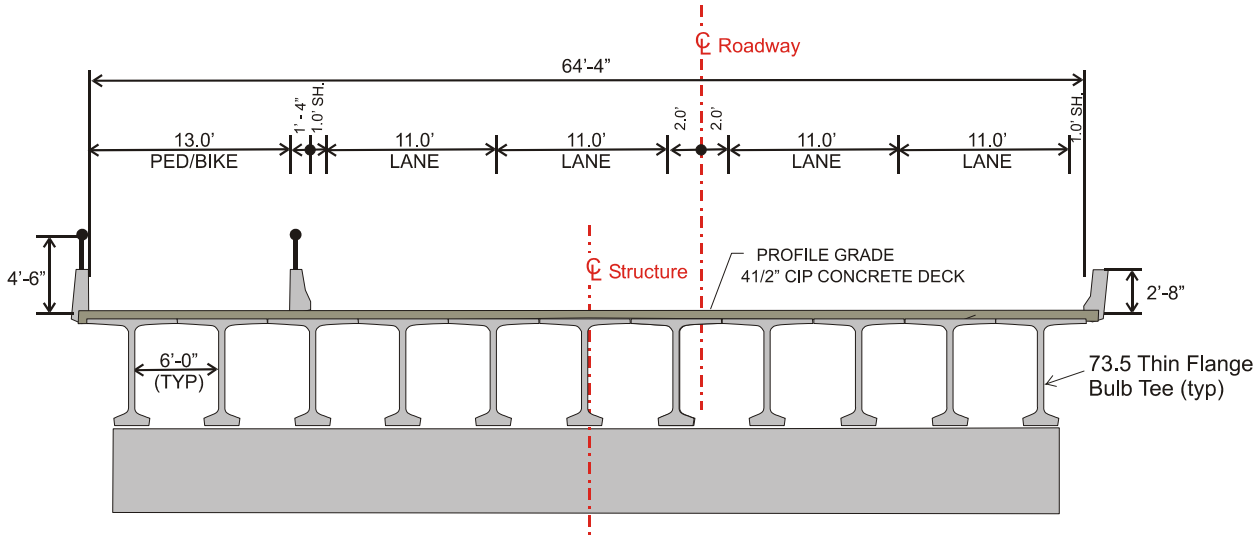


Figure 9
Thin-Flanged Bulb Tee Girders: Typical Cross-Section

Table 6
73.5" Bulb Tee Girder with Cast-in-Place Deck

Maximum span = 140 ft
Deck Area = 2332 ft x 66 ft= 153932 ft^2

Item Description	Unit	Quantity	Unit Cost	Cost
73.5" Bulb Tee Girder	ft	18,656	120.00	$2,238,720
Steel Reinforced Bars in Deck	lbs	726,901	0.65	$472,486
Conc. Class 4000D - Deck	yd^3	2,138	500.00	$1,068,972
Exp. Joint System - Superstructure	ft	396	100.00	$39,600
Traffic Barrier	ft	6,996	63.00	$440,748
Metal Railing Type BP	ft	4,664	45	$209,880
Bearings	each	64	3000	$192,000
Superstructure Cost	ft^2			$30.3
Substructure Cost	ft^2	21	482,000	$65.2
Combined Cost	ft^2			$95.5

Table 6a
73.5" Bulb Tee Girders

Span Length	140
Number of Girders and Spacing	11 at 6'-0"
CIP Concrete Deck Thickness	4.5"
Girder Depth	73.5"
Structural Depth	7.2 ft
Estimated Cost per SF	$95.5

This type of superstructure has a slight cost advantage over standard girders with cast-in-place deck, and the span length can be increased. An additional advantage is the construction time savings that can be achieved because no deck formwork is required.

Despite these advantages, this superstructure type is not suitable for spans on a horizontal curved alignment, such as the South Park Bridge.

6.1.5 Box Girder Bridges

Steel box girder and cast-in-place post-tensioned concrete box girders (as shown in Figures 10, 11 and 12) would both be possible for this bridge. However, steel box girders have a higher unit cost and would not provide a significant advantage over the other types of girders discussed previously. The cast-in-place box girders would be difficult and expensive to construct over the Duwamish waterway, and the longer construction period would cause adverse impacts on the local community.

6.1.6 Other Superstructures

The river crossing at the South Park Bridge site is relatively long, and many other superstructures could be envisioned such as segmental concrete box bridges, arch bridges, or cable-stayed bridges. These bridge types are usually used when the span length is beyond the limit of girder-type bridges, and their cost per square foot is typically higher than for girder type bridges. Long-span bridges are only an economical solution when substructure costs are extremely high or technical or environmental constraints make them mandatory.

We have not pursued any of these superstructure types as part of this study.

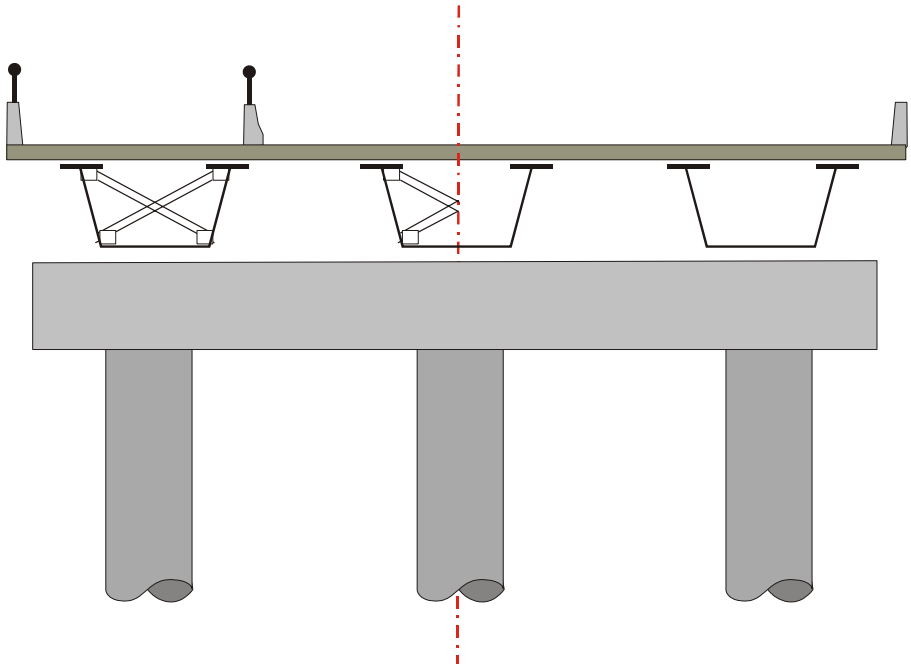


Figure 10
Steel Box Girders

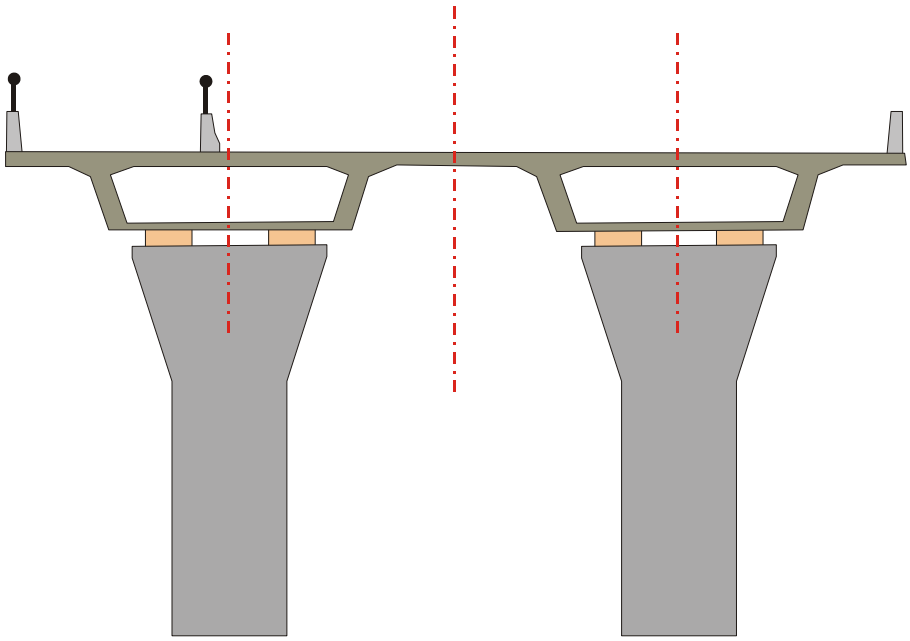


Figure 11
Concrete Box Girders

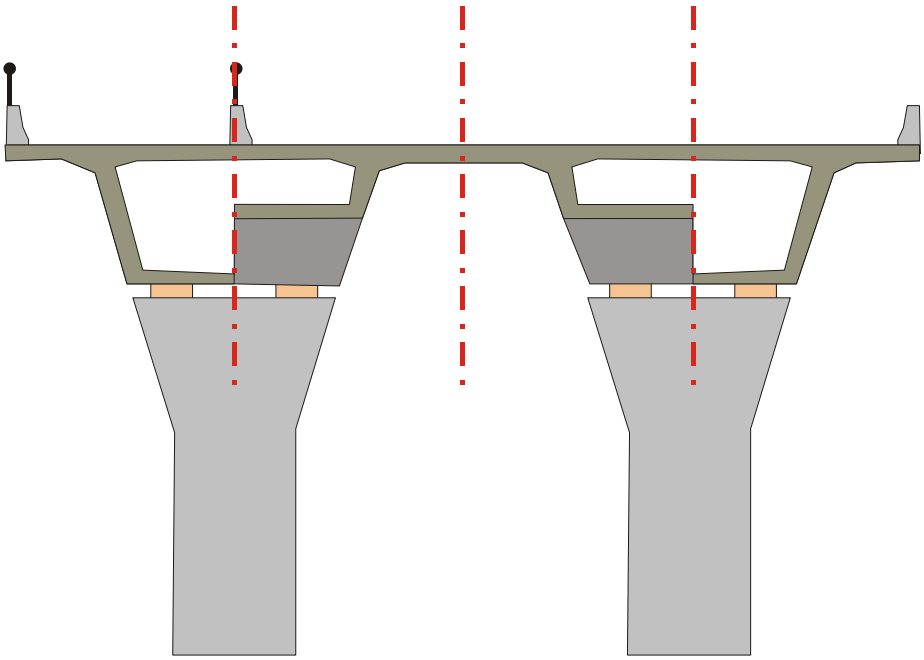


Figure 12
Haunched Concrete Box Girders

6.2. HIGH-LEVEL FIXED-SPAN BRIDGE ALTERNATIVE

The High-Level Fixed-Span Bridge Alternative would provide 100 feet of navigational vertical clearance over the Mean High Water (MHW) level of the Duwamish waterway.

6.2.1 Bridge Layout and Cross Section

The proposed thirteen-span bridge would be 2338 feet from back to back of pavement seats. The 260-foot main span would lie just west or downstream of the existing bascule bridge. The approach structure would have six spans on each side of the main span. The end span would be approximately 170 feet long, followed by three 170-foot spans, a 146-foot span, and finally a 210-foot span leading to the main span (see Figure 13).

This replacement cross section would consist of four 11-foot-wide traffic lanes, a 4-foot-wide median, and a 13-foot wide pedestrian/bike lane separated by a 1'-4" barrier on the west side (downstream side) of the deck. The total width of the bridge deck from the inside faces of the barriers would be 64'4". A traffic barrier at least 4 feet 6 inches high above the road surface is proposed on both sides of the pedestrian/bike lane. Figure 14 shows the proposed section for the High-Level Fixed-Span Bridge Alternative.

6.2.2 Superstructure

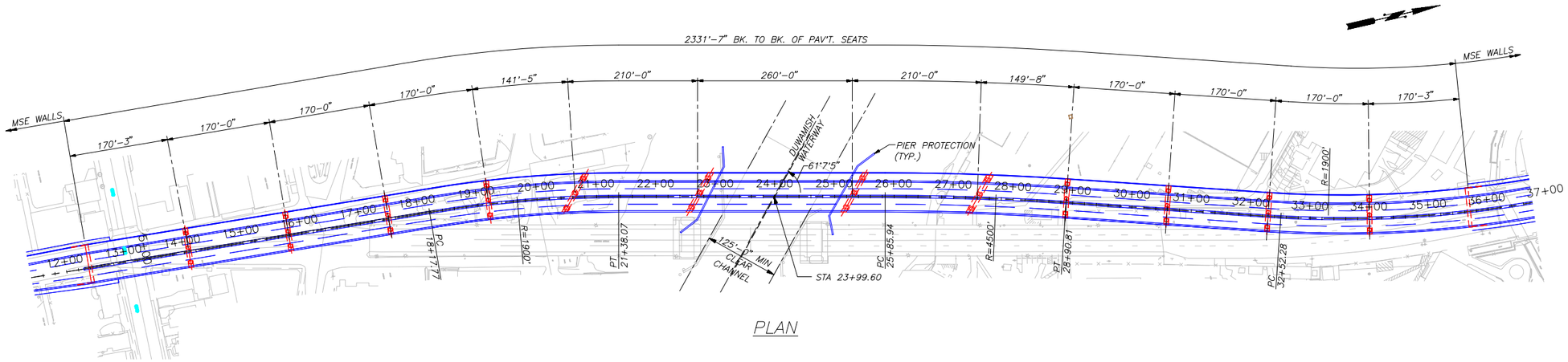
Based on the studies described in previous sections, the WSDOT W83G HPC prestressed concrete girders were selected for the fixed spans, because these girders would provide a well-balanced design for being economical, functional, and aesthetically pleasing.

Because the navigation channel is skewed to the bridge centerline, a 260-foot-long main span would be provided in order to maintain the required horizontal clearance. For such a long span, the design would use haunched girder sections near the main piers, as shown in Figure 15. Haunched precast prestressed girders would be placed over the piers adjacent to the main 260-foot center span. The expected girder depth at the pier locations would be approximately 15 feet, and the depth would be reduced to 7'-11", to match the depth of a W83G girder, at the end of a cantilever that would be 55 feet from the piers. To make the center span continuous, 150-foot-long W83G girders would be dropped in and spliced to the haunched girders over the piers. This haunched girder arrangement would provide the necessary negative moment capacity at the piers and reduce the structural depth over the navigation channel. This would provide the lowest profile available for this alternative, which would be important for minimizing the environmental impact and construction cost.

The two spans adjacent to the main span would each be 210 feet long. 155-foot-long W83G girders would be spliced to the cantilever ends of the haunched girders, and post-tensioned to form a three-span continuous unit to cross the Duwamish River.

By using two short transition spans, a 141'-5"-long span in the south approach, and a 149'-8"-long span in the north approach, the rest of the approach spans (four in each approach) would all be standardized at 170 feet long. This layout would simplify the fabrication and erection, thus lowering the construction cost.

The optimal structure for the High-Level Fixed-Span Bridge Alternative, as shown in Figures 13 and 14, would consist of 13 spans, divided into five continuous structural units separated by expansion joints installed in the bridge deck. The bridge superstructure would consist of a concrete deck slab supported by eight prestressed concrete girders at approximate 8'-3" spacing. The proposed girder type is the WSDOT standard W83G girder, with 7,500 psi minimum concrete compressive strength at release (f'ci). The use of high-strength concrete would allow the W83G girders to span up to 175 feet without applying additional post-tensioning.



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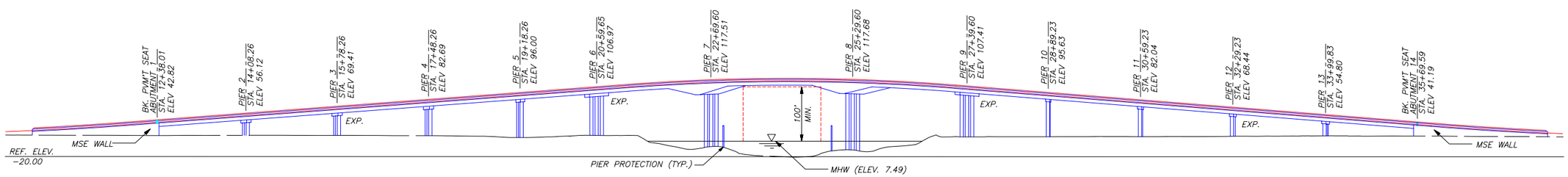

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FIGURE 13
SOUTH PARK BRIDGE

HIGH-LEVEL FIXED-SPAN BRIDGE ALTERNATIVE

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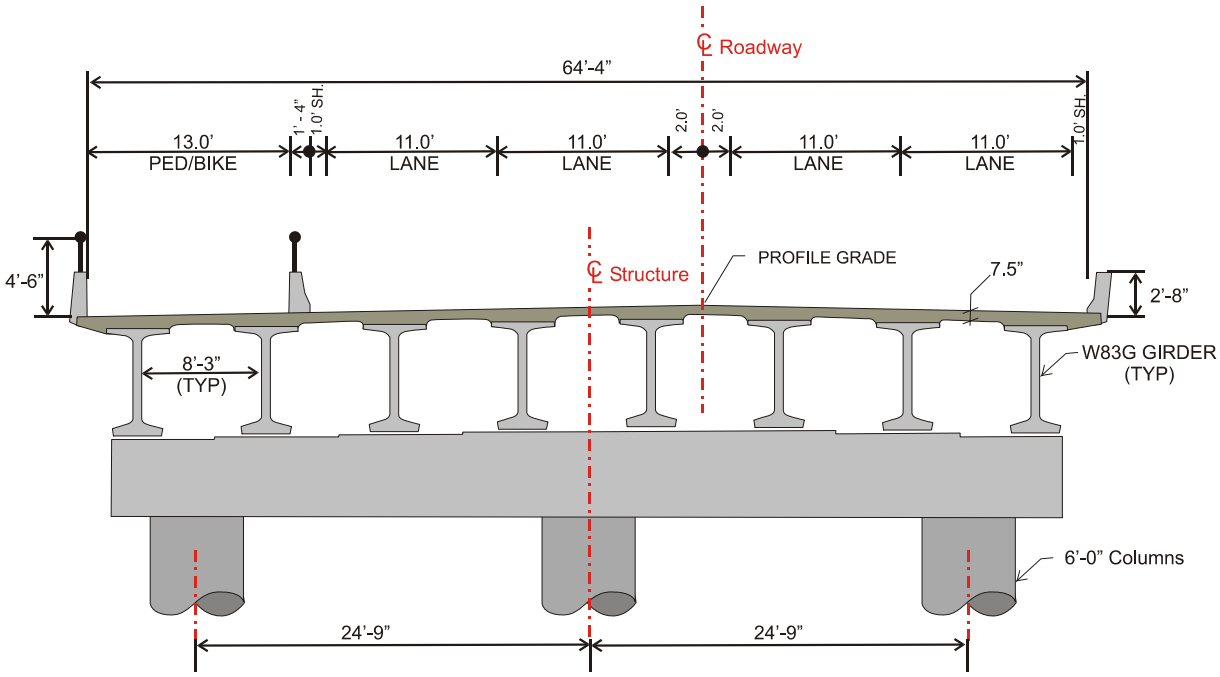


Figure 14
High-Level Fixed-Span Bridge Alternative
Typical Section

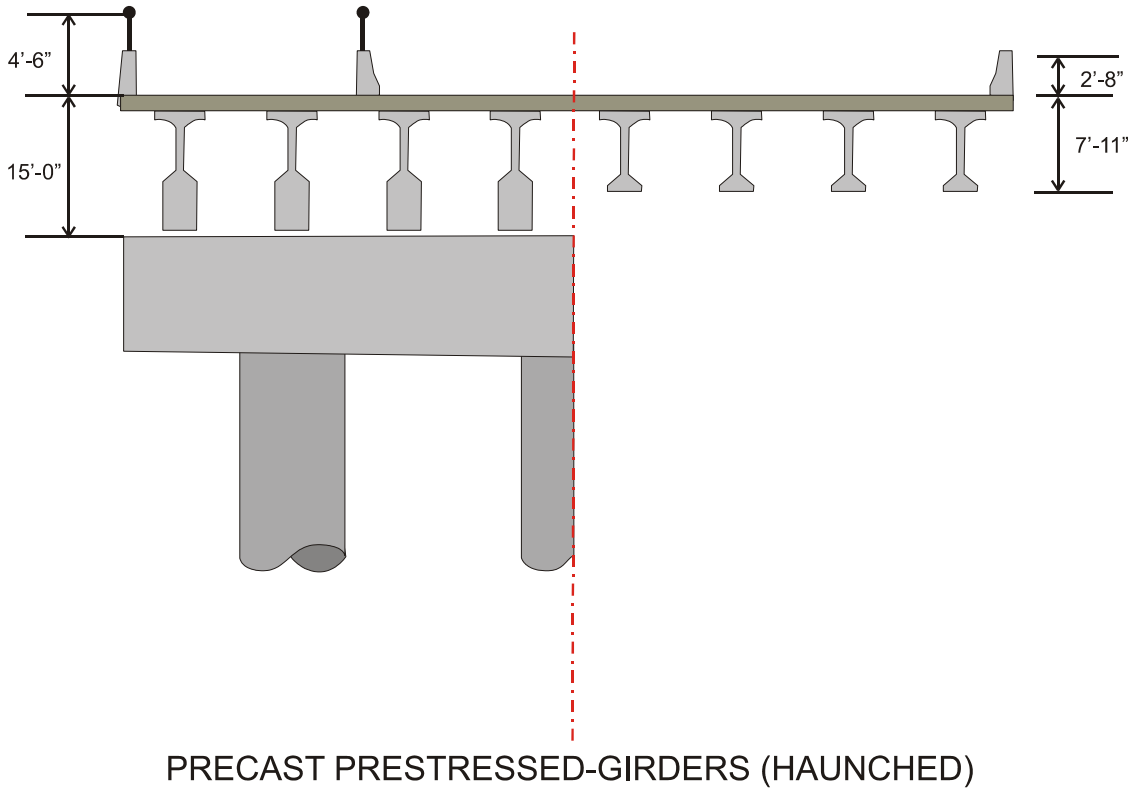


Figure 15
Haunched Girders are Desired for Long Spans

6.2.3 Substructure

A typical pier would consist of a pier diaphragm/cap supported by three columns, as shown in Figure 14. The expected column diameter would be approximately 6 feet, depending on the height and the span length.

A two-column pier alternative is shown in Figure 16. The piers in the river with only two columns are more desirable than three columns, because there is less obstruction in the water. However, the feasibility of two-column piers will need to be confirmed by further seismic analysis and foundation type investigation when additional geotechnical information is available during the preliminary design.

The two most feasible foundation types were studied: driven piles and large-diameter drilled shafts. A conceptual cost comparison (shown in Table 7) of the two foundation types revealed that the construction costs of a driven-pile foundation and a large-diameter drilled shaft foundation are similar.

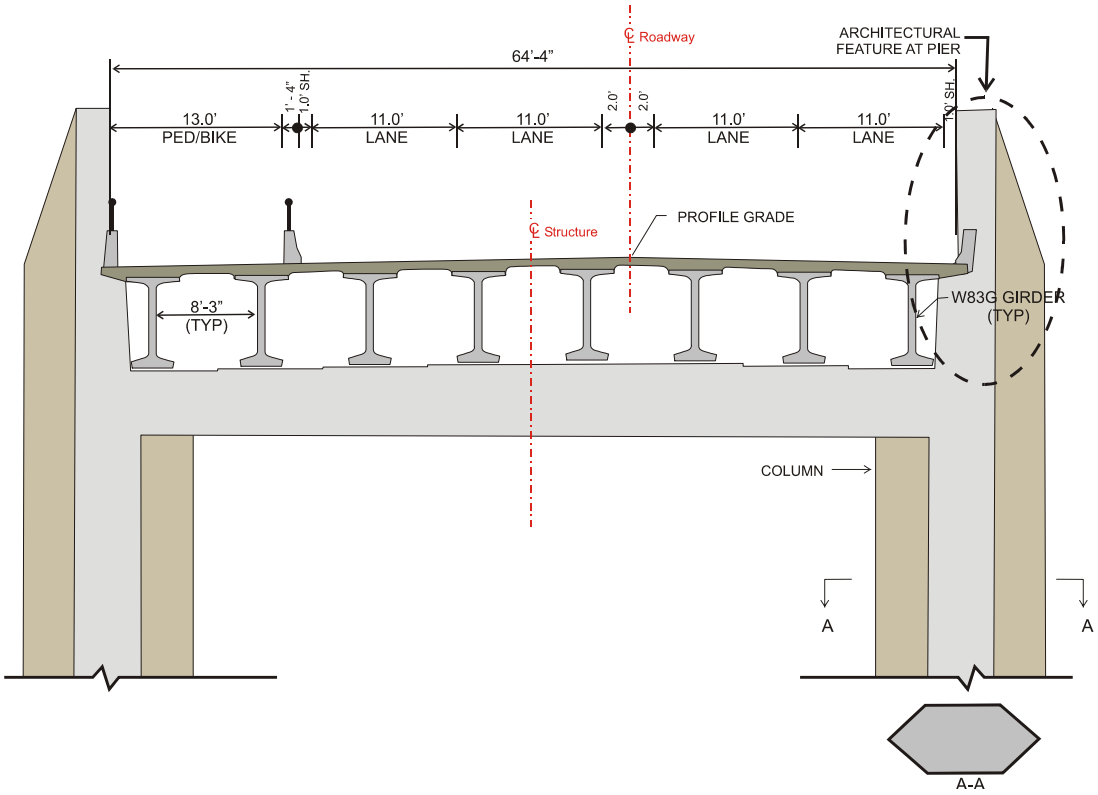


Figure 16
Two-Column Pier Option

Table 7
Substructure Cost Comparison

Average Span Length = 155 feet
Average Pile Length = 60 feet
Average Column Height = 60 feet

ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
Three-Column Bent - Driven Piles with Pile Cap				
Concrete Class 4000 - Cap Beams	yd^3	107	400	42,667
Steel Reinforcing Bars - Cap Beams	lbs.	32,000	0.60	19,200
Concrete Class 4000 - Columns	yd^3	188	350	65,974
Steel Reinforcing Bars - Columns	lbs.	49,009	0.60	29,405
Concrete Class 4000 - Pile Cap	yd^3	189	250	47,333
Steel Reinforcing Bars - Pile Cap	lbs.	37,867	0.60	22,720
Furnishing Concrete Piling	ft	1,920	30	57,600
Driving Concrete Pile	each	24	600	14,400
Concrete - Seal	yd^3	421	100	42,074
Cofferdam	ft^2	4,350	25	108,750
Excavation Inside Cofferdam	yd^3	841	30	25,244
			TOTAL =	475,000
Three-Column Bent - Drilled Shaft				
Concrete Class 4000 - Cap Beams	yd^3	107	400	42,667
Steel Reinforcing Bars - Cap Beams	lbs.	32,000	0.60	19,200
Concrete Class 4000 - Columns	yd^3	188	350	65,974
Steel Reinforcing Bars - Columns	lbs.	49,009	0.60	29,405
Concrete Class 4000P - Shaft	yd^3	698	180	125,664
Furn. and Placing Perm. 1/2" Steel Casing	lbs.	9,621	0.35	3,367
Steel Reinforcing Bars - Shaft	lbs.	111,701	0.50	55,851
Excavation for Drilled Shafts	yd^3	698	200	139,627
			TOTAL =	482,000

6.2.4 Foundations

Pile Foundation

Figure 17 shows the driven-pile foundation configuration for three-column bents over water. The construction cost for the driven pile foundation would increase substantially because of the need for a cofferdam and seal for each pile cap construction. It is likely that the number of piles required would be determined by the seismic requirement for lateral capacity, rather than vertical capacity. The use of battered piles would increase the pile group's lateral capacity significantly, but the stiffness/ductility in relation to the overall structure would need to be carefully investigated.

Drilled Shaft Foundation

Shaft foundations are becoming more common, partly due to increased concern about the lateral capacity of a foundation during a major earthquake. A typical configuration for an in-water application is shown in Figure 18. The shaft is usually 3 feet larger in diameter than the column. To construct the column in the dry, an additional casing would be required.

Based on our investigation of the potential contractor's equipment capacity and availability in the Puget Sound area, drilled shafts with a diameter limited to 10 feet maximum are considered in this conceptual design. This is because with modern construction equipment for drilled shafts, the contractor would have better control of the construction cost and schedule, and the potential risk due to unexpected underground conditions would be reduced.

6.3. MID-LEVEL FIXED-SPAN BRIDGE ALTERNATIVE

The Mid-Level Fixed-Span Bridge Alternative would be similar to the High-Level Fixed-Span Bridge Alternative, but with reduced length and height. It would provide for 65 feet of navigational vertical clearance over the Mean High Water (MHW) level of the Duwamish waterway.

The proposed nine-span bridge would extend 1,661 feet from back to back of pavement seats. The 260-foot main span would lie just west or downstream of the existing bascule bridge. The approach structure would have four spans on each side of the main span. The end span would be 170 feet long, followed by a 170-foot span, an approximately 145-foot or 153-foot span, and finally a 210-foot span leading to the main span (see Figure 19). The proposed bridge deck would be 64 feet 4 inches wide between the inside faces of edge barriers, as described in Section 6.1.

This nine-span bridge would be divided into three continuous structural units separated by expansion joints installed in the bridge deck, as shown in Figure 19. A bike ramp would be separated from the bridge deck at Pier 3 of the south approach. A narrower deck section for the first south approach span is shown in Figure 20. Other superstructure, substructure and foundation features would be similar to the High-Level Fixed-Span Bridge Alternative described previously.

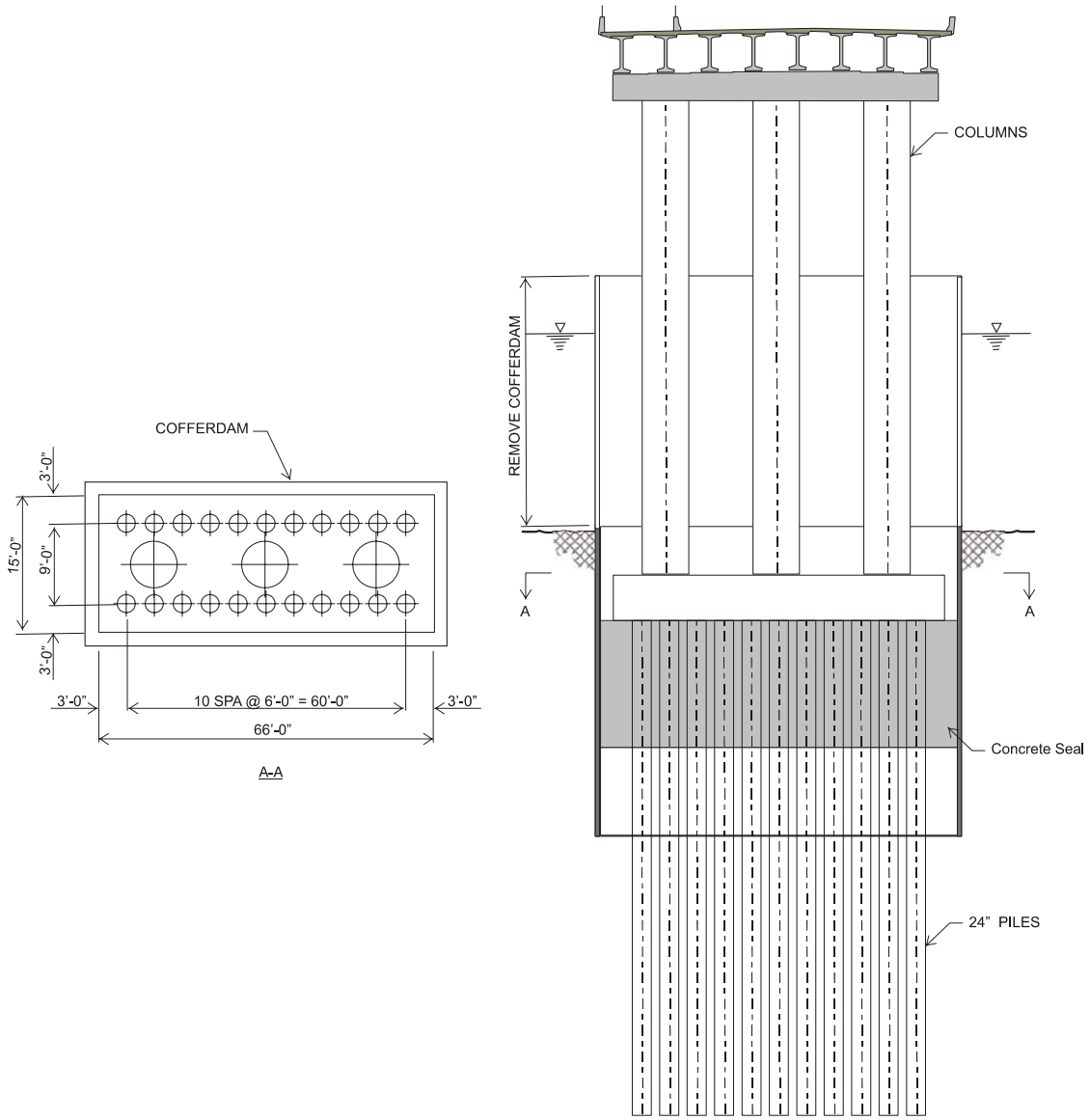


Figure 17
Three-Column Pier Supported by Driven Piles

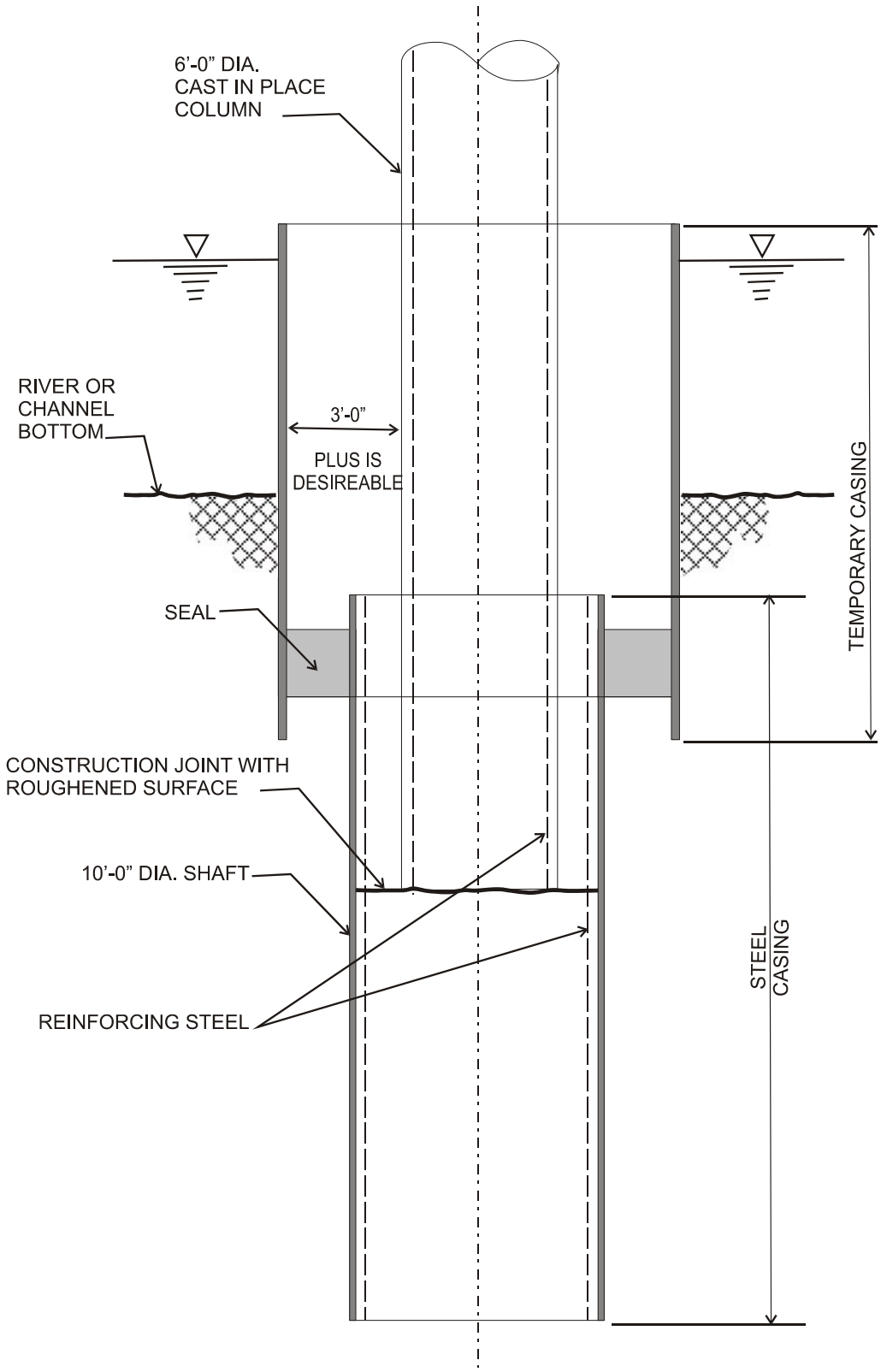
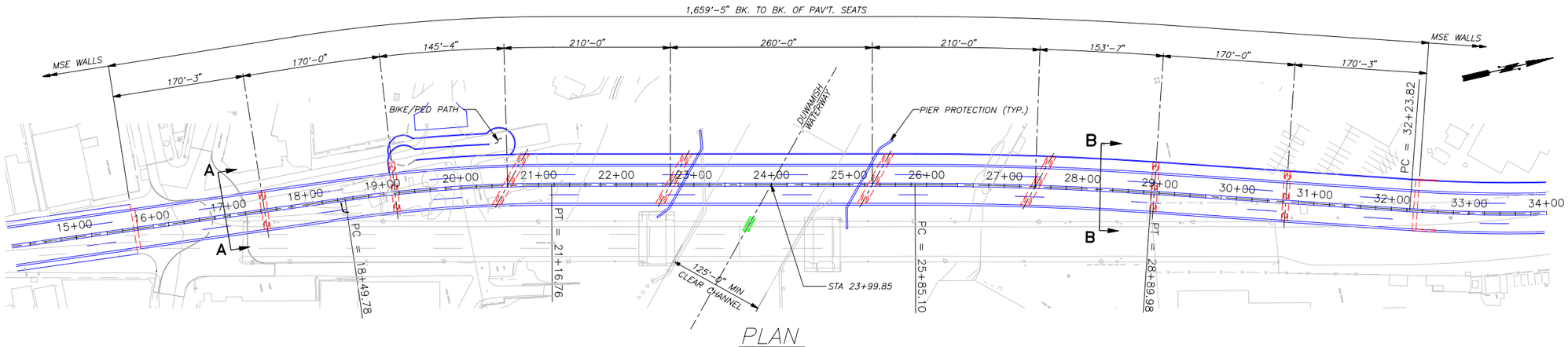


Figure 18
Drilled Shaft Construction in Water



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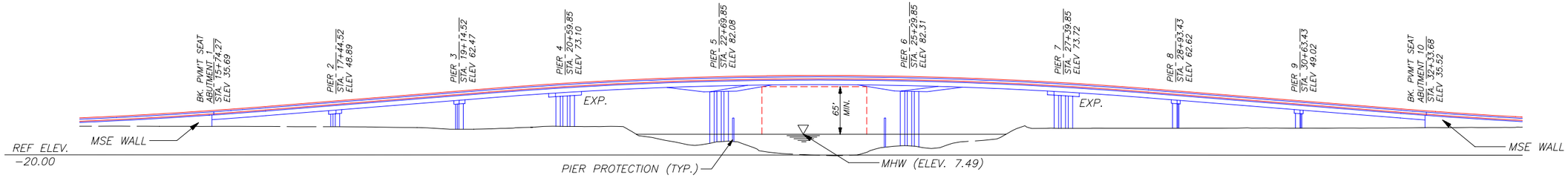

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FIGURE 19
SOUTH PARK BRIDGE

MID-LEVEL FIXED-SPAN BRIDGE ALTERNATIVE

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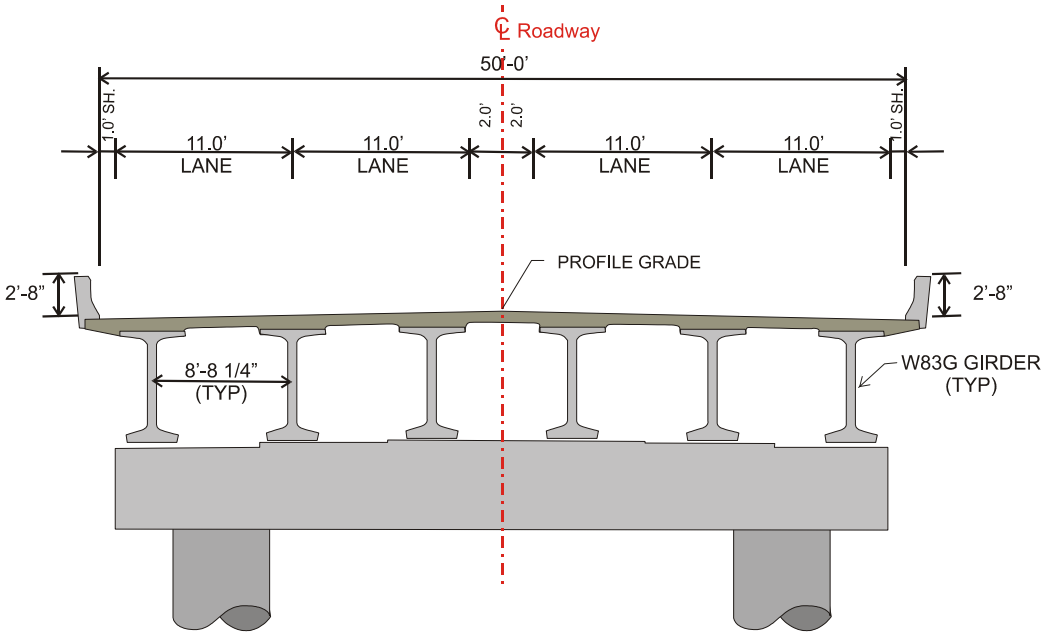
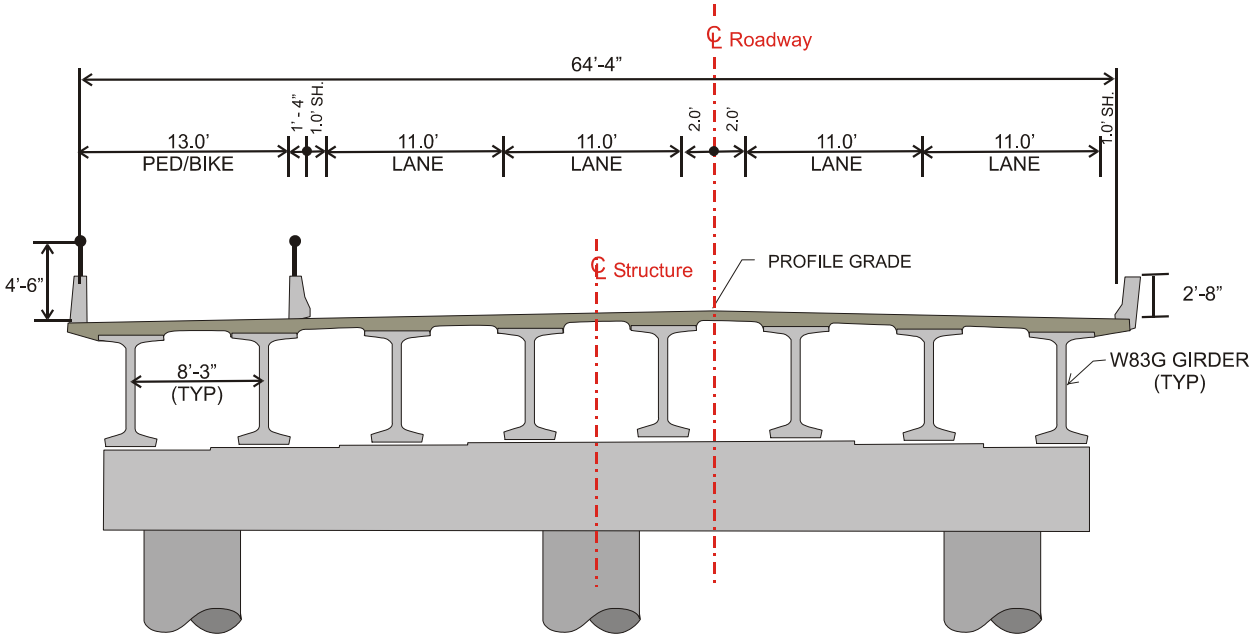


SECTION A-A



SECTION B-B

Figure 20
Mid-Level Fixed-Span Bridge Alternative
Typical Sections

7. Bascule Bridge Alternative

The Bascule Bridge Alternative would be the shortest structure of all the replacement alternatives. It would provide unlimited vertical navigation clearance in the Duwamish waterway when the bascule span is open. When the bascule span is closed, the maximum vertical clearance at the center of the bascule span would be limited to no less than 34 feet at Mean High Water (MHW) level, which would satisfy the U.S. Coast Guard requirement [Ref. 4].

7.1 BRIDGE LAYOUT AND CROSS SECTION

The Bascule Bridge Alternative would be a five-span structure extending 939 feet from back to back of pavement seats (see Figure 21). It would lie just west or downstream of the existing bascule bridge. The main bascule span would be 250 feet between the centerlines of trunnions, and the portion that contains the counterweight would be 38 feet long behind the centerline of trunnion. The approach span layout would be symmetrical on each side of the main span. The end span would be 154'-3" long, followed by a152-foot-long span leading up to the main pier structure that houses the control house and machine room. The proposed bridge deck would be 64'-4" wide between the faces of the edge barriers, as described in Section 7.1.

Because of the increase in bascule span length compared to the existing bridge, the Bascule Bridge Alternative would improve horizontal clearance for navigation from 118 feet to 125 feet.

7.2 BASCULE LEAF SUPERSTRUCTURE

Because the weight of bascule leaves usually impacts much of the drive system costs, steel girders (due to their light weight relative to concrete structures) are proposed as the main support members for the bascule leaves. Steel truss girders, as shown in Figure 22a, are a traditionally popular structural type for bascule leaves, as is the case for the existing South Park Bridge. Steel plate girders, as shown in Figure 22b, have been increasingly used as an alternative to the trusses for the bascule leaves. Compared to truss girders, the simplified plate girder reduces the construction labor cost. Steel box girders, as shown in Figure 22c, would provide more torsional rigidity for the cantilevered bascule leaves than the plate girders.

These issues should be developed further during preliminary engineering if the movable alternative is chosen. For this conceptual-level study, a typical bascule-span section using steel plate girders is shown in Figure 23.

7.3 DECK SYSTEMS

There are generally two types of bridge deck system used on modern bascule bridges: orthotropic steel deck or exodermic deck.

Orthotropic steel deck is a well-established light deck system that has been traditionally used on bascule bridge spans. In an orthotropic deck system, a grid of steel beams carries the deck self-weight and the live load on the deck. The deck could either have a concrete overlay or an open steel grid. A concrete overlay would provide a much desirable closed deck surface, and has a higher friction coefficient than the steel grid. However, a drawback is that a concrete overlay would be much heavier than a steel grid.

Exodermic deck is a newer system of decking that is gaining popularity for its closed deck surface, light weight, and ease of installation. Exodermic deck is a lightweight decking system in which the concrete slab is composite with an unfilled steel grid, but the grid is not fully embedded in the concrete. In this way, the concrete compressive strength and steel tensile strength are maximized. The weight of the exodermic deck system ranges from approximately 40 to 80 pounds per square foot, which is a savings of 35% to 50% in weight over a concrete deck with the same thickness. The total depth of the exodermic deck system is typically 6 to 10 inches and can span to 18 feet or more (see Figure 24).

The concrete slab can be either precast or cast-in-place. If precast, deck modules can be lifted in place for quick overnight installation. This minimizes temporary navigation channel impacts. For cast-in-place construction, the steel grid acts as a stay-in-place form for the deck slab. The exodermic deck is made composite by headed studs welded to the steel superstructure in a concrete haunch area. The haunch area is poured with the cast-in-place deck, or if the deck is precast the haunch area is poured after the deck module is placed. Maintenance of the deck is similar to that of a traditional concrete deck.

A few examples where exodermic deck systems were used on movable bridges include: the 17th Street Causeway in Fort Lauderdale, Florida; the Tappan Zee Bridge in New York, New York; and the Troy-Menands Bridge over the Hudson River in Albany, New York.

For this project, we recommend the exodermic deck system for its closed deck surface and light weight.

7.4 BASCULE PIERS AND FOUNDATIONS

Bascule bridges typically have two massive piers and foundations that support the superstructure, including the bascule spans and approach spans. A primary reason that bascule piers are of such large size is that the pier has to accommodate the bascule leaf counterweight in both closed and open positions, and it also has to house the electrical and mechanical systems.

Drilled shafts and steel pipe piles are both feasible foundation types, as recommended in the *South Park Bridge Project Geotechnical Report Phase II* (Shannon & Wilson, Inc., November 2003) {Ref. 6}. The large-diameter drilled shafts are assumed because of their better axial and lateral capacities.

7.5 OPERATING SYSTEM

Whether a rolling lift or trunnion bascule is chosen, two basic options exist for operating bascule leaves: mechanical power transmission equipment or fluid power (hydraulic) power transmission equipment. Within these two categories, there are many different machinery layouts that could be designed. In either case, the prime mover would be an electric motor. Generally speaking, a mechanical system would consist of an electric motor driving a differential primary reducer that would transmit power to two secondary reducers, then to rack-and-pinion sets at or near each main girder. A fluid power system would use a hydraulic-power unit to operate two or four hydraulic cylinders that would extend and contract to operate the bascule leaves.

Both types of systems have been implemented successfully on movable bridges and are in widespread use. Hydraulic systems generally require a smaller capital investment to implement. However, these systems are less efficient and generally require more frequent maintenance by specially trained technicians. Mechanical systems generally have a higher initial cost, but tend to be more reliable due to the simplicity of the design and robustness of the components. Regardless of the type of bascule, mechanical systems have generally proven to be the more cost- effective option over the life of the bridge.

7.6 APPROACH SPANS

The approach structure for the Bascule Bridge Alternative would be similar to that described for the High-Level (Figure 14) and Mid-Level Fixed Span Bridge Alternatives. The span arrangement would include two spans for each approach, and the span length would be approximately 152 feet long. WSDOT HPC W74G girders would be used for the superstructure.

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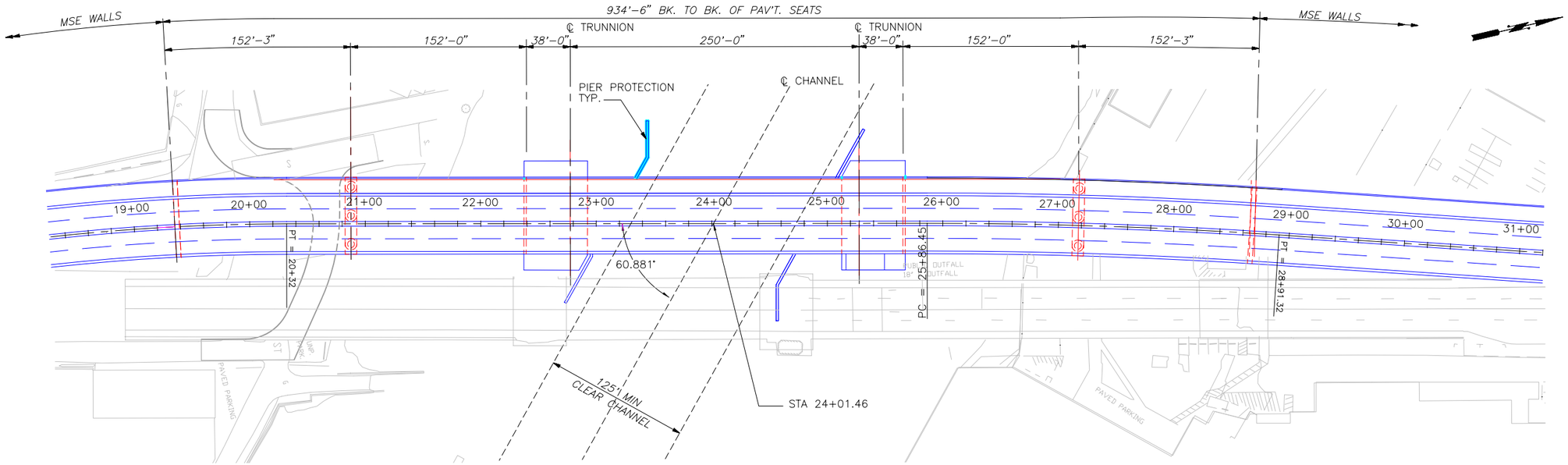
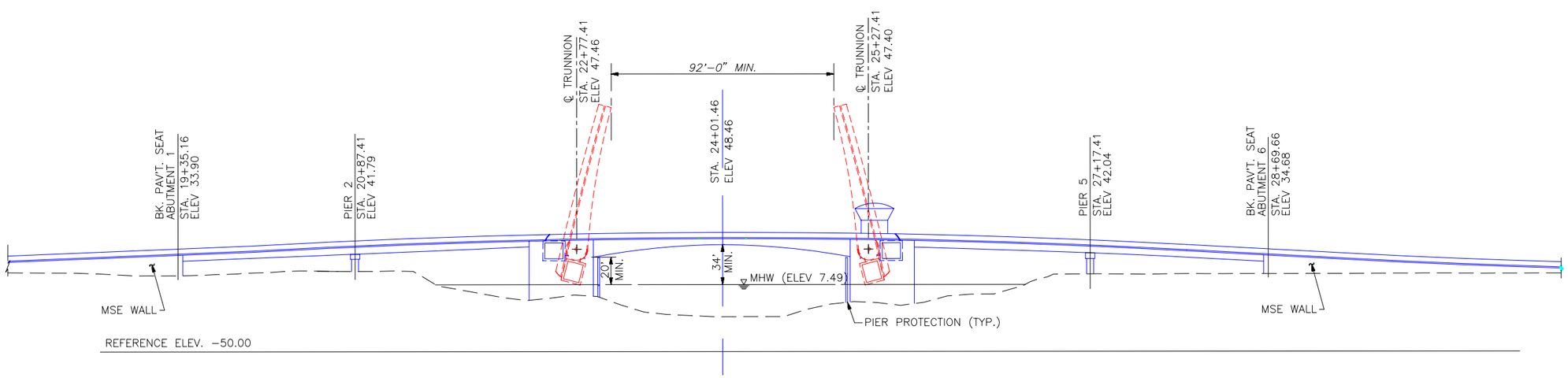


PLAN



ELEVATION

N.G.V.D. OF 1988

FIGURE 21
SOUTH PARK BRIDGE
BASCULE BRIDGE ALTERNATIVE

PLOT DATE: 05/02/03 j:\25317c_so_park\strc-all\figures\layout-low_graphics.dwg

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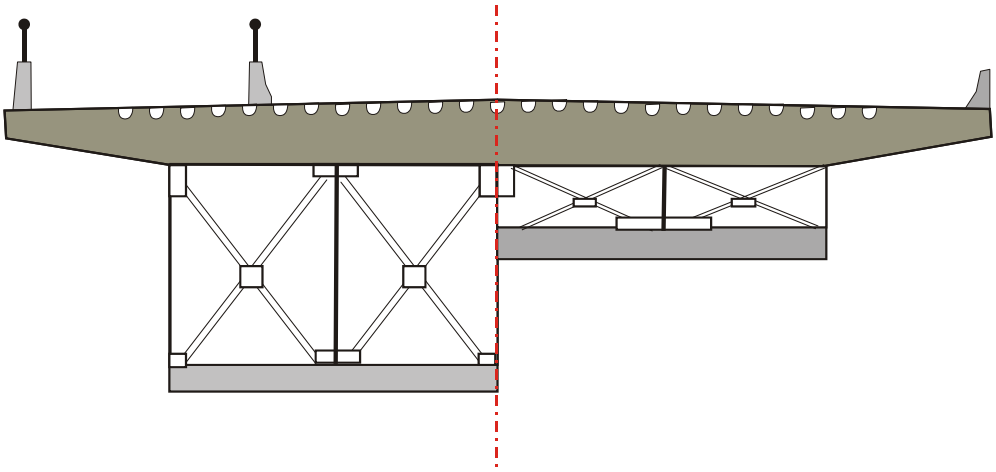


Figure 22a
Steel Trusses

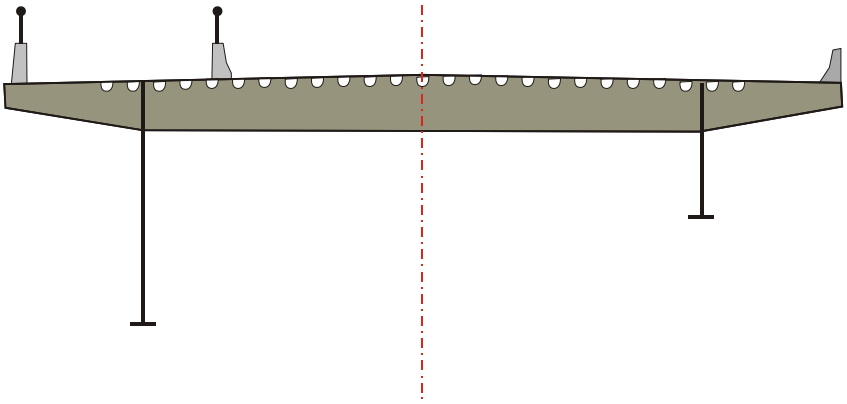


Figure 22b
Steel Plate Girders

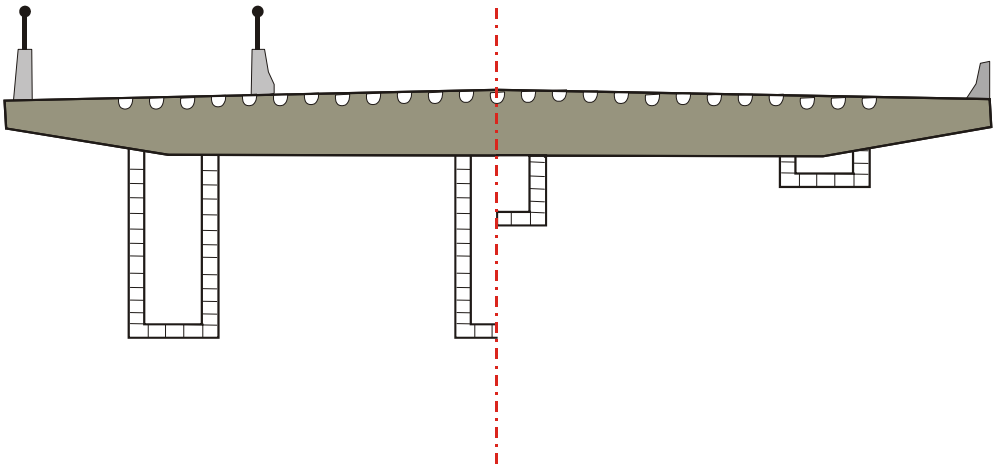


Figure 22c
Steel Box Girders

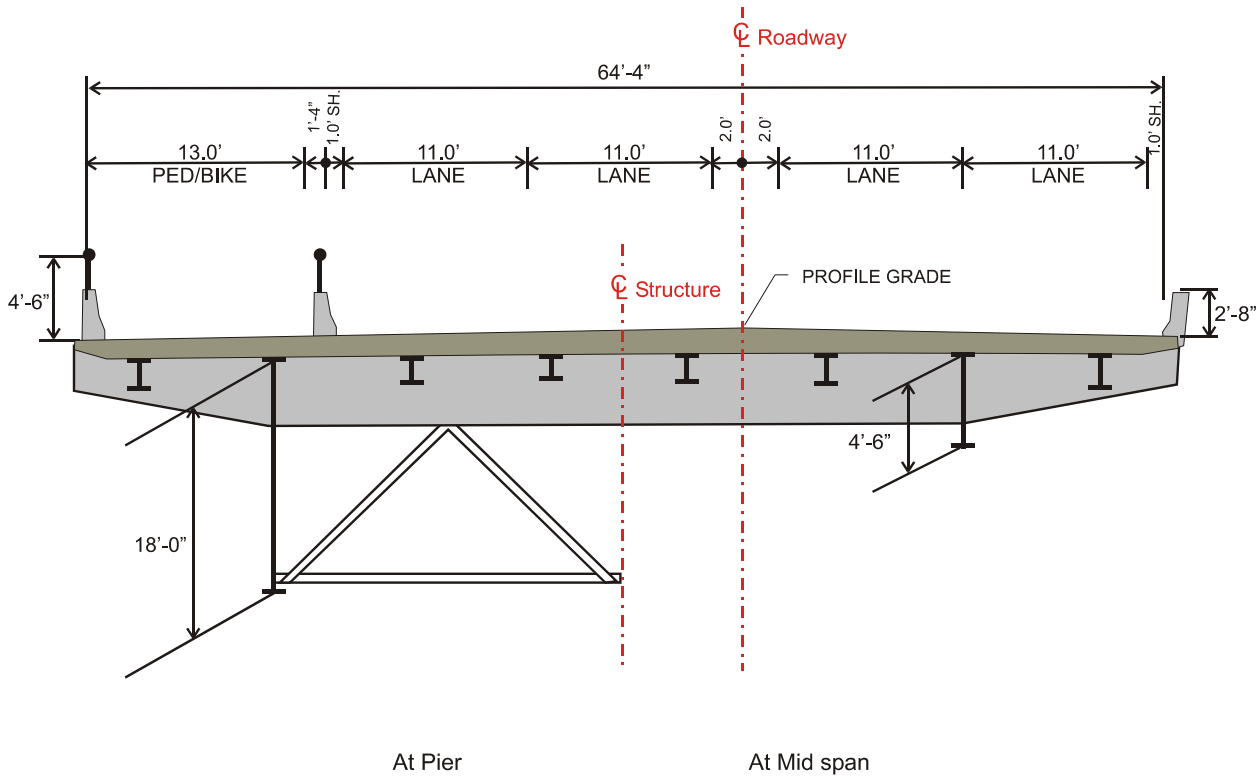
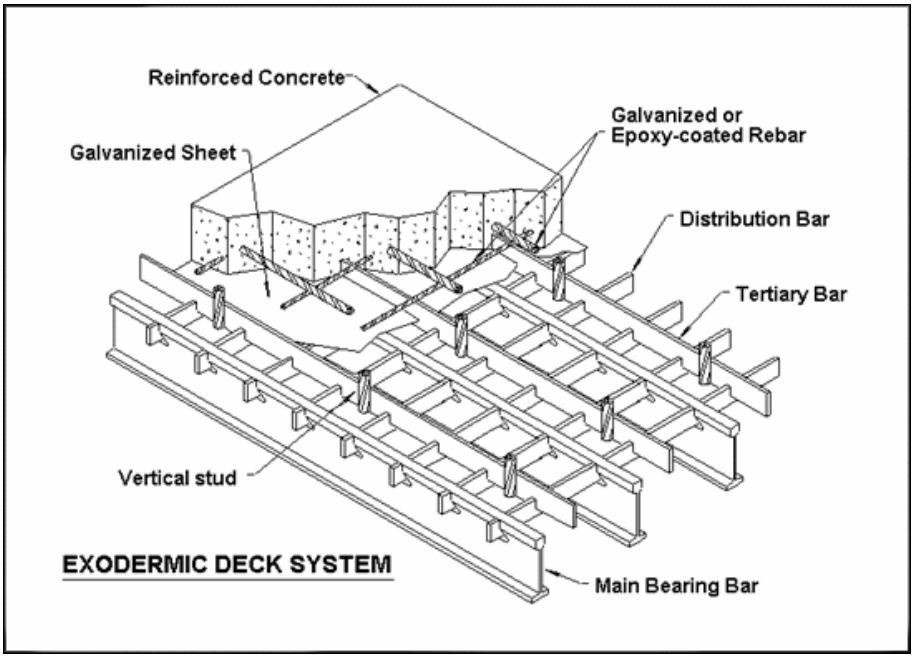


Figure 23
Bascule Bridge Alternative: Typical Section



Source: Exodermic Bridge Deck, Inc.

Figure 24
Schematic of Exodermic Deck

8. Geotechnical Considerations

8.1. PROPOSED FOUNDATION TYPE

As stated in the *South Park Bridge Project Geotechnical Report Phase II* (Shannon & Wilson Inc., November 2003) [Ref. 6], it is the geotechnical consultant's opinion that due to the presence of loose/soft recent deposits, shallow foundations would not be suitable to support the proposed bridge rehabilitation/replacement. Another reason that shallow foundations would not be suitable is that excessive settlements could result from potential liquefaction of the underlying loose granular soils at the site during a seismic event. Deep foundations that extend into the underlying glacial material and/or rock are recommended in the *Geotechnical Report Phase II*, to support the proposed bridge rehabilitation/replacement. Recommended suitable deep foundation types include driven steel pipe piles or large-diameter drilled shafts.

Large-diameter drilled shafts are the assumed foundation type for rehabilitation/replacement bridge alternatives at this conceptual engineering level. This is because a drilled shaft can provide large axial and lateral capacity, and a single drilled shaft can directly support a column without a file cap. This reduces the amount of soil excavation.

For the proposed bascule structure, driven steel pipe piles may be a viable alternative foundation type to large-diameter drilled shafts, since the large footprint of a bascule pier would require a pile cap on either driven piles or drilled shafts. A recent field test pile program conducted by Shannon & Wilson [Ref. 6] concluded that there would not be any noticeable detrimental impacts on the existing bridge due to pile driving.

8.2. SUBSURFACE SOIL IMPROVEMENT OPTIONS

For the purpose of liquefaction mitigation, the *Geotechnical Report Phase II* identified two feasible ground improvement techniques for the project site: compaction grouting and earthquake drains. Initial investigation found that the earthquake drain technique would cost significantly less than compaction grouting, so the earthquake drain is the option selected in this conceptual study.

9. Retaining Walls

Retaining walls are proposed to retain fills under the bridge's north and south approaches. Mechanical Stabilized Earth (MSE) retaining walls are the preferred wall type because of their many advantages compared to conventional reinforced concrete and concrete gravity-retaining walls, as summarized in the U.S. Department of Transportation and Federal Highway Administration *Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines* [Ref. 7]. The advantages of using MSE walls for this project would include:

- They use simple, rapid construction procedures and do not require large construction equipment, which would speed construction and reduce costs;
- They require less site preparation than other alternatives, which also would speed construction and reduce costs;
- They need less space in front of structures for construction operations. This is an important benefit, considering that some of the property would be very close to the proposed bridge alignment;
- They reduce right-of-way acquisition, which would help save project costs;
- They do not need rigid, unyielding foundation support because MSE structures are tolerant to deformations. This is important because of the liquefaction potential of soils underlying this project site; and
- They are cost effective.

Because the bridge site is in an urban environment, MSE walls with concrete facing is preferred for this project.

10. Bridge Aesthetics

The South Park Bridge and its vicinity represent a number of significant features that need to be reflected in the aesthetics of the proposed bridge rehabilitation or replacement project.

The King County Landmarks and Heritage Commission designated the South Park Bridge as a King County Landmark in 1996. In the bridge vicinity, The Boeing Company represents both a slice of United States aviation history and 21st century technology - a combination of past history and a futuristic vision. The Rehabilitation Alternative (see Figure 25) would make the best effort to preserve the existing South Park Bridge's historic appearance, by either rehabilitating or replacing the existing bridge components. Further description can be found in the *South Park Bridge Rehabilitation Study* [Ref. 5].

If the High-Level Fixed-Span or Mid-Level Fixed-Span replacement alternative is chosen as the preferred alternative, the proposed scheme would be to create a structure that has a simple streamlined appearance and is enhanced with architectural details (e.g., the shapes or details of pier columns and lamp posts). Figures 26a and 26b show possible appearances of the two-column bent options.

If the Bascule Bridge Alternative is chosen as the preferred alternative, the new bridge could present a more traditional appearance (see Appearance Option 1 in Figures 27a, 27b, 27c, and 27d) that is relatively consistent with its current appearance. On the other hand, the new bascule bridge could have a more contemporary or even futuristic appearance (see Appearance Option 2 in Figures 28a, 28b, 28c, and 28d) that reflects the strong presence of modern industry near the bridge.

Figure 25
Rehabilitation Alternative

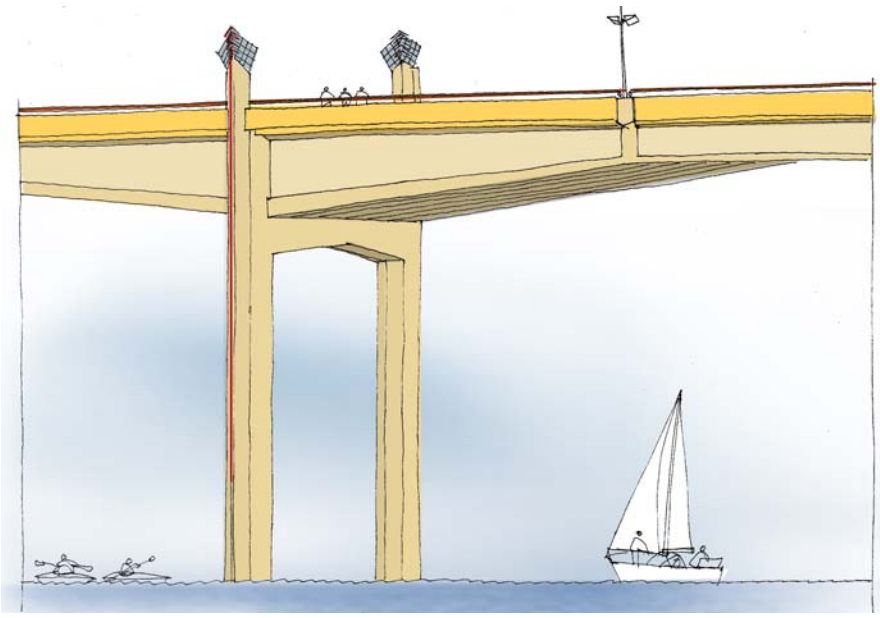


Figure 26a
High- or Mid-Level Fixed-Span Bridge Alternative

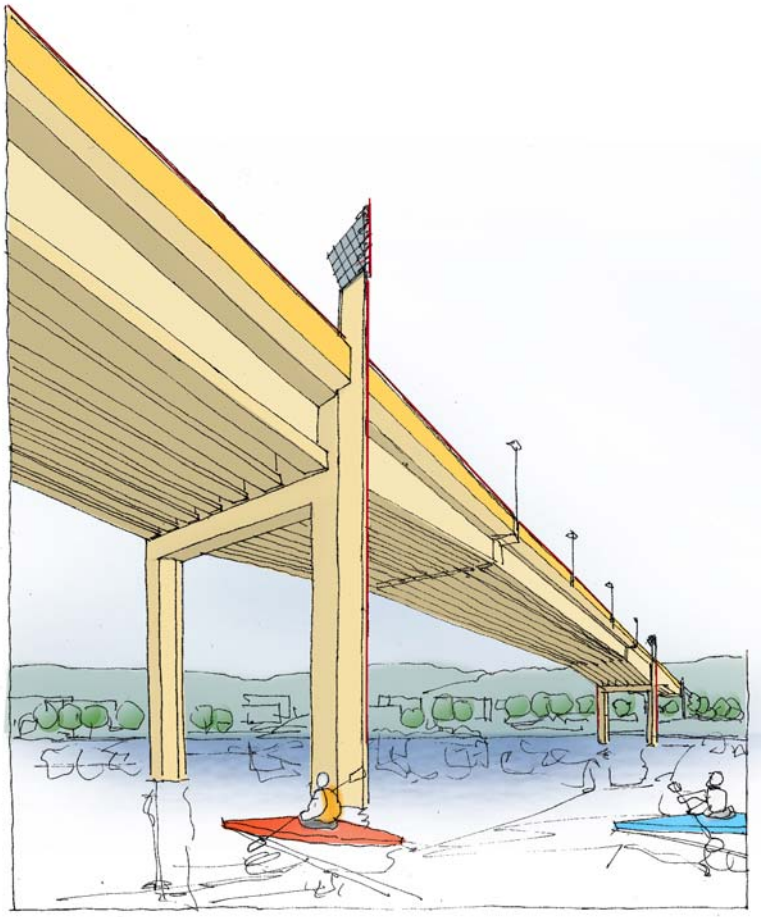


Figure 26b
High- or Mid-Level Fixed-Span Bridge Alternative

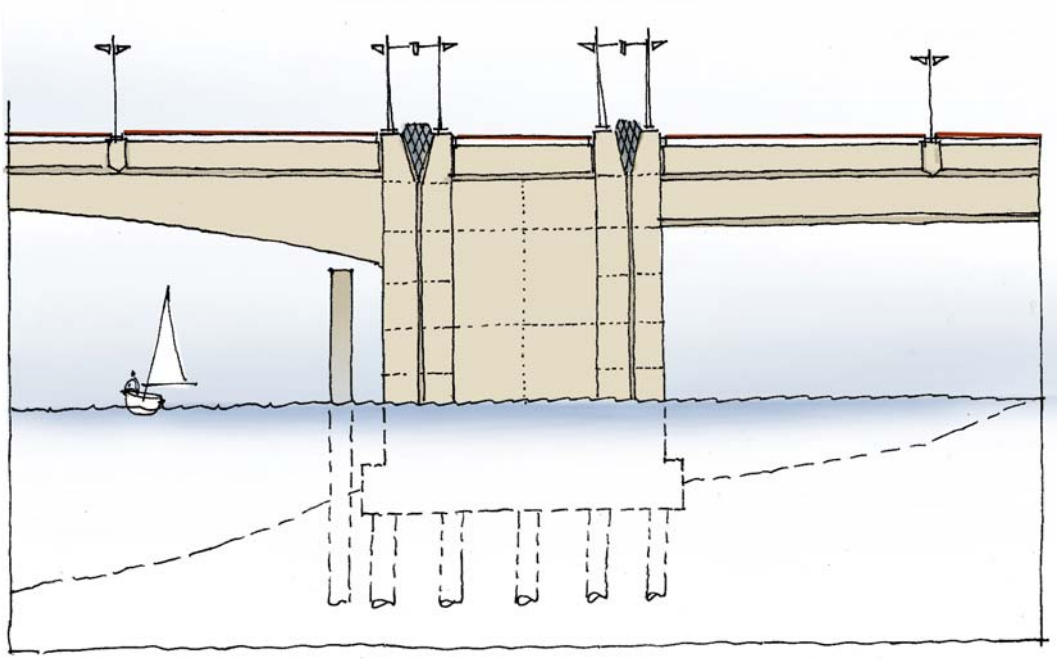


Figure 27a
Bascule Bridge Alternative: Appearance Option 1
(Side Without Control Tower)

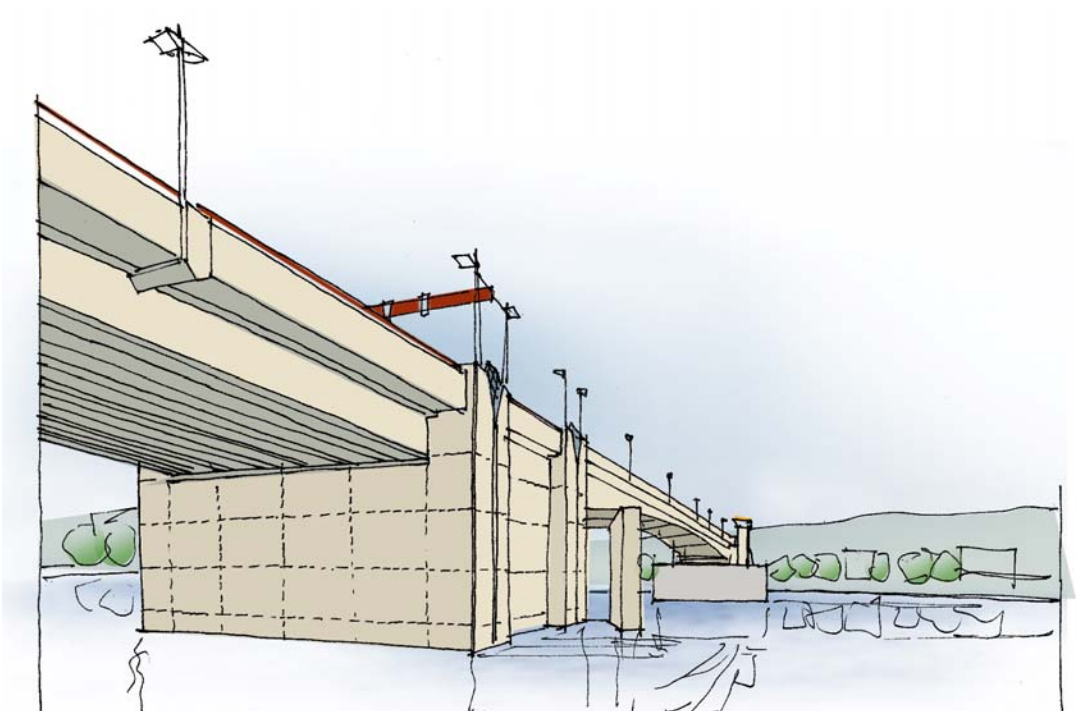


Figure 27b
Bascule Bridge Alternative: Appearance Option 1
(Side Without Control Tower)

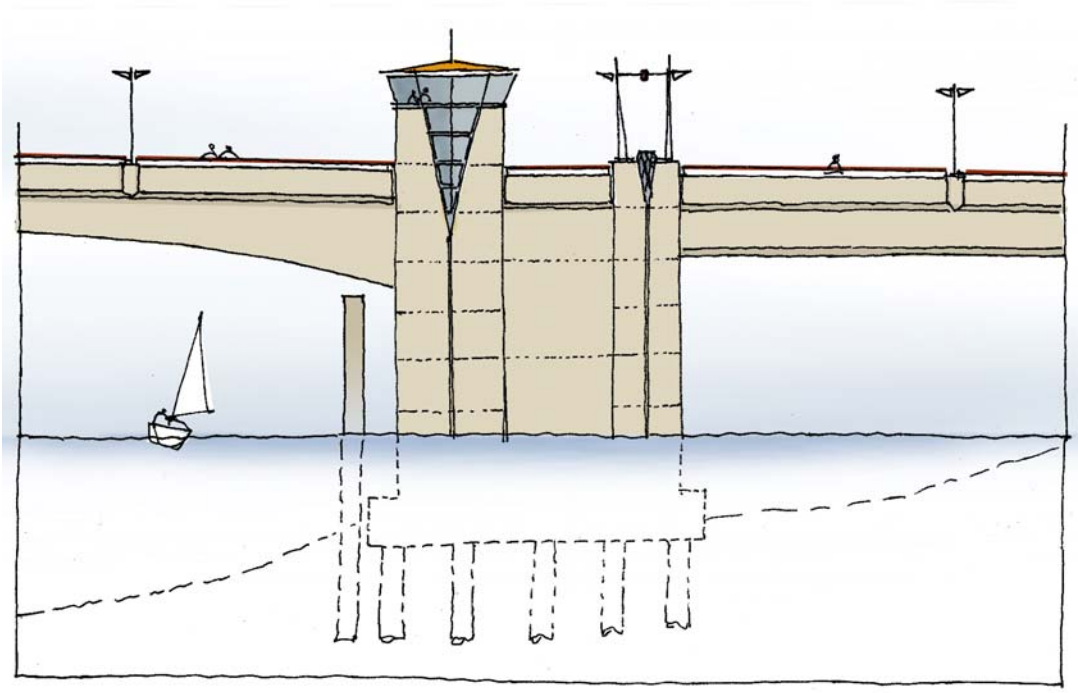


Figure 27c
Bascule Bridge Alternative: Appearance Option 1
(Side With Control Tower)

Figure 27d
Bascule Bridge Alternative: Appearance Option 1
(Side With Control Tower)

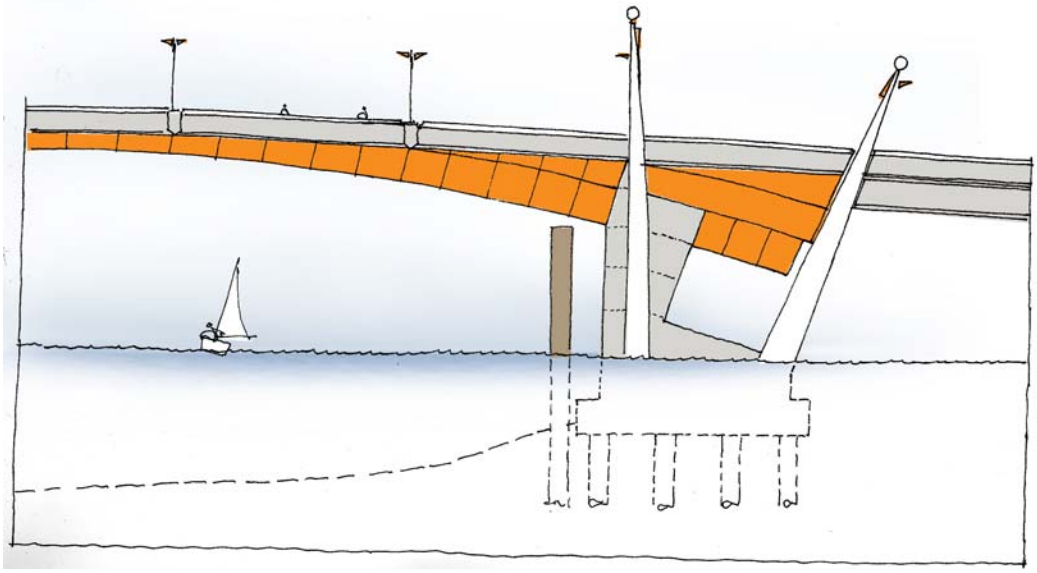


Figure 28a
Bascule Bridge Alternative: Appearance Option 2
(Side Without Control Tower)

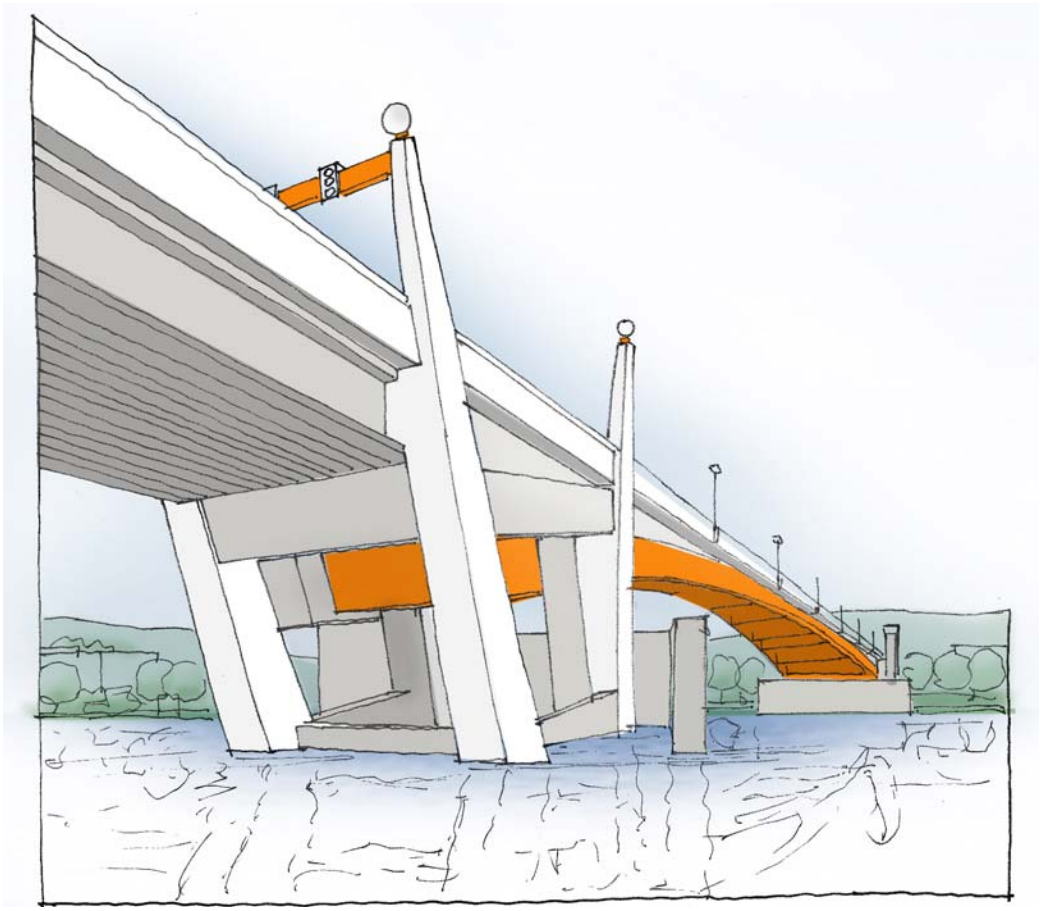


Figure 28b
Bascule Bridge Alternative: Appearance Option 2
(Side Without Control Tower)

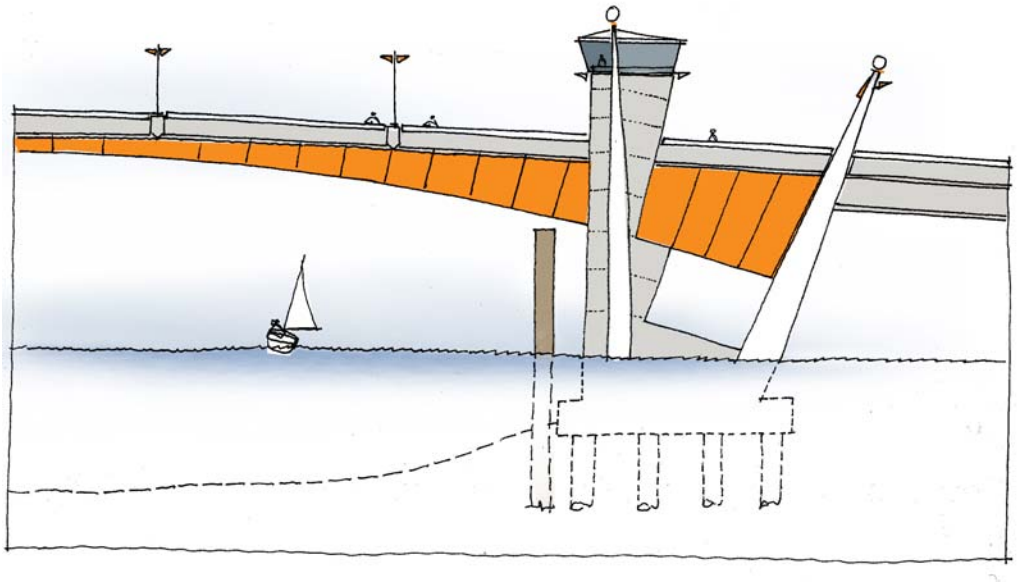


Figure 28c
Bascule Bridge Alternative: Appearance Option 2
(Side With Control Tower)

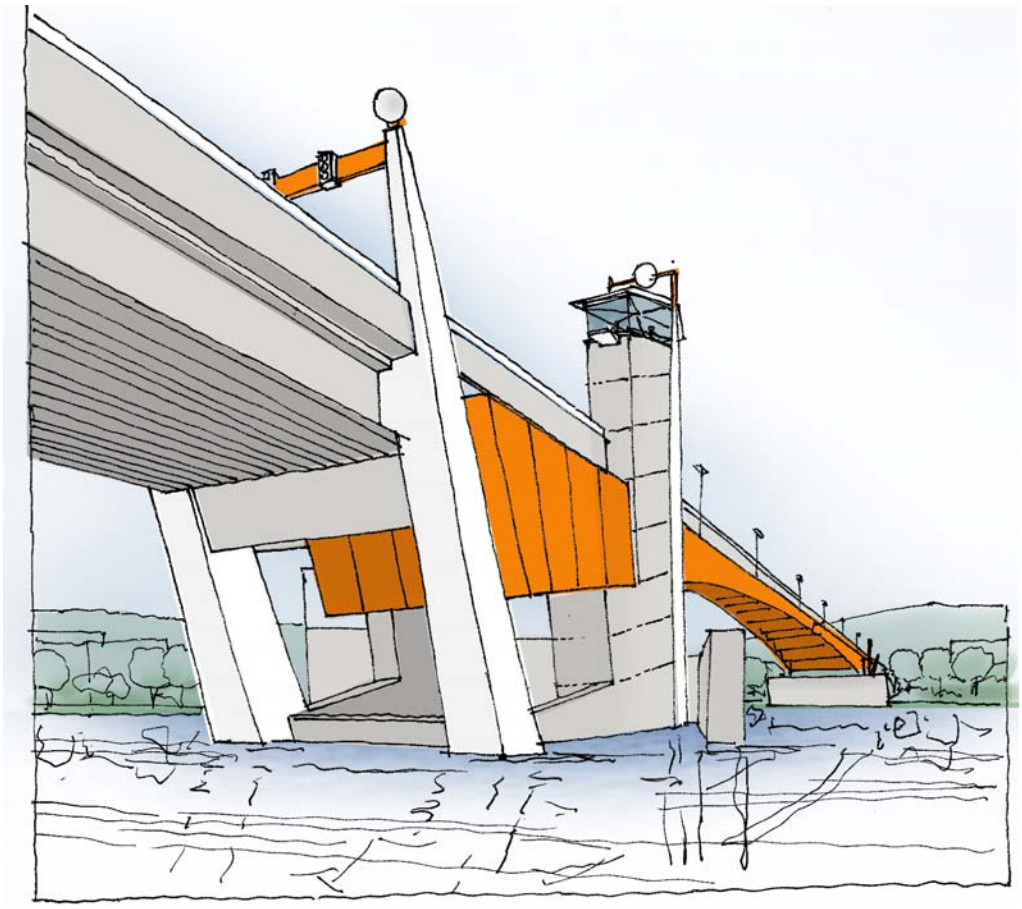


Figure 28d
Bascule Bridge Alternative: Appearance Option 2
(Side With Control Tower)

11. Construction Considerations

11.1. MAJOR CONSTRUCTION ACTIVITIES

In this section, major construction activities for each structural alternative are listed in the approximate sequence of construction. Many of these activities will be concurrent or overlapping.

11.1.1 No Action Alternative

Although this is referred to as the "No Action Alternative" because the existing bridge would not be rehabilitated or replaced, the bridge would be removed and the following construction activities would be expected:

1. Placing road blocks and modifying traffic signals to close the existing bridge;
2. Providing signing for the construction site and mobilization;
3. Installing a construction access trestle for removing the existing bridge (work in the main channel would be likely performed from a barge);
4. Installing protective nets under the existing bridge girders to prevent construction debris from falling into the Duwamish River;
5. If necessary, installing sheet piles around the river piers to prevent construction debris from falling into the Duwamish River;
6. Removing the existing bridge deck;
7. Removing the existing bridge superstructures;
8. Removing piers and abutments;
9. Removing existing foundations and timber protection piers to the mud level;
10. Removing retaining walls along the approaches;
11. Removing the construction access trestle; and
12. Cleaning and preparing the site for future use.

To minimize the risk of polluting the Duwamish River, it is recommended that all existing in-water piles be cut off at the mud level instead of pulling them out of the riverbed.

11.1.2 Rehabilitation Alternative

Major construction activities for the Rehabilitation Alternative would include Items 1 through 10 listed for the No Action Alternative, except that in Item 3, the access trestle would be used for both removing the existing structure and installing the new structural components. The following construction activities would also be anticipated (see Figure 29):

11. Refurbishing and strengthening the existing bascule span trusses and approach span trusses;
12. Making underlying soil improvements based on the geotechnical consultant's recommendation;
13. Constructing the foundations;
14. Constructing piers and abutments;
15. Erecting the approach span prestressed girders;
16. Erecting the approach steel truss spans;
17. Placing the approach span roadway deck;
18. Replacing the refurbished bascule span and counterweights;
19. Installing the bascule span drive machinery and control system;
20. Placing the bascule span roadway deck;
21. Constructing the approach fill and retaining walls;

22. Constructing traffic barriers and sidewalks;
23. Installing expansion joints and railings;
24. Installing bridge luminaries, traffic gates and signals;
25. Removing the construction access trestle; and
26. Constructing pier protections.

11.1.3 High-Level or Mid-Level Fixed-Span Bridge Alternative

Anticipated major construction activities for the High-Level or Mid-Level Fixed-Span Bridge alternatives would include the following. (High-Level Alternative shown in Figure 30.)

1. Providing signing for the construction site and mobilization;
2. Relocating existing utilities;
3. Installing a construction access trestle;
   (the work in the main channel would be likely performed from a barge);
4. Intermittent traffic reconfiguration
5. Making underlying soil improvements based on the geotechnical consultant's recommendation;
6. Constructing the foundations;
7. Constructing piers;
8. Constructing abutments;
9. Fabricating and erecting prestressed girders;
10. Placing the roadway deck;
11. Constructing barriers;
12. Installing expansion joints and railings;
13. Installing bridge luminaries;
14. Constructing access roadways and retaining walls;
15. Diverting traffic to the new bridge;
16. Removing the construction access trestle;
17. Removing the existing bridge, as described previously for the No Action Alternative;
18. Traffic signal work;
19. Surface street and intersection construction;
20. Relocation of (High Level) selected properties; and
21. Construction of Trenton Bypass (High-Level)

11.1.4 Bascule Bridge Alternative

Anticipated major construction activities for the Bascule Bridge Alternative would include Items 1 to 7 listed above for the High-Level or Mid-Level Fixed-Span Bridge alternatives. Construction activities would also include (see Figure 31):

8. Fabricating and erecting approach-span prestressed girders;
9. Fabricating and erecting bascule leaves and counterweights;
10. Installing the bascule-span drive machinery and control system;
11. Placing the approach-span roadway deck;
12. Installing the bascule-span exodermic deck;
13. Constructing barriers;
14. Installing expansion joints and railings;
15. Installing bridge luminaries, traffic gates and signals;
16. Constructing access roadways and retaining walls;
17. Diverting traffic to the new bridge;
18. Removing the construction access trestle;
19. Removing the existing bridge, as described previously for the No Action Alternative; and
20. Constructing pier protections.

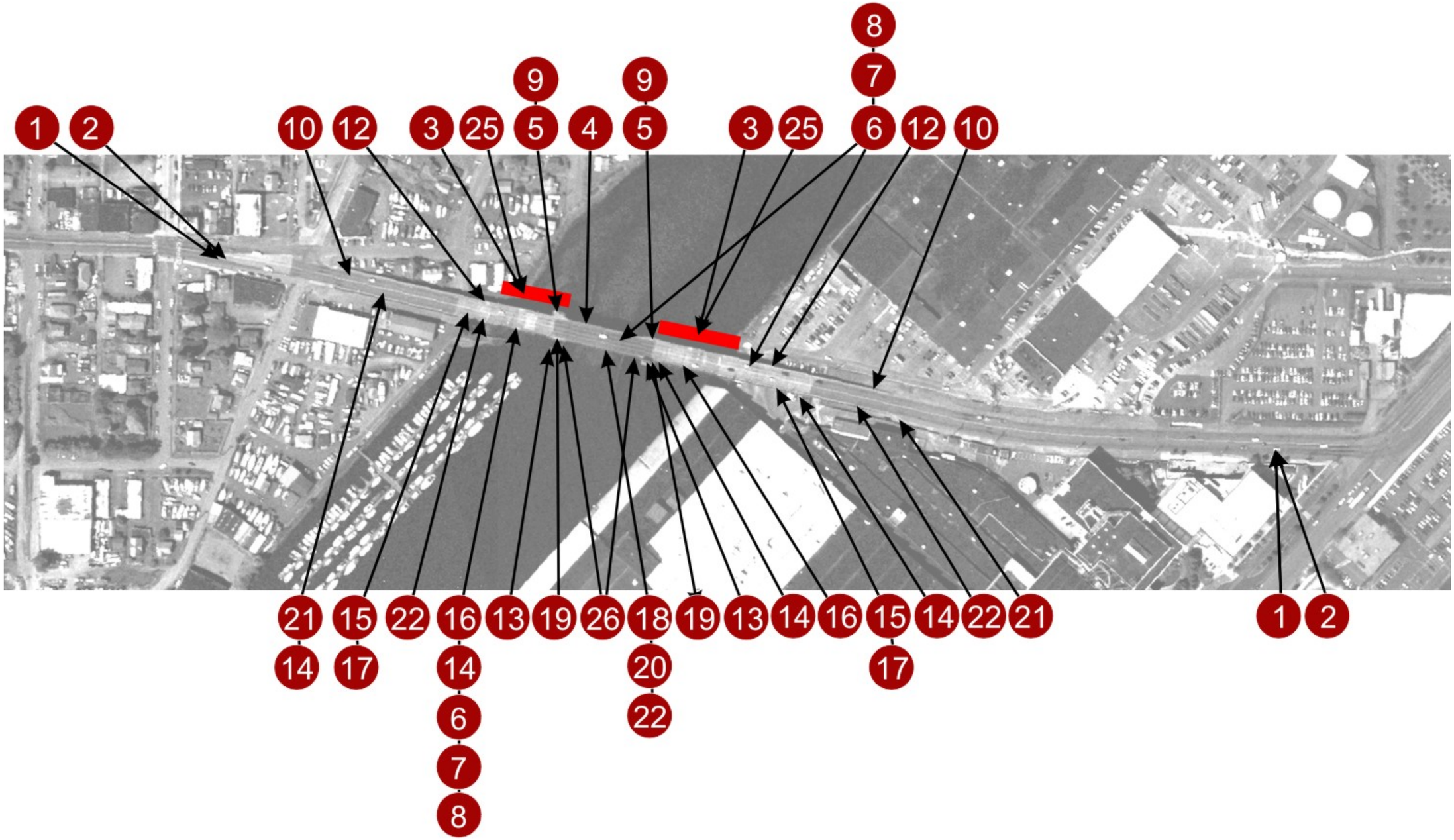


Figure 29
Rehabilitation Alternative
Construction Activities

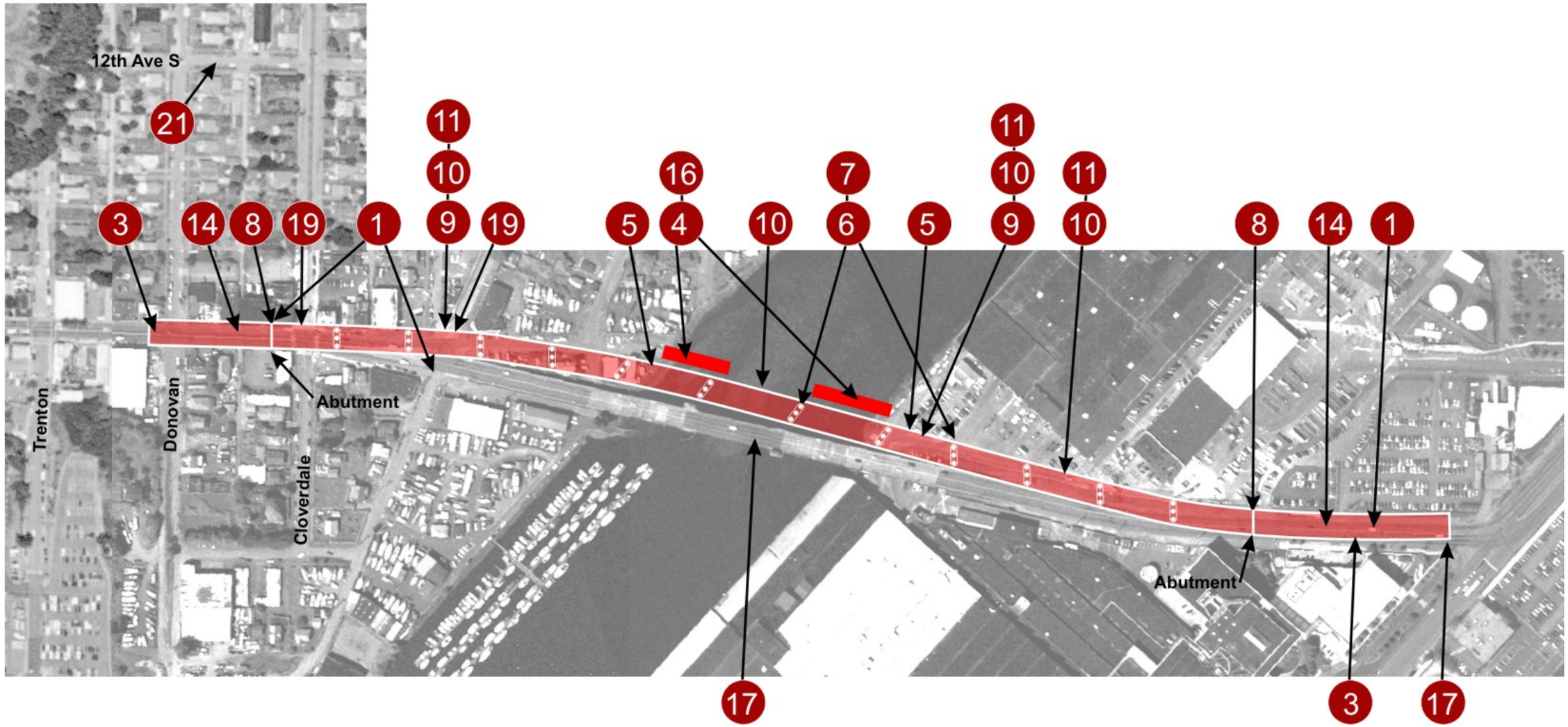


Figure 30
High-Level Fixed-Span Bridge Alternative
Construction Activities

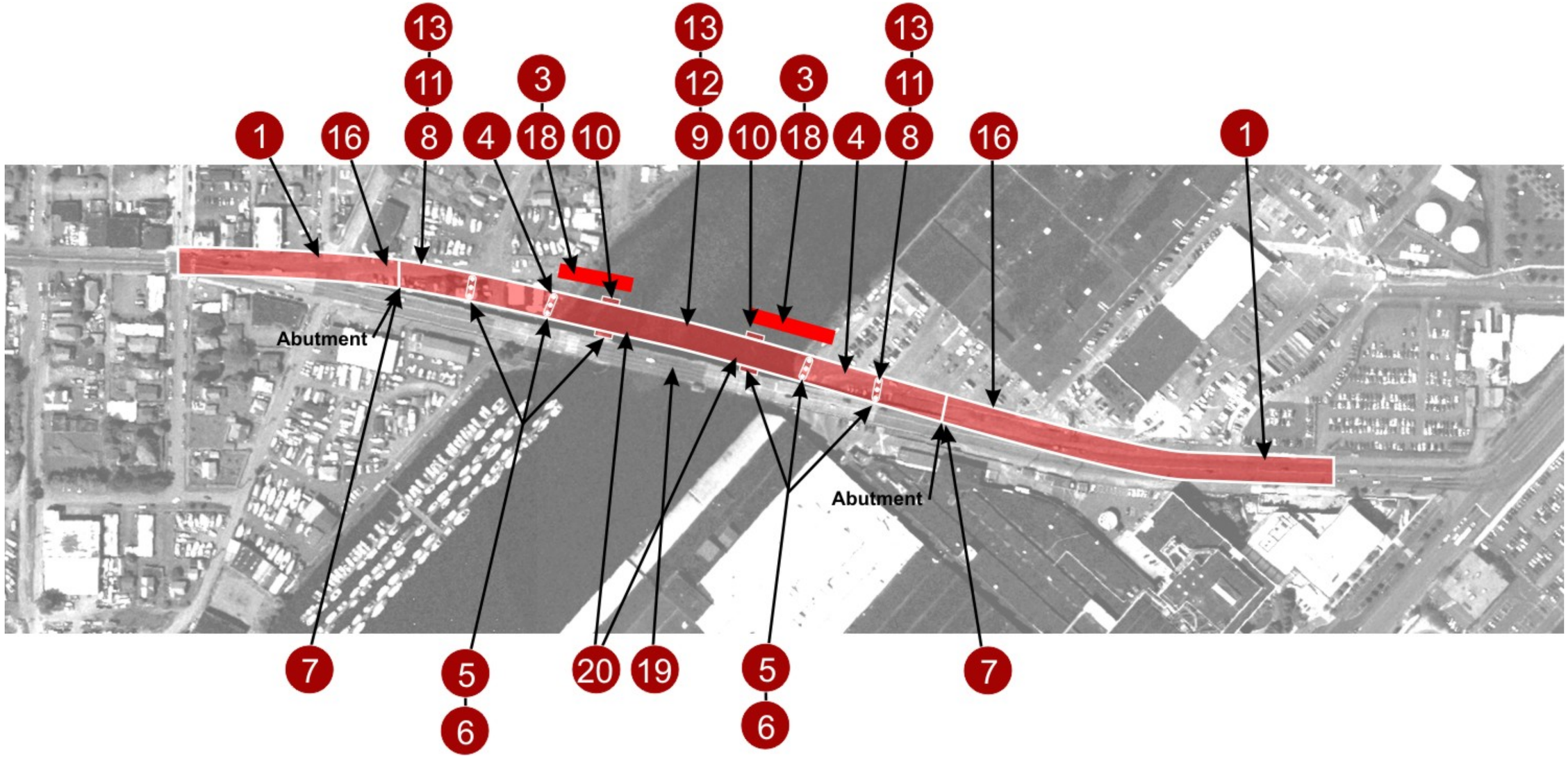


Figure 31
Bascule Bridge Alternative
Construction Activities

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11.2. CONSTRUCTION TIME

Table 8 shows the estimated construction duration for each structural alternative at this conceptual study phase. Because estimated construction durations for the four Build Alternatives are longer than 12 months (except for the No Action Alternative), the construction trestle has to be designed for the high-water season.

The Rehabilitation Alternative would have a much longer vehicle/pedestrian traffic interruption time than the other three replacement alternatives. For the replacement alternatives, the existing South Park Bridge would be available for land traffic during most of the construction period, and the new replacement bridge would be constructed along a parallel alignment. In contrast, the Rehabilitation Alternative would remove the existing bridge first, then reconstruct the bridge from the foundation up, so the bridge would be closed to traffic during almost the entire construction period.

11.3. CONSTRUCTION ACCESS

To provide construction access for the contractor during bridge construction, it is assumed that a construction trestle would be erected immediately downstream of the proposed bridge alignment for the Replacement Alternative, or downstream of the existing bridge for the Rehabilitation Alternative.

The bridge portion in the main channel of the Duwamish River would probably be constructed from barges. Some construction materials or large items, such as girders, could be shipped in by barge.

Table 8
Construction Schedule

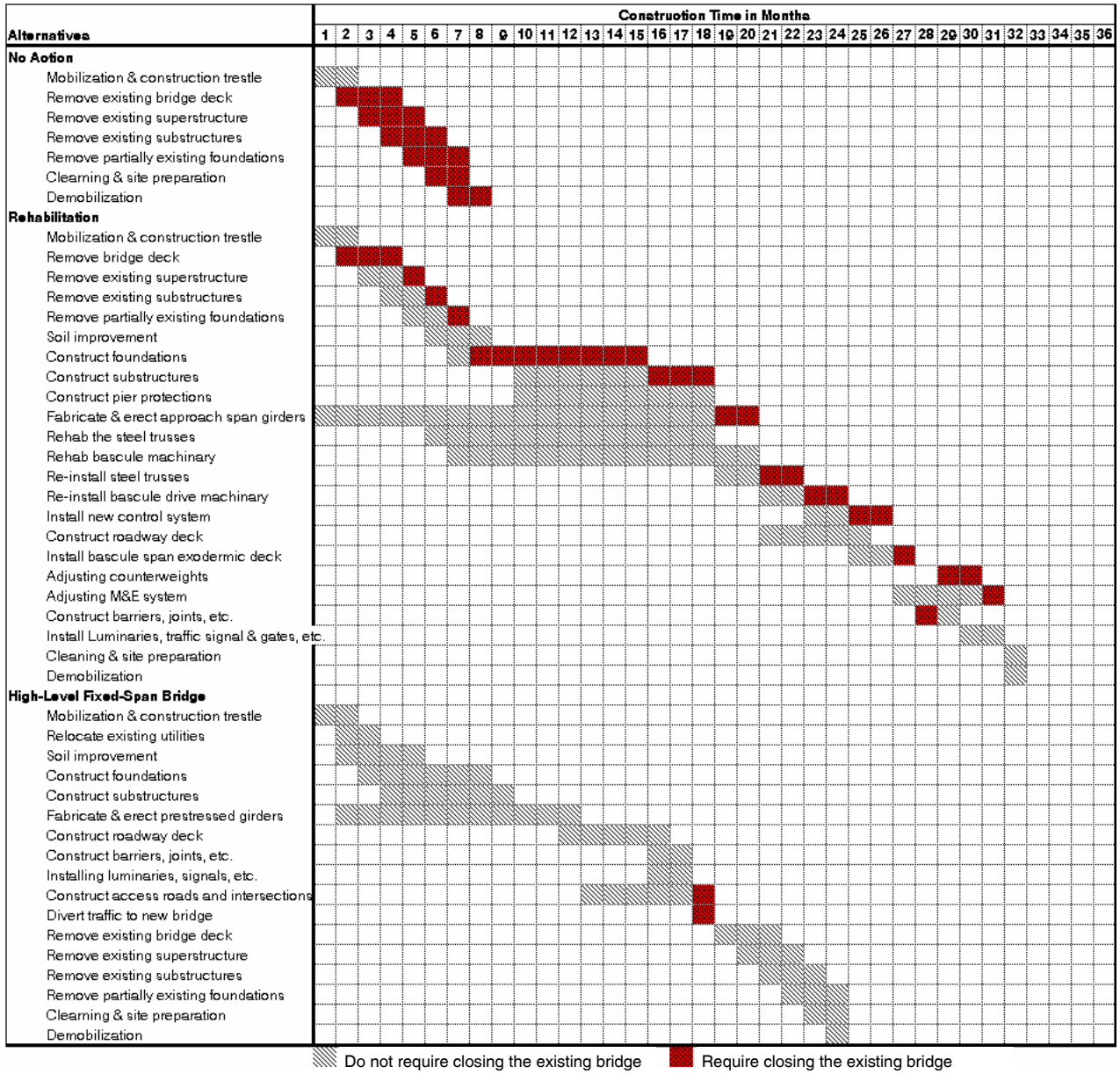
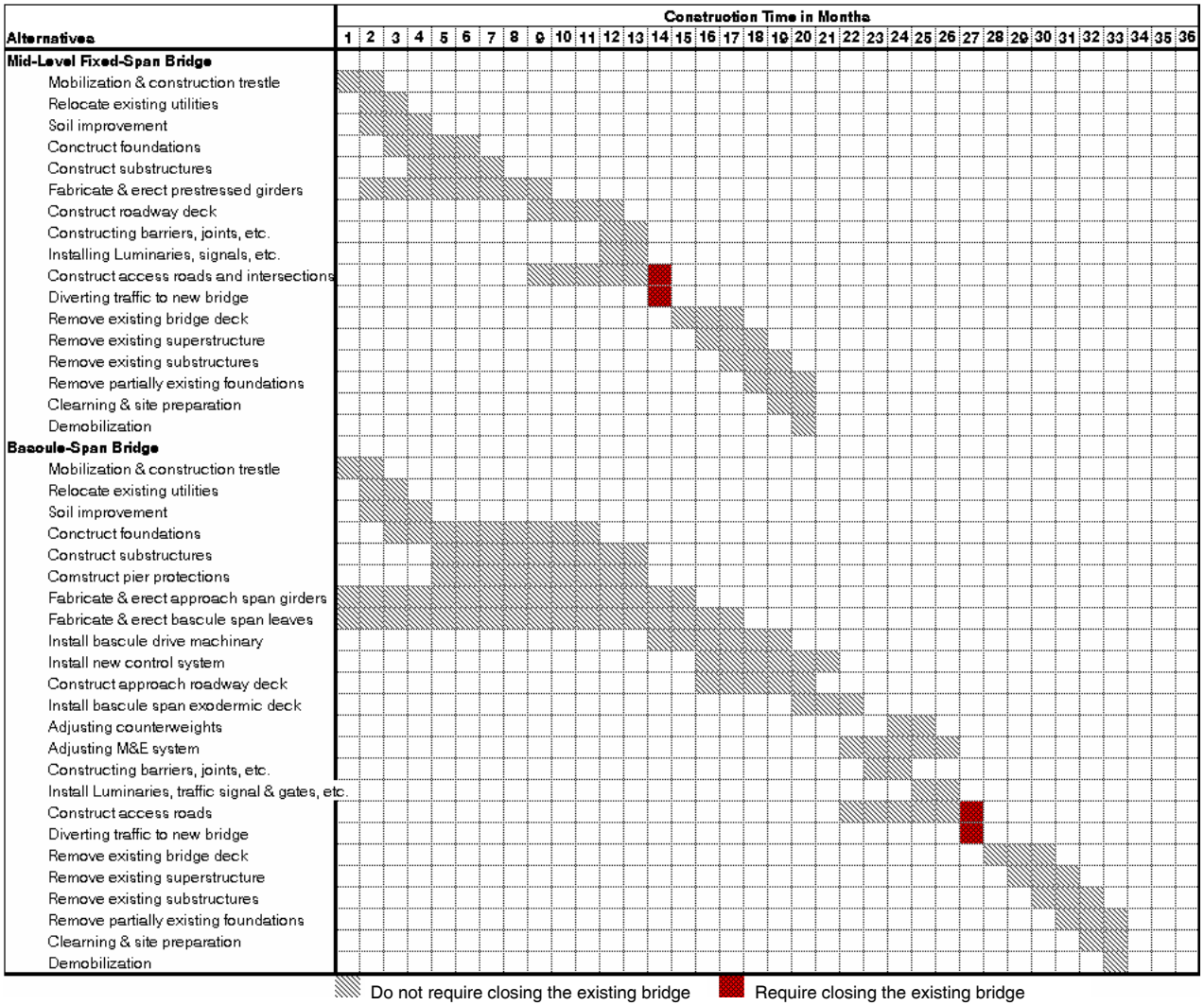


Table 8 (continued)
Construction Schedule



12. Conceptual Cost Estimate

12.1. ESTIMATED PROJECT COSTS

Conceptual-level cost estimates were prepared for each build alternative. At the conceptual-level design stage, estimated bridge construction costs are typically calculated based on the total bridge deck area multiplied by average per-square-foot costs. However, because there are no established per-square-foot cost data available for this type of bridge rehabilitation/retrofit project, the Rehabilitation Alternative costs were calculated based on preliminary quantities of major construction items, as determined from conceptual designs. In order to be as consistent as possible in determining costs for the different alternatives, cost estimates for the other three bridge replacement alternatives were also calculated based on preliminary quantities of major construction items where the quantities are available, as determined from conceptual designs that have developed adequate information. Unit costs for each of the items were established using the following sources:

- WSDOT bid item unit price tabulations
- WSDOT *Bridge Design Manual*, Volume 2, Section 12
- WSDOT bid item website
- Data from previous similar projects

Because there is limited bid price data available in Washington State for the Bascule Bridge Alternative compared to the other alternatives, additional cost data from projects in other states were collected and used as references for the Bascule Bridge Alternative cost estimate.

To arrive at total project cost estimates, the following allowances and contingencies were used:

- 5% of construction cost for construction detours, staging areas, and mitigations
- 10% of construction cost for mobilization
- The percentage of construction contingency varies depending on the alternatives.

These percentages were estimated based on common engineering practice and/or industry standards. Conceptual cost estimates for the four build alternatives are included in the Appendix.

12.2. ESTIMATED LIFE CYCLE COSTS

Life-cycle cost analyses were performed on the four construction alternatives. The present values of the life-cycle costs were calculated based on estimated construction costs, maintenance and operation costs, and environmental mitigation costs. The life-cycle costs were not calculated based on other economic impacts, such as potential tax revenue changes or costs assigned to traffic delays. The following assumptions were used in the life-cycle cost analyses:

- The bridge life cycle for this evaluation is assumed to be 75 years
- The projected inflation rate is assumed to be 3%
- The real discount rate is assumed to be 4%
- The nominal discount rate is assumed to be 7.12%

The life-cycle cost analyses results are included in the Appendix.

12.3. COST ESTIMATE SUMMARY

The estimated conceptual-level project costs and 75-year life-cycle costs increase are summarized in the Appendix.

13. References

1. *South Park Bridge Project, Summary Technical Report: Alternatives Development and Screening*, Parsons Brinckerhoff, Inc., September 6, 2002.
2. *Findings and Fact Decision – 14th Avenue South Bridge*, King County Landmarks and Heritage Commission. Decision made December 19, 1996 and filed January 2, 1997.
3. *King County Landmark Registration Form – 14th Avenue South Bridge*, King County Department of Parks, Planning and Resources, Cultural Resources Division, Landmarks and Heritage Commission. Form prepared by Kevin A. Palmer and Christine Savage Palmer, November 1996.
4. Letter from Austin Pratt, Chief, Bridge Section of 13th U.S. Coast Guard District to Timothy Lane, King County Project Manager, clarifying the status of the permit for the South Park Bridge, August 16, 2002.
5. *South Park Bridge Rehabilitation Feasibility Study Technical Memorandum*, Parsons Brinckerhoff, Inc., May 2003.
6. *Geotechnical Report Phase II, South Park Bridge Project, King County, Washington* Shannon & Wilson, Inc., November 2003.
7. *Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines,* U.S. Department of Transportation and Federal Highway Administration. Publication No. FHWA-SA-96-071, August 1997.
8. *South Park Bridge Environmental Impact Statement Project Advisory Committee Meeting Minutes*, King County, May 24, 2002.
9. *Questions and Answers about the South Park Bridge Environmental Impact Statement (EIS) Process,* King County Department of Transportation/Road Services Division. Distributed at public workshop, June 19, 2002.

Appendix: Conceptual Cost Estimates

Table 1 - Conceptual Cost Estimate Summary

Table 1a - Rehabilitation Alternative Conceptual Cost Estimate

Table 1b - Rehabilitation Alternative Life Cycle Cost Estimate

Table 2a - High-Level Fixed-Span Bridge Alternative Conceptual Cost Estimate

Table 2b - High-Level Fixed-Span Bridge Alternative Life Cycle Cost Estimate

Table 3a - Mid-Level Fixed-Span Bridge Alternative Conceptual Cost Estimate

Table 3b - Mid-Level Fixed-Span Bridge Alternative Life Cycle Cost Estimate

Table 4a - Bascule Bridge Alternative Conceptual Cost Estimate

Table 4b - Bascule Bridge Alternative Life Cycle Cost Estimate

Table 1. Conceptual Cost Estimate Summary

Structural Alternatives	Project Total Cost	75 Year Life Cost Increase Present Value
	$ (in 2008)	$ (in 2008)
Rehabilitation Alternative (3 lanes)	$74 mil	$11 mil
High Level Fixed Span Bridge Alternative (4 Lanes)	$82 mil	$3 mil
Mid Level Fixed Span Bridge Alternative (4 Lanes)	$71 mil	$2 mil
Bascule Bridge Alternative (4 Lanes)	$90 mil	$11 mil

Note 1
Project Total Cost include: Construction, traffic maintenance, mitigation and risk allowance, contingencies, engineering and right of way.
Note 2
75 Year Life Cost Increase include: Maintenance and operation, inspection, deck repairing, mechanical and electronical equipment replace and upgrade.

Appendix Table 1a
Rehabilitation Alternative Conceptual Cost Estimate

ITEM	UNIT MEASURE	QUANTITY	UNIT COST	COST
Direct Construction Cost				
Structural				
Removal of Existing Structures				**$ 1,999,000**
Removal of Bascule Spans	SF	12,000	$ 50	$ 600,000
Removal of Steel Trusses from Truss Approach Spans	SF	16,900	$ 40	$ 676,000
Demolition of Concrete Approach Spans	SF	24,125	$ 25	$ 603,125
Demolition of Approach Fill and Retaining Walls	SF	12,000	$ 10	$ 120,000
Bascule Spans				**$ 10,107,000**
Shafts and Footings				***$ 7,268,000***
Soil Excavation For Footings Incl. Haul	CY	2,200	$ 50	$ 110,000
Coffer Dam	SF	52,800	$ 30	$ 1,584,000
Soil Excavation For Shaft Incl. Haul (North Pier)	CY	3,200	$ 450	$ 1,439,897
Soil Excavation For Shaft Incl. Haul (South Pier)	CY	2,618	$ 450	$ 1,178,097
Furnishing & Placing Temp. Casing For 10 Ft Diam. Shaft (North Pier)	LF	1,100	$ 200	$ 220,000
Furnishing & Placing Temp. Casing For 10 Ft Diam. Shaft (South Pier)	LF	900	$ 200	$ 180,000
Furnishing Permanent Casing For 10 Ft Diam. Shaft (North Pier)	LF	100	$ 350	$ 35,000
Placing Permanent Casing For 10 Ft Diam. Shaft (North Pier)	EA	10	$ 1,250	$ 12,500
Furnishing Permanent Casing For 10 Ft Diam. Shaft (South Pier)	LF	100	$ 350	$ 35,000
Placing Permanent Casing For 10 Ft Diam. Shaft (South Pier)	EA	10	$ 1,250	$ 12,500
Conc. Class 4000p For Shaft	CY	5,818	$ 180	$ 1,047,198
St. Reinf. Bar For Shaft (1.2%)	LB	924,440	$ 0.50	$ 462,220
Conc. Class 4000 For Footing	CY	1,692	$ 400	$ 676,978
St. Reinf. Bar For Footing (200 lbs per Cubic Yard)	LB	338,489	$ 0.60	$ 203,093
CSL Access Tube	LF	24,000	$ 3.0	$ 72,000
Pier Substructure, Machine Room and Control House				***$ 2,010,000***
Concrete Class 4000	CY	3,035	$ 400	$ 1,214,075
St. Reinf. Bar (300lbs/cy)	LB	910,556	$ 0.6	$ 546,334
FRP - Pier Caps and Control Houses	LS		$ 150,000	$ 150,000
Interior Finishes for Control Tower	LS		$ 100,000	$ 100,000
Seismic Upgrade of Bascule Leaves				**$ 229,000**
Restrainers at Tracks and Counter Weights				$ 161,000
Track Restrainers	EA		$ 19,096	$ 76,385
Counterweight Restrainers	EA		$ 15,914	$ 63,654
Hydraulic Power Units	EA		$ 5,305	$ 21,218
Add Angles to Top Laterals				$ 4,455
8-L3 1/2x3 1/2x1/2,11' long	LB	443	$ 3.71	$ 3,628
Connections	LB	88	$ 4.24	$ 828
Frame 0 New Members				$ 63,353
16 - 2L5x3 1/2 x3/4, 10' long	LB	2874	$ 3.71	$ 23,527
2-W18x143, 36' long	LB	4670	$ 3.18	$ 32,769
Connections	LB	754	$ 4.24	$ 7,057
Bascule Leaf Refurbishing and Reinstallation				***$ 600,000***
Bascule Leaf Refurbishing and Reinstallation	LB			$ 600,000
Steel Truss Approach Spans				**$ 3,413,000**
Shafts				***$ 1,487,000***
Soil Excavation For Shaft Incl. Haul	CY	1,862	$ 450	$ 837,758
Furnishing & Placing Temp. Casing For 10 Ft Diam. Shaft	LF	640	$ 200	$ 128,000
Furnishing Permanent Casing For 10 Ft Diam. Shaft	LF	80	$ 350	$ 28,000
Placing Permanent Casing For 10 Ft Diam. Shaft	EA	8	$ 1,250	$ 10,000
Conc. Class 4000p For Shaft	CY	1,862	$ 180	$ 335,103
St. Reinf. Bar For Shaft (Assume ~1.2%)	LB	295,821	$ 0.50	$ 147,910
CSL Access Tube (6 for each shaft)	LF	48	$ 3.00	$ 144
Columns and Pier Caps				***$ 939,000***
Conc. Class 4000 For 8' Columns (Pier 1)	CY	156	$ 400	$ 62,553
Conc. Class 4000 For 8' Columns (Pier 2)	CY	97	$ 400	$ 38,723
St. Reinf. Bar For Columns (Use ~2%)	LB	50,290	$ 0.60	$ 30,174
Conc. Class 4000 For Pier Caps	CY	1,351	$ 400	$ 540,444
St. Reinf. Bar For Caps (300lbs/cy)	LB	405,333	$ 0.60	$ 243,200
Bearing Replacement	EA	8	$ 3,000	$ 24,000

Appendix Table 1a
Rehabilitation Alternative Conceptual Cost Estimate

	ITEM	UNIT MEASURE	QUANTITY	UNIT COST	COST
	Seismic Upgrade				***$ 167,000***
	Brace Frames @ Bascules				$ 90,732
	8-WT12x38, 33' long	LB	10,032	$ 3.71	$ 37,250
	24- 2L5x3 1/2x 3/4, 6.5' long	LB	6,178	$ 3.71	$ 22,940
	24- 2L5x3 1/2x 3/4, 3.5' long	LB	3,326	$ 3.71	$ 12,350
	24- L3x3x1/4, 3' long	LB	353	$ 3.71	$ 1,311
	Connections	LB	3,978	$ 4.24	$ 16,881
	Anchor Bolts @ Fixed Supports				$ 849
	16-1 1/2" diameter HS anchor bolts	each	16	$ 53	$ 849
	Rod Restrainers				$ 356
	8-1" diameter. 4' long HS rod restrainers	each	8	$ 45	$ 356
	Transverse Shear Key				$ 24,666
	4 ksi concrete	CY	40	$ 530	$ 21,218
	A706 reinforcement	LB	1,760	$ 0.95	$ 1,680
	6-W12x22, 3' long & connections	LB	476	$ 3.71	$ 1,767
	Longitudinal Shear Key				$ 50,529
	32 - 6'x1.5'x1/2 plates	LB	5,880	$ 3.71	$ 21,833
	64 - 6'x6"x3/4" plates	LB	5,880	$ 3.18	$ 18,714
	Connections	LB	2,352	$ 4.24	$ 9,981
	Steel Truss Refurbishing and Reinstallation				***$ 800,000***
	Steel Truss Removal and Reinstallation	LS			$ 800,000
	Expansion Joint				***$ 20,000***
	Expansion Joint	LF	200	$ 100	$ 20,000
Concrete Approaches					**$ 2,393,000**
	Shafts				***$ 1,146,000***
	Soil Excavation For 6' Shaft Incl. Haul	CY	2,011	$ 250	$ 502,655
	Furnishing & Placing Temp. Casing For 8 Ft Diam. Shaft	LF	1,920	$ 100	$ 192,000
	Furnishing Permanent Casing For 8 Ft Diam. Shaft	LF	240	$ 200	$ 48,000
	Placing Permanent Casing For 8 Ft Diam. Shaft	EA	24	$ 1,000	$ 24,000
	Conc. Class 4000p For Shaft	CY	2,011	$ 125	$ 251,327
	St. Reinf. Bar For Shaft (Assume ~1.2%)	LB	319,487	$ 0.40	$ 127,795
	CSL Access Tube (6 for each shaft)	LF	144	$ 3.00	$ 432
	Columns and Pier Caps				***$ 975,000***
	Conc. Class 4000 For 4' Columns	CY	246	$ 400	$ 98,520
	St. Reinf. Bar For Columns (Use ~2%)	LB	65,229	$ 0.60	$ 39,137
	Conc. Class 4000 For Pier Caps	CY	1,444	$ 400	$ 577,778
	St. Reinf. Bar For Caps (300lbs/cy)	LB	433,333	$ 0.60	$ 260,000
	Superstructure				***$ 272,000***
	W42G Girders	LF	3,080	$ 85	$ 261,800
	Expansion Joint	LF	100	$ 100	$ 10,000
Approach Fill and Retaining Walls					**$ 165,000**
	MSE Walls	SF	5,635	$ 20	$ 112,704
	Approach Fill	CY	5,216	$ 10	$ 52,156
	ACP Pavement	SY	444	$ 30	$ 13,333
Deck Reconstruction					**$ 1,435,000**
	Deck Reconstruction				***$ 1,176,000***
	Concrete Class 4000D	CY	1,636	$ 500	$ 817,901
	St. Reinf. Bar, Epoxy Coated (160lbs/cy)	LB	261,728	$ 0.75	$ 196,296
	St. Reinf. Bar (180lbs/cy)	LB	294,444	$ 0.55	$ 161,944
	Traffic Barriers and Bridge Rails				***$ 259,000***
	Traffic Barriers and Bridge Rails to match historical	LF	1,294	$ 200	$ 258,800
Soil Improvement					**$ 400,000**
	Earthquake Drain System	LS		$ -	$ 400,000
Pier Protection					**$ 1,500,000**
	Pier Protection	each		$ 750,000	$ 1,500,000
Temporary Construction Platform					**$ 1,200,000**
		SF	1115	$ 100	$ 1,200,000
Utilities					**$ 250,000**
		LS			$ 250,000
Testing and Disposal of Contaminated Waste					**$ 3,000,000**
		LS			$ 3,000,000

Appendix Table 1a

Rehabilitation Alternative Conceptual Cost Estimate

	ITEM	UNIT MEASURE	QUANTITY	UNIT COST	COST
	Mechanical & Electrical				
	Electrical				***$ 1,255,000***
	Electrical Service Entrance	LS		$ 50,000	$ 50,000
	Motor Control Centers	EA		$ 40,000	$ 80,000
	SCR Drives	EA		$ 70,000	$ 280,000
	Bridge Control Desk and Panels	LS		$ 225,000	$ 225,000
	Traffic Gates	EA		$ 30,000	$ 120,000
	Traffic Signals	EA		$ 25,000	$ 50,000
	Submarine Cable	LS		$ 200,000	$ 200,000
	House Lights and Receptacles	LS		$ 25,000	$ 25,000
	Emergency Generator	LS		$ 75,000	$ 75,000
	125 hp Shunt Wound DC Motors	EA		$ 25,000	$ 100,000
	Illumination	LS		$ 50,000	$ 50,000
	Mechanical				***$ 2,000,000***
	Rehab cost	LS			$ 2,000,000
A.	**Summary of Direct Construction Cost**				**$ 29,117,000**
B.	**Construction Contingency (40% of A, also includes pavement, traffic revision, drainage and signalization)**				**$ 11,647,000**
	Construction Related cost				
	Staging/Detours/Mitigation				$ 4,268,000
	Mobilization (10%)				$ 3,089,000
C.	**Summary of Construction Related Cost**				**$ 7,357,000**
	Engineering cost				
	Construction Support & Administration (18%)				$ 8,212,000
	PS&E Design (15%)				$ 6,843,000
D.	**Summary of Engineering Cost**				**$ 15,055,000**
E.	**Right of Way**				**$ 754,000**
	PROJECT TOTAL (A+B+C+D+E, 2003 Dollar)				**$ 63,930,000**

Appendix Table 1b
Rehabilitation Alternative Life Cycle Cost Estimate

Parameters for present value cost analysis

i =	*0.04*	*(Real discount rate)*
f =	*0.03*	*(Projected inflation rate)*
i_f =	0.0712	*(Nominal discount rate)*
n =	*75*	*years*

Conceptual Operation and Maintenance Cost

ITEM	*UNIT MEASURE*	*QUANTITY*	*UNIT COST*	*COST (2003 dollars)*	
Operating Cost					
Operation Supervisor (1 person, 40hrs/week)	*Hrs*	*2,080*	*$ 40.00*	*$ 83,200*	*per year*
Operators (5 people, 200hrs/week)	*Hrs*	*2,080*	*$ 20.00*	*$ 208,000*	*per year*
Maintenance Cost					
Maintenance, (2 person, 16 hrs/month)	*Hrs*	*192*	*$ 60.00*	*$ 11,520*	*per year*
Maintenance Materials & Utilities	*Months*	*12*	*$ 3,000.00*	*$ 36,000*	*per year*
Repainting Steel Members	*LB*	*1,920,000*	*$ 0.75*	*$ 1,440,000*	*every 20 years*
Repair LMC Wearing Surface	*SF*	*44,840*	*$ 15.00*	*$ 672,600*	*every 20 years*
Repair ACP Wearing Surface	*SY*	*929*	*$ 30.00*	*$ 27,867*	*every 10 years*
Routine Inspection				*$ 2,000*	*every 2 years*
Replace Motor Control Centers	*EA*	*2*	$ 40,000	*$ 80,000*	*every 35 years*
Replace SCR Drives	*EA*	*4*	$ 70,000	*$ 280,000*	*every 35 years*
Replace 125 hp Shunt Wound DC Motors	*EA*	*4*	$ 25,000	*$ 100,000*	*every 35 years*
Replace Mechanical Parts	*EA*	*1*	*$ 400,000*	*$ 400,000*	*every 35 years*

Project Total Cost (2003 Dollar)	***$***	***63,930,000***
Project Total Cost (2008 Dollar)	***$***	***74,112,392***
PRESENT VALUE OF LIFE CYCLE COST (2003 Dollar):	**$**	**73,672,000**
PRESENT VALUE OF LIFE CYCLE COST (2008 Dollar):	**$**	**85,406,040**

Appendix Table 1b
Rehabilitation Alternative Life Cycle Cost Estimate

				Periodic Costs				
Year	Routine Maintenance	Operating Cost	Inspection	Painting	Wearing Surface	Mechanical & Electrical	Annual Total	Present Value
0	***Total Capital Cost***						$ 63,930,000	$ 63,930,000
1	$ 47,520	$ 291,200					$ 338,720	$ 316,206
2	$ 48,946	$ 299,936	$ 2,060				$ 350,942	$ 305,840
3	$ 50,414	$ 308,934					$ 359,348	$ 292,350
4	$ 51,926	$ 318,202	$ 2,185				$ 372,314	$ 282,766
5	$ 53,484	$ 327,748					$ 381,232	$ 270,294
6	$ 55,089	$ 337,581	$ 2,319				$ 394,988	$ 261,433
7	$ 56,741	$ 347,708					$ 404,449	$ 249,902
8	$ 58,444	$ 358,139	$ 2,460				$ 419,043	$ 241,709
9	$ 60,197	$ 368,883					$ 429,080	$ 231,049
10	$ 62,003	$ 379,950	$ 2,610		$ 37,450		$ 482,013	$ 242,300
11	$ 63,863	$ 391,348					$ 455,211	$ 213,618
12	$ 65,779	$ 403,089	$ 2,768				$ 471,636	$ 206,614
13	$ 67,752	$ 415,182					$ 482,934	$ 197,501
14	$ 69,785	$ 427,637	$ 2,937				$ 500,359	$ 191,027
15	$ 71,878	$ 440,466					$ 512,344	$ 182,601
16	$ 74,035	$ 453,680	$ 3,116				$ 530,831	$ 176,615
17	$ 76,256	$ 467,291					$ 543,546	$ 168,825
18	$ 78,543	$ 481,309	$ 3,306				$ 563,158	$ 163,290
19	$ 80,900	$ 495,749					$ 576,648	$ 156,088
20	$ 83,327	$ 510,621	$ 3,507	$ 2,600,800	$ 1,265,121		$ 4,463,375	$ 1,127,852
21	$ 85,826	$ 525,940					$ 611,766	$ 144,312
22	$ 88,401	$ 541,718	$ 3,721				$ 633,840	$ 139,581
23	$ 91,053	$ 557,969					$ 649,023	$ 133,425
24	$ 93,785	$ 574,708	$ 3,947				$ 672,440	$ 129,051
25	$ 96,598	$ 591,950					$ 688,548	$ 123,359
26	$ 99,496	$ 609,708	$ 4,188				$ 713,392	$ 119,315
27	$ 102,481	$ 627,999					$ 730,481	$ 114,052
28	$ 105,556	$ 646,839	$ 4,443				$ 756,838	$ 110,313
29	$ 108,722	$ 666,245					$ 774,967	$ 105,448
30	$ 111,984	$ 686,232	$ 4,713		$ 67,640		$ 870,569	$ 110,582
31	$ 115,344	$ 706,819					$ 822,162	$ 97,492
32	$ 118,804	$ 728,023	$ 5,000				$ 851,827	$ 94,296
33	$ 122,368	$ 749,864					$ 872,232	$ 90,137
34	$ 126,039	$ 772,360	$ 5,305				$ 903,704	$ 87,182
35	$ 129,820	$ 795,531				$ 2,419,922	$ 3,345,273	$ 301,274
36	$ 133,715	$ 819,397	$ 5,628				$ 958,739	$ 80,605
37	$ 137,726	$ 843,979					$ 981,705	$ 77,050
38	$ 141,858	$ 869,298	$ 5,970				$ 1,017,126	$ 74,524
39	$ 146,114	$ 895,377					$ 1,041,491	$ 71,237
40	$ 150,497	$ 922,238	$ 6,334	$ 4,697,334	$ 2,284,949		$ 8,061,353	$ 514,737
41	$ 155,012	$ 949,905					$ 1,104,917	$ 65,862
42	$ 159,662	$ 978,403	$ 6,720				$ 1,144,785	$ 63,703
43	$ 164,452	$ 1,007,755					$ 1,172,207	$ 60,893
44	$ 169,386	$ 1,037,987	$ 7,129				$ 1,214,502	$ 58,897
45	$ 174,467	$ 1,069,127					$ 1,243,594	$ 56,299
46	$ 179,701	$ 1,101,201	$ 7,563				$ 1,288,465	$ 54,454
47	$ 185,092	$ 1,134,237					$ 1,319,329	$ 52,052
48	$ 190,645	$ 1,168,264	$ 8,024				$ 1,366,933	$ 50,345
49	$ 196,365	$ 1,203,312					$ 1,399,676	$ 48,125
50	$ 202,256	$ 1,239,411	$ 8,512		$ 122,165		$ 1,572,344	$ 50,468
51	$ 208,323	$ 1,276,593					$ 1,484,917	$ 44,494
52	$ 214,573	$ 1,314,891	$ 9,031				$ 1,538,495	$ 43,035
53	$ 221,010	$ 1,354,338					$ 1,575,348	$ 41,137
54	$ 227,640	$ 1,394,968	$ 9,581				$ 1,632,189	$ 39,789
55	$ 234,470	$ 1,436,817					$ 1,671,287	$ 38,034
56	$ 241,504	$ 1,479,922	$ 10,164				$ 1,731,590	$ 36,787
57	$ 248,749	$ 1,524,319					$ 1,773,068	$ 35,164
58	$ 256,211	$ 1,570,049	$ 10,783				$ 1,837,043	$ 34,012
59	$ 263,898	$ 1,617,150					$ 1,881,048	$ 32,511
60	$ 271,815	$ 1,665,665	$ 11,440	$ 8,483,908	$ 4,126,872		$ 14,559,699	$ 234,919
61	$ 279,969	$ 1,715,635					$ 1,995,604	$ 30,059
62	$ 288,368	$ 1,767,104	$ 12,137				$ 2,067,609	$ 29,073
63	$ 297,019	$ 1,820,117					$ 2,117,136	$ 27,791
64	$ 305,930	$ 1,874,720	$ 12,876				$ 2,193,526	$ 26,880
65	$ 315,108	$ 1,930,962					$ 2,246,070	$ 25,694
66	$ 324,561	$ 1,988,891	$ 13,660				$ 2,327,112	$ 24,852
67	$ 334,298	$ 2,048,558					$ 2,382,855	$ 23,756
68	$ 344,327	$ 2,110,014	$ 14,492				$ 2,468,833	$ 22,977
69	$ 354,656	$ 2,173,315					$ 2,527,971	$ 21,964
70	$ 365,296	$ 2,238,514	$ 15,374		$ 220,643	$ 6,809,327	$ 9,649,155	$ 78,262
71	$ 376,255	$ 2,305,670					$ 2,681,925	$ 20,307
72	$ 387,543	$ 2,374,840	$ 16,311				$ 2,778,693	$ 19,641
73	$ 399,169	$ 2,446,085					$ 2,845,254	$ 18,775
74	$ 411,144	$ 2,519,468	$ 17,304				$ 2,947,915	$ 18,159
75	$ 423,478	$ 2,595,052					$ 3,018,530	$ 17,358
						TOTAL COST:		**$ 73,672,000**

Appendix Table 2a

High-Level Fixed Span Bridge Alternative Conceptual Cost Estimate

ITEM	UNIT MEASURE	QUANTITY	UNIT COST	COST
Direct Construction Cost				
Structural				
Removal of Existing Structures				**$ 1,999,000**
Removal of Bascule Spans	SF	12,000	$ 50	$ 600,000
Removal of Steel Trusses from Truss Approach Spans	SF	16,900	$ 40	$ 676,000
Demolition of Concrete Approach Spans	SF	24,125	$ 25	$ 603,125
Demolition of Approach Fill and Retaining Walls	SF	12,000	$ 10	$ 120,000
Substructure		150,184	$ 73	**$ 10,919,000**
Shafts				***$ 8,895,000***
Soil Excavation For Shaft Incl. Haul	CY	9,774	$ 450	$ 4,398,230
Furnishing & Placing Temp. Casing For 10 Ft Diam. Shaft	LF	3,360	$ 200	$ 672,000
Furnishing Permanent Casing For 10 Ft Diam. Shaft	LF	3,360	$ 350	$ 1,176,000
Placing Permanent Casing For 10 Ft Diam. Shaft	EA	42	$ 1,250	$ 52,500
Conc. Class 4000p For Shaft	CY	9,774	$ 180	$ 1,759,292
St. Reinf. Bar For Shaft (Assume ~1.2%)	LB	1,553,060	$ 0.50	$ 776,530
CSL Access Tube (6 for each shaft)	LF	20,160	$ 3.00	$ 60,480
Columns and Pier Caps				***$ 2,024,000***
Conc. Class 4000 For 6' Columns	CY	2,199	$ 400	$ 879,646
St. Reinf. Bar For Columns (Use ~2%)	LB	582,397	$ 0.60	$ 349,438
Conc. Class 4000 For Pier Caps	CY	1,371	$ 400	$ 548,267
St. Reinf. Bar For Caps (300lbs/cy)	LB	411,200	$ 0.60	$ 246,720
Superstructure				**$ 5,704,000**
Girders				***$ 2,431,000***
W83G Girders	LF	18,700	$ 130	$ 2,431,000
Deck				***$ 2,500,000***
Concrete Class 4000D	CY	3,476	$ 500	$ 1,738,245
St. Reinf. Bar, Epoxy Coated (160lbs/cy)	LB	556,238	$ 0.75	$ 417,179
St. Reinf. Bar (180lbs/cy)	LB	625,768	$ 0.55	$ 344,173
Diaphragms				***$ 113,871***
Conc. Class 4000	CY	196	$ 400	$ 78,532
St. Reinf. Bar For Caps (300lbs/cy)	LB	58,899	$ 0.60	$ 35,339
Expansion Joint				***$ 25,700***
Expansion Joint	LF	257	$ 100	$ 25,700
Bearing Placement				***$ 192,000***
Bearing Placement	EA	64	$ 3,000	$ 192,000
Traffic Barriers				***$ 441,788***
Traffic Barriers	LF	7,013	$ 63	$ 441,788
Approach				**$ 934,389**
Approach Fill	SF	64,250	$ 10.0	$ 643,000
MSE Walls	SF	11,000	$ 20.0	$ 220,000
ACP Pavement	SY	2,380	$ 30.0	$ 71,389
Soil Improvement				**$ 960,000**
Earthquake Drain System	LS		$ -	$ 960,000
Pier Protection				**$ 1,500,000**
Pier Protection	each		$ 750,000	$ 1,500,000
Temporary Construction Platform				**$ 1,200,000**
	SF	1115	$ 100	$ 1,200,000
Utilities (TBD)				**$ 250,000**
	LS			$ 250,000
Testing and Disposal of Contaminated Waste (TBD)				**$ 1,400,000**
	CY			$ 1,400,000
Illumination				**$ 50,000**
	LS		$ 50,000	$ 50,000
A. Summary of Direct Construction Cost				**$ 24,916,000**

Appendix Table 2a
High-Level Fixed Span Bridge Alternative Conceptual Cost Estimate

B.	**Construction Contingency (25% of A, also includes pavement, traffic revision, drainage and signalization)**	**$**	**6,229,000**
	Construction Related cost		
	Staging/Detours/Mitigation	$	9,808,000
	Mobilization (10%)	$	2,622,000
C.	**Summary of Construction Related Cost**	**$**	**12,430,000**
	Engineering cost		
	Construction Support & Administration (18%)	$	6,314,000
	PS&E Design (15%)	$	5,261,000
D.	**Summary of Engineering Cost**	**$**	**11,575,000**
E.	**Right of Way**	**$**	**15,310,000**

Appendix Table 2b

High-Level Fixed Span Bridge Alternative Life Cycle Cost Estimate

Parameters for present value cost analysis

i =	*0.04*	*(Real discount rate)*
f =	*0.03*	*(Projected inflation rate)*
i_r =	0.0712	*(Nominal discount rate)*
n =	*75*	*years*

Conceptual Maintenance Cost

ITEM	*UNIT MEASURE*	*QUANTITY*		*UNIT COST*		*COST*	
Maintenance, (2 person, 16 hrs/month)	*Hrs*	*192*	*$*	*60.00*	*$*	*11,520*	*per year*
Maintenance Materials	*Months*	*12*	*$*	*2,000.00*	*$*	*24,000*	*per year*
Repair LMC Wearing Surface	*SF*	*150,184*	*$*	*15.00*	*$*	*2,252,766*	*every 20 years*
Repair ACP Wearing Surface	*SY*	*1,428*	*$*	*30.00*	*$*	*42,833*	*every 10 years*
Routine Inspection					*$*	*2,000*	*every 2 years*

Project Total Cost (2003 Dollar)	***$***	***70,460,000***
Project Total Cost (2008 Dollar)	***$***	***81,682,451***
PRESENT VALUE OF LIFE CYCLE COST (2003 Dollar):	**$**	**73,094,000**
PRESENT VALUE OF LIFE CYCLE COST (2008 Dollar):	**$**	**84,735,979**

Appendix Table 2b
High-Level Fixed-Span Bridge Alternative Life Cycle Cost Estimate

			Periodic Costs			
Year	Total Capitol Cost	Routine Maintenance	Inspection	Wearing Surface	Annual Total	Present Value
0	$ 70,460,000				$ 70,460,000	$ 70,460,000
1		$ 35,520			$ 35,520	$ 33,159
2		$ 36,586	$ 2,060		$ 38,646	$ 33,679
3		$ 37,683			$ 37,683	$ 30,657
4		$ 38,814	$ 2,185		$ 40,999	$ 31,138
5		$ 39,978			$ 39,978	$ 28,345
6		$ 41,177	$ 2,319		$ 43,496	$ 28,789
7		$ 42,413			$ 42,413	$ 26,206
8		$ 43,685	$ 2,460		$ 46,145	$ 26,617
9		$ 44,996			$ 44,996	$ 24,229
10		$ 46,346	$ 2,610	$ 57,564	$ 106,520	$ 53,546
11		$ 47,736			$ 47,736	$ 22,401
12		$ 49,168	$ 2,768		$ 51,936	$ 22,752
13		$ 50,643			$ 50,643	$ 20,711
14		$ 52,162	$ 2,937		$ 55,099	$ 21,036
15		$ 53,727			$ 53,727	$ 19,149
16		$ 55,339	$ 3,116		$ 58,455	$ 19,449
17		$ 56,999			$ 56,999	$ 17,704
18		$ 58,709	$ 3,306		$ 62,015	$ 17,981
19		$ 60,470			$ 60,470	$ 16,368
20		$ 62,285	$ 3,507	$ 4,146,107	$ 4,211,899	$ 1,064,306
21		$ 64,153			$ 64,153	$ 15,133
22		$ 66,078	$ 3,721		$ 69,798	$ 15,371
23		$ 68,060			$ 68,060	$ 13,992
24		$ 70,102	$ 3,947		$ 74,049	$ 14,211
25		$ 72,205			$ 72,205	$ 12,936
26		$ 74,371	$ 4,188		$ 78,559	$ 13,139
27		$ 76,602			$ 76,602	$ 11,960
28		$ 78,900	$ 4,443		$ 83,343	$ 12,148
29		$ 81,267			$ 81,267	$ 11,058
30		$ 83,705	$ 4,713	$ 103,968	$ 192,386	$ 24,437
31		$ 86,216			$ 86,216	$ 10,224
32		$ 88,803	$ 5,000		$ 93,803	$ 10,384
33		$ 91,467			$ 91,467	$ 9,452
34		$ 94,211	$ 5,305		$ 99,516	$ 9,600
35		$ 97,037			$ 97,037	$ 8,739
36		$ 99,948	$ 5,628		$ 105,576	$ 8,876
37		$ 102,947			$ 102,947	$ 8,080
38		$ 106,035	$ 5,970		$ 112,006	$ 8,207
39		$ 109,216			$ 109,216	$ 7,470
40		$ 112,493	$ 6,334	$ 7,488,331	$ 7,607,157	$ 485,735
41		$ 115,868			$ 115,868	$ 6,907
42		$ 119,344	$ 6,720		$ 126,063	$ 7,015
43		$ 122,924			$ 122,924	$ 6,386
44		$ 126,612	$ 7,129		$ 133,741	$ 6,486
45		$ 130,410			$ 130,410	$ 5,904
46		$ 134,322	$ 7,563		$ 141,885	$ 5,996
47		$ 138,352			$ 138,352	$ 5,458
48		$ 142,503	$ 8,024		$ 150,526	$ 5,544
49		$ 146,778			$ 146,778	$ 5,047
50		$ 151,181	$ 8,512	$ 187,777	$ 347,471	$ 11,153
51		$ 155,716			$ 155,716	$ 4,666
52		$ 160,388	$ 9,031		$ 169,419	$ 4,739
53		$ 165,199			$ 165,199	$ 4,314
54		$ 170,155	$ 9,581		$ 179,736	$ 4,382
55		$ 175,260			$ 175,260	$ 3,988
56		$ 180,518	$ 10,164		$ 190,682	$ 4,051
57		$ 185,933			$ 185,933	$ 3,688
58		$ 191,511	$ 10,783		$ 202,295	$ 3,745
59		$ 197,257			$ 197,257	$ 3,409
60		$ 203,175	$ 11,440	$ 13,524,758	$ 13,739,372	$ 221,683
61		$ 209,270			$ 209,270	$ 3,152
62		$ 215,548	$ 12,137		$ 227,685	$ 3,202
63		$ 222,014			$ 222,014	$ 2,914
64		$ 228,675	$ 12,876		$ 241,551	$ 2,960
65		$ 235,535			$ 235,535	$ 2,694
66		$ 242,601	$ 13,660		$ 256,261	$ 2,737
67		$ 249,879			$ 249,879	$ 2,491
68		$ 257,375	$ 14,492		$ 271,867	$ 2,530
69		$ 265,097			$ 265,097	$ 2,303
70		$ 273,050	$ 15,374	$ 339,147	$ 627,571	$ 5,090
71		$ 281,241			$ 281,241	$ 2,129
72		$ 289,678			$ 289,678	$ 2,048
73		$ 298,369			$ 298,369	$ 1,969
74		$ 307,320			$ 307,320	$ 1,893
75		$ 316,539			$ 316,539	$ 1,820
				TOTAL COST:		**$ 73,094,000**

Appendix Table 3a

Mid-Level Fixed Span Bridge Alternative Conceptual Cost Estimate

ITEM	UNIT MEASURE	QUANTITY	UNIT COST	COST
Direct Construction Cost				
Structural				
Removal of Existing Structures				**$ 1,999,000**
Removal of Bascule Spans	SF	12,000	$ 50	$ 600,000
Removal of Steel Trusses from Truss Approach Spans	SF	16,900	$ 40	$ 676,000
Demolition of Concrete Approach Spans	SF	24,125	$ 25	$ 603,125
Demolition of Approach Fill and Retaining Walls	SF	12,000	$ 10	$ 120,000
Substructure				**$ 7,425,000**
Shafts				***$ 6,131,000***
Soil Excavation For Shaft Incl. Haul	CY	6,749	$ 450	$ 3,036,873
Furnishing & Placing Temp. Casing For 10 Ft Diam. Shaft	LF	2,320	$ 200	$ 464,000
Furnishing Permanent Casing For 10 Ft Diam. Shaft	LF	2,320	$ 350	$ 812,000
Placing Permanent Casing For 10 Ft Diam. Shaft	EA	20	$ 1,250	$ 25,000
Conc. Class 4000p For Shaft	CY	6,749	$ 180	$ 1,214,749
St. Reinf. Bar For Shaft (Assume ~1.2%)	LB	1,072,351	$ 0.50	$ 536,175
CSL Access Tube (6 for each shaft)	LF	13,920	$ 3.00	$ 41,760
Columns and Pier Caps				***$ 1,294,000***
Conc. Class 4000 For 6' Columns (Pier 2)	CY	1,367	$ 400	$ 546,637
St. Reinf. Bar For Columns (Use ~2%)	LB	361,918	$ 0.60	$ 217,151
Conc. Class 4000 For Pier Caps	CY	914	$ 400	$ 365,511
St. Reinf. Bar For Caps (300lbs/cy)	LB	274,133	$ 0.60	$ 164,480
Superstructure				**$ 4,099,000**
Girders				***$ 1,727,000***
W83G Girders	LF	13,284	$ 130.0	$ 1,726,920
Deck				***$ 1,776,000***
Concrete Class 4000D	CY	2,470	$ 500	$ 1,234,805
St. Reinf. Bar, Epoxy Coated (160lbs/cy)	LB	395,138	$ 0.75	$ 296,353
St. Reinf. Bar (180lbs/cy)	LB	444,530	$ 0.55	$ 244,491
Diaphragms				***$ 112,126***
Conc. Class 4000	CY	193	$ 400	$ 77,328
St. Reinf. Bar For Caps (300lbs/cy)	LB	57,996	$ 0.60	$ 34,798
Expansion Joint				***$ 25,700***
Expansion Joint	LF	257	$ 100	$ 25,700
Bearing Placement				***$ 144,000***
Bearing Placement	EA	48	$ 3,000	$ 144,000
Traffic Barriers				***$ 313,835***
Traffic Barriers	LF	4,982	$ 63.0	$ 313,835
Approach				**$ 967,956**
Approach Fill	SF	71,960	$ 10.0	$ 720,000
MSE Walls	SF	8,400	$ 20.0	$ 168,000
ACP Pavement	SY	2,665	$ 30.0	$ 79,956
Soil Improvement				**$ 770,000**
Earthquake Drain System	LS		$ -	$ 770,000
Pier Protection				**$ 1,500,000**
Pier Protection	each		$ 750,000	$ 1,500,000
Temporary Construction Platform				**$ 1,200,000**
	SF	1115	$ 100	$ 1,200,000
Utilities (TBD)				**$ 250,000**
	LS			$ 250,000
Testing and Disposal of Contaminated Waste (TBD)				**$ 1,200,000**
	CY			$ 1,200,000
Pedestrian/Bike Facility				**$ 582,400**
	SF	7,280	$ 80.0	$ 582,400
Illumination				**$ 50,000**
	LS		$ 50,000	$ 50,000
A. Summary of Direct Construction Cost				**$ 20,043,000**

Appendix Table 3a

Mid-Level Fixed Span Bridge Alternative Conceptual Cost Estimate

B.	**Construction Contingency (25% of A, also includes pavement, traffic revision, drainage and signalization)**	**$**	**5,011,000**
	Construction Related cost		
	Staging/Detours/Mitigation	$	18,665,000
	Mobilization (10%)	$	2,111,000
C.	**Summary of Construction Related Cost**	**$**	**20,776,000**
	Engineering cost		
	Construction Support & Administration (18%)	$	5,081,000
	PS&E Design (15%)	$	4,235,000
D.	**Summary of Engineering Cost**	**$**	**9,316,000**
E.	**Right of Way**	**$**	**6,377,000**
	PROJECT TOTAL (A+B+C+D+E, 2003 Dollar)	**$**	**61,523,000**

Appendix Table 3b

Mid-Level Fixed Span Bridge Alternative Life Cycle Cost Estimate

Parameters for present value cost analysis

i =	*0.04*	*(Real discount rate)*
f =	*0.03*	*(Projected inflation rate)*
i_f =	0.0712	*(Nominal discount rate)*
n =	*75*	*years*

Conceptual Maintenance Cost

ITEM	*UNIT MEASURE*	*QUANTITY*	*UNIT COST*	*COST*	
Maintenance, (2 person, 16 hrs/month)	*Hrs*	*192*	*$ 60.00*	*$ 11,520*	*per year*
Maintenance Materials	*Months*	*12*	*$ 2,000.00*	*$ 24,000*	*per year*
Repair LMC Wearing Surface	*SF*	*106,687*	*$ 15.00*	*$ 1,600,307*	*every 20 years*
Repair ACP Wearing Surface	*SY*	*1,249*	*$ 30.00*	*$ 37,479*	*every 10 years*
Routine Inspection				*$ 2,000*	*every 2 years*

Project Total Cost (2003 Dollar)	***$***	***61,523,000***
Project Total Cost (2008 Dollar)	***$***	***71,322,019***
PRESENT VALUE OF LIFE CYCLE COST (2003 Dollar):	**$**	**63,651,000**
PRESENT VALUE OF LIFE CYCLE COST (2008 Dollar):	**$**	**73,788,954**

Appendix Table 3b
Mid-Level Fixed-Span Bridge Alternative Life Cycle Cost Estimate

		Periodic Costs				
Year	Total Capitol Cost	Routine Maintenance	Inspection	Wearing Surface	Annual Total	Present Value
0	$ 61,523,000				$ 61,523,000	$ 61,523,000
1		$ 35,520			$ 35,520	$ 33,159
2		$ 36,586	$ 2,060		$ 38,646	$ 33,679
3		$ 37,683			$ 37,683	$ 30,657
4		$ 38,814	$ 2,185		$ 40,999	$ 31,138
5		$ 39,978			$ 39,978	$ 28,345
6		$ 41,177	$ 2,319		$ 43,496	$ 28,789
7		$ 42,413			$ 42,413	$ 26,206
8		$ 43,685	$ 2,460		$ 46,145	$ 26,617
9		$ 44,996			$ 44,996	$ 24,229
10		$ 46,346	$ 2,610	$ 50,369	$ 99,324	$ 49,928
11		$ 47,736			$ 47,736	$ 22,401
12		$ 49,168	$ 2,768		$ 51,936	$ 22,752
13		$ 50,643			$ 50,643	$ 20,711
14		$ 52,162	$ 2,937		$ 55,099	$ 21,036
15		$ 53,727			$ 53,727	$ 19,149
16		$ 55,339	$ 3,116		$ 58,455	$ 19,449
17		$ 56,999			$ 56,999	$ 17,704
18		$ 58,709	$ 3,306		$ 62,015	$ 17,981
19		$ 60,470			$ 60,470	$ 16,368
20		$ 62,285	$ 3,507	$ 2,958,024	$ 3,023,815	$ 764,089
21		$ 64,153			$ 64,153	$ 15,133
22		$ 66,078	$ 3,721		$ 69,798	$ 15,371
23		$ 68,060			$ 68,060	$ 13,992
24		$ 70,102	$ 3,947		$ 74,049	$ 14,211
25		$ 72,205			$ 72,205	$ 12,936
26		$ 74,371	$ 4,188		$ 78,559	$ 13,139
27		$ 76,602			$ 76,602	$ 11,960
28		$ 78,900	$ 4,443		$ 83,343	$ 12,148
29		$ 81,267			$ 81,267	$ 11,058
30		$ 83,705	$ 4,713	$ 90,972	$ 179,390	$ 22,787
31		$ 86,216			$ 86,216	$ 10,224
32		$ 88,803	$ 5,000		$ 93,803	$ 10,384
33		$ 91,467			$ 91,467	$ 9,452
34		$ 94,211	$ 5,305		$ 99,516	$ 9,600
35		$ 97,037			$ 97,037	$ 8,739
36		$ 99,948	$ 5,628		$ 105,576	$ 8,876
37		$ 102,947			$ 102,947	$ 8,080
38		$ 106,035	$ 5,970		$ 112,006	$ 8,207
39		$ 109,216			$ 109,216	$ 7,470
40		$ 112,493	$ 6,334	$ 5,342,520	$ 5,461,347	$ 348,720
41		$ 115,868			$ 115,868	$ 6,907
42		$ 119,344	$ 6,720		$ 126,063	$ 7,015
43		$ 122,924			$ 122,924	$ 6,386
44		$ 126,612	$ 7,129		$ 133,741	$ 6,486
45		$ 130,410			$ 130,410	$ 5,904
46		$ 134,322	$ 7,563		$ 141,885	$ 5,996
47		$ 138,352			$ 138,352	$ 5,458
48		$ 142,503	$ 8,024		$ 150,526	$ 5,544
49		$ 146,778			$ 146,778	$ 5,047
50		$ 151,181	$ 8,512	$ 164,305	$ 323,998	$ 10,400
51		$ 155,716			$ 155,716	$ 4,666
52		$ 160,388	$ 9,031		$ 169,419	$ 4,739
53		$ 165,199			$ 165,199	$ 4,314
54		$ 170,155	$ 9,581		$ 179,736	$ 4,382
55		$ 175,260			$ 175,260	$ 3,988
56		$ 180,518	$ 10,164		$ 190,682	$ 4,051
57		$ 185,933			$ 185,933	$ 3,688
58		$ 191,511	$ 10,783		$ 202,295	$ 3,745
59		$ 197,257			$ 197,257	$ 3,409
60		$ 203,175	$ 11,440	$ 9,649,185	$ 9,863,800	$ 159,151
61		$ 209,270			$ 209,270	$ 3,152
62		$ 215,548	$ 12,137		$ 227,685	$ 3,202
63		$ 222,014			$ 222,014	$ 2,914
64		$ 228,675	$ 12,876		$ 241,551	$ 2,960
65		$ 235,535			$ 235,535	$ 2,694
66		$ 242,601	$ 13,660		$ 256,261	$ 2,737
67		$ 249,879			$ 249,879	$ 2,491
68		$ 257,375	$ 14,492		$ 271,867	$ 2,530
69		$ 265,097			$ 265,097	$ 2,303
70		$ 273,050	$ 15,374	$ 296,753	$ 585,177	$ 4,746
71		$ 281,241			$ 281,241	$ 2,129
72		$ 289,678			$ 289,678	$ 2,048
73		$ 298,369			$ 298,369	$ 1,969
74		$ 307,320			$ 307,320	$ 1,893
75		$ 316,539			$ 316,539	$ 1,820
				TOTAL COST:		**$ 63,651,000**

Appendix Table 4a

Bascule Bridge Alternative Conceptual Cost Estimate

ITEM	UNIT MEASURE	QUANTITY	UNIT COST	COST
Direct Construction Cost				
Structural				
Removal of Existing Structures				**$ 1,999,000**
Removal of Bascule Spans	SF	12,000	$ 50	$ 600,000
Removal of Steel Trusses from Truss Approach Spans	SF	16,900	$ 40	$ 676,000
Demolition of Concrete Approach Spans	SF	24,125	$ 25	$ 603,125
Demolition of Approach Fill and Retaining Walls	SF	12,000	$ 10	$ 120,000
Bascule Spans				**$ 16,563,000**
Substructure				**$ 11,509,000**
Shafts and Footings				***$ 8,918,000***
Soil Excavation For Footings Incl. Haul	CY	9,312	$ 50	$ 465,586
Coffer Dam	SF	54,272	$ 30	$ 1,628,160
Soil Excavation For Shaft Incl. Haul	CY	6,981	$ 450	$ 3,141,593
Furnishing & Placing Temp. Casing For 10 Ft Diam. Shaft	LF	2,400	$ 200	$ 480,000
Furnishing Permanent Casing For 10 Ft Diam. Shaft	LF	240	$ 350	$ 84,000
Placing Permanent Casing For 10 Ft Diam. Shaft	EA	24	$ 1,250	$ 30,000
Conc. Class 4000p For Shaft	CY	6,981	$ 180	$ 1,256,637
St. Reinf. Bar For Shaft (1.2%)	LB	1,109,328	$ 0.50	$ 554,664
Conc. Class 4000 For Footing	CY	2,290	$ 400	$ 915,956
St. Reinf. Bar For Footing (200 lbs per Cubic Yard)	LB	457,978	$ 0.60	$ 274,787
CSL Access Tube	LF	28,800	$ 3.0	$ 86,400
Pier Substructure, Machine Room and Control House				***$ 2,591,000***
Concrete Class 4000	CY	4,037	$ 400	$ 1,614,720
St. Reinf. Bar (300lbs/cy)	LB	1,211,040	$ 0.6	$ 726,624
FRP - Pier Caps and Control Houses	LS		$ 150,000	$ 150,000
Interior Finishes for Control Tower	LS		$ 100,000	$ 100,000
Superstructure				**$ 5,054,214**
Bascule Leaves				***$ 4,034,000***
Structural Steel	LB	2,528,064	$ 1.20	$ 3,033,677
Counter Weight	EA	1	$ 1,000,000	$ 1,000,000
Bascule Span Deck				***$ 932,000***
Exodermic Deck	SF	21,679	$ 43.00	$ 932,197
Traffic Barriers				***$ 61,614***
Traffic Barriers	LF	978	$ 63.0	$ 61,614
Expansion Joint				***$ 26,600***
Expansion Joint	LF	266	$ 100	$ 26,600
Concrete Approaches				**$ 5,202,000**
Substructure				**$ 3,565,000**
Shafts				***$ 3,315,000***
Soil Excavation For Shaft Incl. Haul	CY	2,793	$ 450	$ 1,256,637
Furnishing & Placing Temp. Casing For 10 Ft Diam. Shaft	LF	960	$ 200	$ 192,000
Furnishing Permanent Casing For 10 Ft Diam. Shaft	LF	960	$ 350	$ 336,000
Placing Permanent Casing For 10 Ft Diam. Shaft	EA	12	$ 1,250	$ 15,000
Conc. Class 4000p For Shaft	CY	2,793	$ 180	$ 502,655
St. Reinf. Bar For Shaft (Assume ~1.2%)	LB	443,731	$ 0.50	$ 221,866
Soil Excavation For Shaft Incl. Haul	CY	628	$ 450	$ 282,743
Furnishing & Placing Temp. Casing For 6 Ft Diam. Shaft	LF	600	$ 200	$ 120,000
Furnishing Permanent Casing For 6 Ft Diam. Shaft	LF	600	$ 350	$ 210,000
Placing Permanent Casing For 6 Ft Diam. Shaft	EA	12	$ 1,250	$ 15,000
Conc. Class 4000p For Shaft	CY	628	$ 180	$ 113,097
St. Reinf. Bar For Shaft (Assume ~1.2%)	LB	99,840	$ 0.50	$ 49,920
CSL Access Tube (6 for each shaft)	LF	72	$ 3.00	$ 216
Columns and Pier Caps				***$ 250,000***
Conc. Class 4000 For 8' Columns	CY	201	$ 400	$ 80,425
St. Reinf. Bar For Columns (Use ~2%)	LB	53,248	$ 0.60	$ 31,949
Conc. Class 4000 For Pier Caps	CY	236	$ 400	$ 94,578
St. Reinf. Bar For Caps (300lbs/cy)	LB	70,933	$ 0.60	$ 42,560

Appendix Table 4a

Bascule Bridge Alternative Conceptual Cost Estimate

	ITEM	UNIT MEASURE	QUANTITY	UNIT COST	COST
	Superstructure				**$ 1,637,000**
	Girders				***$ 633,000***
	W83G Girders	LF	4,868	$ 130.0	$ 632,840
	Deck				***$ 673,000***
	Concrete Class 4000D	CY	937	$ 500	$ 468,348
	St. Reinf. Bar, Epoxy Coated (160lbs/cy)	LB	149,871	$ 0.75	$ 112,403
	St. Reinf. Bar (180lbs/cy)	LB	168,605	$ 0.55	$ 92,733
	Diaphragms				***$ 46,149***
	Conc. Class 4000	CY	80	$ 400	$ 31,827
	St. Reinf. Bar For Caps (300lbs/cy)	LB	23,870	$ 0.60	$ 14,322
	End Diaphragms				***$ 45,713***
	Conc. Class 4000	CY	79	$ 400	$ 31,526
	St. Reinf. Bar For Caps (300lbs/cy)	LB	23,644	$ 0.60	$ 14,187
	Expansion Joint				***$ 26,600***
	Expansion Joint	LF	266	$ 100	$ 26,600
	Bearing Placement				***$ 144,000***
	Bearing Placement	EA	48	$ 3,000	$ 144,000
	Traffic Barriers				***$ 115,007***
	Traffic Barriers	LF	1,826	$ 63.0	$ 115,007
	Approach Fill and Retaining Walls				**$ 289,000**
	MSE Walls - South End	SF	4,110	$ 20	$ 82,200
	MSE Walls - North End	SF	4,800	$ 21	$ 100,800
	Approach Fill	CY	5,911	$ 10	$ 59,111
	ACP Pavement	SF	1,547	$ 30	$ 46,403
	Soil Improvement				**$ 540,000**
	Earthquake Drain System	LS		$ -	$ 540,000
	Pier Protection				**$ 1,500,000**
	Pier Protection	EA		$ 750,000	$ 1,500,000
	Temporary Construction Platform				**$ 1,200,000**
		SF	1115	$ 100	$ 1,200,000
	Utilities				**$ 250,000**
		LS			$ 250,000
	Testing and Disposal of Contaminated Waste				**$ 2,000,000**
		LS			$ 2,000,000
	Mechanical & Electrical				**$ 9,570,000**
	Electrical				***$ 2,570,000***
	Electrical Control System	LS		$ 500,000	$ 500,000
	SCR Drives	EA	4	$ 100,000	$ 400,000
	Bridge Control Desk and Panels	LS		$ 225,000	$ 225,000
	DC Motors	EA	4	$ 50,000	$ 200,000
	Traffic Gates	EA	4	$ 30,000	$ 120,000
	Traffic Signals	EA	2	$ 25,000	$ 50,000
	House Lights and Receptacles	LS		$ 25,000	$ 25,000
	Emergency Generator	LS		$ 100,000	$ 100,000
	Illumination	LS		$ 50,000	$ 50,000
	Submarine Cable	LS		$ 400,000	$ 400,000
	Misc.	LS		$ 500,000	$ 500,000
	Mechanical				***$ 7,000,000***
	Machinary Cost (Speed Reducer, Span Lock, Mech Casing, Finger Joint etc)	LS			$ 7,000,000
A.	**Summary of Direct Construction Cost**				**$ 39,113,000**
B.	**Construction Contingency (25% of A, also includes pavement, traffic revision, drainage and signalization)**				**$ 9,778,000**
	Construction Related cost				
	Staging/Detours/Mitigation				$ 2,518,000
	Mobilization (10%)				$ 4,113,000
C.	**Summary of Construction Related Cost**				**$ 6,631,000**
	Engineering cost				
	Construction Support & Administration (18%)				$ 9,904,000
	PS&E Design (15%)				$ 8,253,000
D.	**Summary of Engineering Cost**				**$ 18,157,000**
E.	**Right of Way**				**$ 3,655,000**
	PROJECT TOTAL (A+B+C+D+E, 2003 Dollar)				**$ 77,334,000**

Appendix Table 4b

Bascule Bridge Alternative Life Cycle Cost Estimate

Parameters for present value cost analysis

i =	*0.04*	*(Real discount rate)*
f =	*0.03*	*(Projected inflation rate)*
i_f =	0.0712	*(Nominal discount rate)*
n =	*75*	*years*

Conceptual Operation and Maintenance Cost

ITEM	*UNIT MEASURE*	*QUANTITY*	*UNIT COST*	*COST (2003 dollars)*	
Operating Cost					
Operation Supervisor (1 person, 40hrs/week)	*Hrs*	*2,080*	*$ 40.00*	*$ 83,200*	*per year*
Operators (5 people, 200hrs/week)	*Hrs*	*2,080*	*$ 20.00*	*$ 208,000*	*per year*
Maintenance Cost					
Maintenance, (2 person, 16 hrs/month)	*Hrs*	*192*	*$ 60.00*	*$ 11,520*	*per year*
Maintenance Materials & Utilities	*Months*	*12*	*$ 2,000.00*	*$ 24,000*	*per year*
Repainting Steel Members	*LB*	*2,496,000*	*$ 0.75*	*$ 1,872,000*	*every 20 years*
Repair LMC Wearing Surface	*SF*	*44,840*	*$ 15.00*	*$ 672,600*	*every 20 years*
Repair ACP Wearing Surface	*SY*	*929*	*$ 30.00*	*$ 27,867*	*every 10 years*
Routine Inspection				*$ 2,000*	*every 2 years*
Replace Motor Control Centers	*EA*	*2*	$ 40,000	*$ 80,000*	*every 35 years*
Replace SCR Drives	*EA*	*4*	$ 70,000	*$ 280,000*	*every 35 years*
Replace DC Motors	*EA*	*4*	$ 50,000	*$ 200,000*	*every 35 years*
Replace Mechanical Parts	*EA*	*1*	*$ 400,000*	*$ 400,000*	*every 35 years*

Project Total Cost (2003 Dollar)	***$***	***77,334,000***
Project Total Cost (2008 Dollar)	***$***	***89,651,301***
PRESENT VALUE OF LIFE CYCLE COST (2003 Dollar):	**$**	**87,160,000**
PRESENT VALUE OF LIFE CYCLE COST (2008 Dollar):	**$**	**101,042,328**

Appendix Table 4b
Bascule Bridge Alternative Life Cycle Cost Estimate

				Periodic Costs				
Year	Routine Maintenance	Operating Cost	Inspection	Painting	Wearing Surface	Mechanical & Electrical	Annual Total	Present Value
0	***Total Capital Cost***						$ 77,334,000	$ 77,334,000
1	$ 35,520	$ 291,200					$ 326,720	$ 305,004
2	$ 36,586	$ 299,936	$ 2,060				$ 338,582	$ 295,068
3	$ 37,683	$ 308,934					$ 346,617	$ 281,993
4	$ 38,814	$ 318,202	$ 2,185				$ 359,201	$ 272,807
5	$ 39,978	$ 327,748					$ 367,726	$ 260,718
6	$ 41,177	$ 337,581	$ 2,319				$ 381,077	$ 252,225
7	$ 42,413	$ 347,708					$ 390,121	$ 241,049
8	$ 43,685	$ 358,139	$ 2,460				$ 404,284	$ 233,197
9	$ 44,996	$ 368,883					$ 413,879	$ 222,863
10	$ 46,346	$ 379,950	$ 2,610		$ 37,450		$ 466,356	$ 234,429
11	$ 47,736	$ 391,348					$ 439,084	$ 206,050
12	$ 49,168	$ 403,089	$ 2,768				$ 455,025	$ 199,337
13	$ 50,643	$ 415,182					$ 465,825	$ 190,504
14	$ 52,162	$ 427,637	$ 2,937				$ 482,736	$ 184,299
15	$ 53,727	$ 440,466					$ 494,193	$ 176,132
16	$ 55,339	$ 453,680	$ 3,116				$ 512,135	$ 170,394
17	$ 56,999	$ 467,291					$ 524,290	$ 162,844
18	$ 58,709	$ 481,309	$ 3,306				$ 543,324	$ 157,539
19	$ 60,470	$ 495,749					$ 556,219	$ 150,558
20	$ 62,285	$ 510,621	$ 3,507	$ 3,381,040	$ 1,265,121		$ 5,222,573	$ 1,319,694
21	$ 64,153	$ 525,940					$ 590,093	$ 139,200
22	$ 66,078	$ 541,718	$ 3,721				$ 611,516	$ 134,665
23	$ 68,060	$ 557,969					$ 626,029	$ 128,698
24	$ 70,102	$ 574,708	$ 3,947				$ 648,757	$ 124,506
25	$ 72,205	$ 591,950					$ 664,154	$ 118,989
26	$ 74,371	$ 609,708	$ 4,188				$ 688,267	$ 115,112
27	$ 76,602	$ 627,999					$ 704,601	$ 110,012
28	$ 78,900	$ 646,839	$ 4,443				$ 730,182	$ 106,428
29	$ 81,267	$ 666,245					$ 747,512	$ 101,712
30	$ 83,705	$ 686,232	$ 4,713		$ 67,640		$ 842,290	$ 106,990
31	$ 86,216	$ 706,819					$ 793,035	$ 94,038
32	$ 88,803	$ 728,023	$ 5,000				$ 821,826	$ 90,975
33	$ 91,467	$ 749,864					$ 841,331	$ 86,944
34	$ 94,211	$ 772,360	$ 5,305				$ 871,876	$ 84,111
35	$ 97,037	$ 795,531				$ 2,701,308	$ 3,593,876	$ 323,663
36	$ 99,948	$ 819,397	$ 5,628				$ 924,973	$ 77,766
37	$ 102,947	$ 843,979					$ 946,925	$ 74,320
38	$ 106,035	$ 869,298	$ 5,970				$ 981,304	$ 71,899
39	$ 109,216	$ 895,377					$ 1,004,593	$ 68,713
40	$ 112,493	$ 922,238	$ 6,334	$ 6,106,535	$ 2,284,949		$ 9,432,549	$ 602,291
41	$ 115,868	$ 949,905					$ 1,065,773	$ 63,529
42	$ 119,344	$ 978,403	$ 6,720				$ 1,104,466	$ 61,459
43	$ 122,924	$ 1,007,755					$ 1,130,679	$ 58,736
44	$ 126,612	$ 1,037,987	$ 7,129				$ 1,171,728	$ 56,823
45	$ 130,410	$ 1,069,127					$ 1,199,537	$ 54,305
46	$ 134,322	$ 1,101,201	$ 7,563				$ 1,243,086	$ 52,536
47	$ 138,352	$ 1,134,237					$ 1,272,589	$ 50,208
48	$ 142,503	$ 1,168,264	$ 8,024				$ 1,318,790	$ 48,572
49	$ 146,778	$ 1,203,312					$ 1,350,089	$ 46,420
50	$ 151,181	$ 1,239,411	$ 8,512		$ 122,165		$ 1,521,269	$ 48,829
51	$ 155,716	$ 1,276,593					$ 1,432,310	$ 42,918
52	$ 160,388	$ 1,314,891	$ 9,031				$ 1,484,310	$ 41,520
53	$ 165,199	$ 1,354,338					$ 1,519,537	$ 39,680
54	$ 170,155	$ 1,394,968	$ 9,581				$ 1,574,704	$ 38,387
55	$ 175,260	$ 1,436,817					$ 1,612,077	$ 36,686
56	$ 180,518	$ 1,479,922	$ 10,164				$ 1,670,604	$ 35,491
57	$ 185,933	$ 1,524,319					$ 1,710,253	$ 33,919
58	$ 191,511	$ 1,570,049	$ 10,783				$ 1,772,344	$ 32,814
59	$ 197,257	$ 1,617,150					$ 1,814,407	$ 31,360
60	$ 203,175	$ 1,665,665	$ 11,440	$ 11,029,081	$ 4,126,872		$ 17,036,232	$ 274,878
61	$ 209,270	$ 1,715,635					$ 1,924,905	$ 28,994
62	$ 215,548	$ 1,767,104	$ 12,137				$ 1,994,788	$ 28,049
63	$ 222,014	$ 1,820,117					$ 2,042,131	$ 26,806
64	$ 228,675	$ 1,874,720	$ 12,876				$ 2,116,271	$ 25,933
65	$ 235,535	$ 1,930,962					$ 2,166,497	$ 24,784
66	$ 242,601	$ 1,988,891	$ 13,660				$ 2,245,152	$ 23,977
67	$ 249,879	$ 2,048,558					$ 2,298,437	$ 22,914
68	$ 257,375	$ 2,110,014	$ 14,492				$ 2,381,882	$ 22,168
69	$ 265,097	$ 2,173,315					$ 2,438,412	$ 21,185
70	$ 273,050	$ 2,238,514	$ 15,374		$ 220,643	$ 7,601,109	$ 10,348,691	$ 83,936
71	$ 281,241	$ 2,305,670					$ 2,586,911	$ 19,587
72	$ 289,678	$ 2,374,840					$ 2,664,518	$ 18,834
73	$ 298,369	$ 2,446,085					$ 2,744,454	$ 18,109
74	$ 307,320	$ 2,519,468					$ 2,826,787	$ 17,413
75	$ 316,539	$ 2,595,052					$ 2,911,591	$ 16,743
						TOTAL COST:		**$ 87,160,000**