

Appendix P

Structural Engineering Criteria

Date: December 2022 By: SL, AB BEI No. _____ Sheet No. 1 of 20 Sheets
Subject: Engineering Services for Sediment Cleanup of Upper Reach of Lower Duwamish Waterway

A - DESIGN CRITERIA AND GENERAL INFORMATION

Relevant Codes and Standards

AISC Steel Construction Manual, Fifteenth Edition, 2017

ASCE/ SEI 7-18 Minimum Design Loads for Building and Other Structures

AWS D1.1/D1.1M: 2020 Structural Welding Code-Steel

IBC (International Building Code), 2018

SBC (Seattle Building Code), 2018

B - MATERIAL PROPERTIES

Structural steel

Wide flange shapes: ASTM A572 or ASTM A992, Grade 50, unless otherwise noted.

Tees, channels, angels, plates & bars: ASTM A36, unless otherwise noted.

Pipe Piles: ASTM A252, Grade 3 (Mod), $f_y = 50\text{ksi}$

Sheet Piles: ASTM A572, Grade 50, $f_y = 50\text{ksi}$ (Type PZ)

Welding: 70XX Electrodes

Tieback Anchor

7-Wire low relaxation prestressing steel strand: ASTM A 416, Grade 270, $f'_s = 270\text{ksi}$

Double corrosion protection for permanent anchors

C – SEISMIC LOADS

Longitude 47.5222, Latitude -122.306

PGA = 0.41 (475 years return period – magnitude 7.0 Richter scale)

Site Class: D/E

D – WIND LOADS

Wind Speed = 115 mph (ultimate)

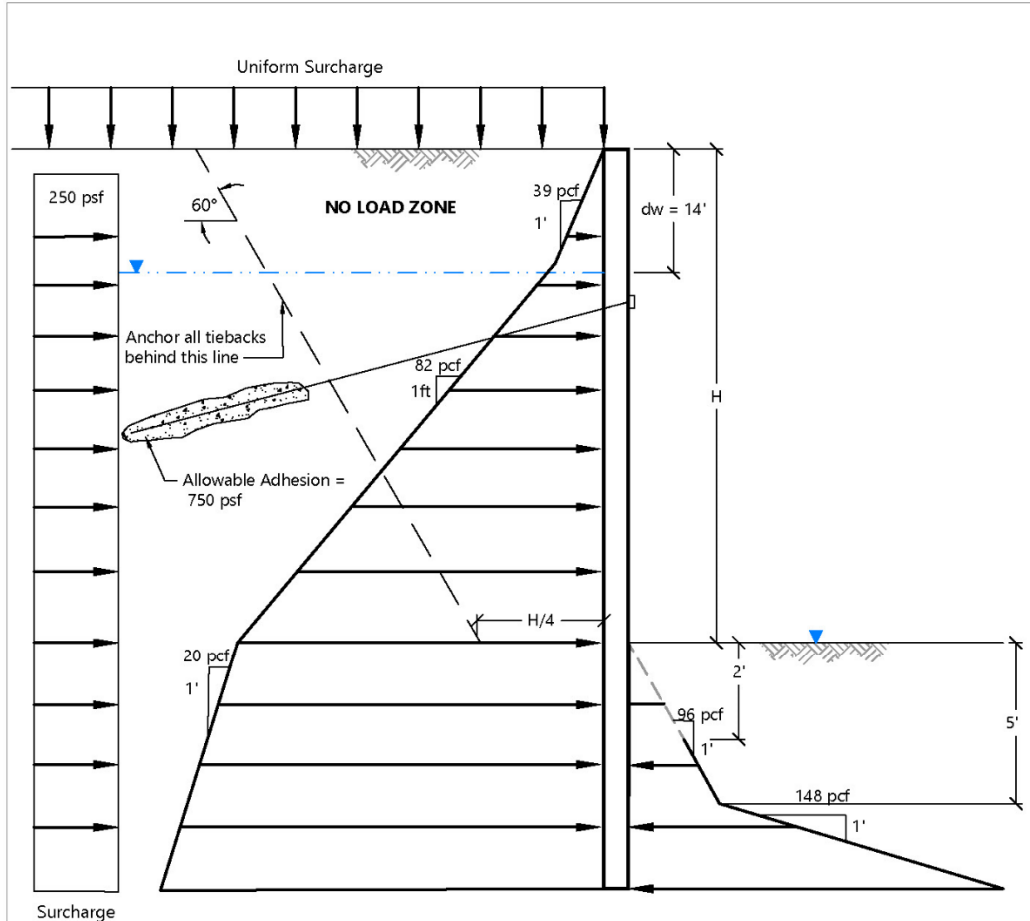
Exposure = D

Importance Factor = 1.0

E - FOUNDATION

1. Retaining Walls

Design Soil Lateral Pressures



Not to Scale

NOTES:

1. Yielding walls are those walls that will deform at least 0.001 times the height of the wall.
2. Passive pressures are Ultimate values and do not include a factor of safety. We recommend applying a factor of safety of at least 1.5 when computing static passive pressures.
3. Ignore the contribution of the upper 2 feet of soil at the base of the wall when computing passive pressures.
4. Active and at-rest earth pressures are for cantilever walls or walls supported by a single row of tiebacks.

Passive Earth Pressure Reduction Factors			
Offset Distance	Reduction Factor		
	2H:1V	1.5H:1V	1H:1V
0	0.75	0.56	0.38
2	0.85	0.66	0.48
4	0.95	0.76	0.58

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Additional Design Soil Lateral Pressures Notes:

- a) Diagram applies to drilled soldier pile walls with lagging and sheet pile walls designed as a cantilevered wall or with a single row of tieback.
- b) All pressures expressed as an equivalent fluid unit weight
- c) Active earth and surcharge pressures act over the pile spacing within retained wall height and over pile width or shaft diameter below bottom of excavation, whichever is lesser.
- d) Passive resistance are ultimate values. Divide with a safety factor of 1.5 for allowable values.
- e) Passive earth pressure acts over **3** times shaft diameter or pile width; or pile spacing, whichever is lesser.
- f) 50% of active surcharge pressure act on all lagging between soldier piles.

2. Single Piles

L-PILE Modeling Parameters

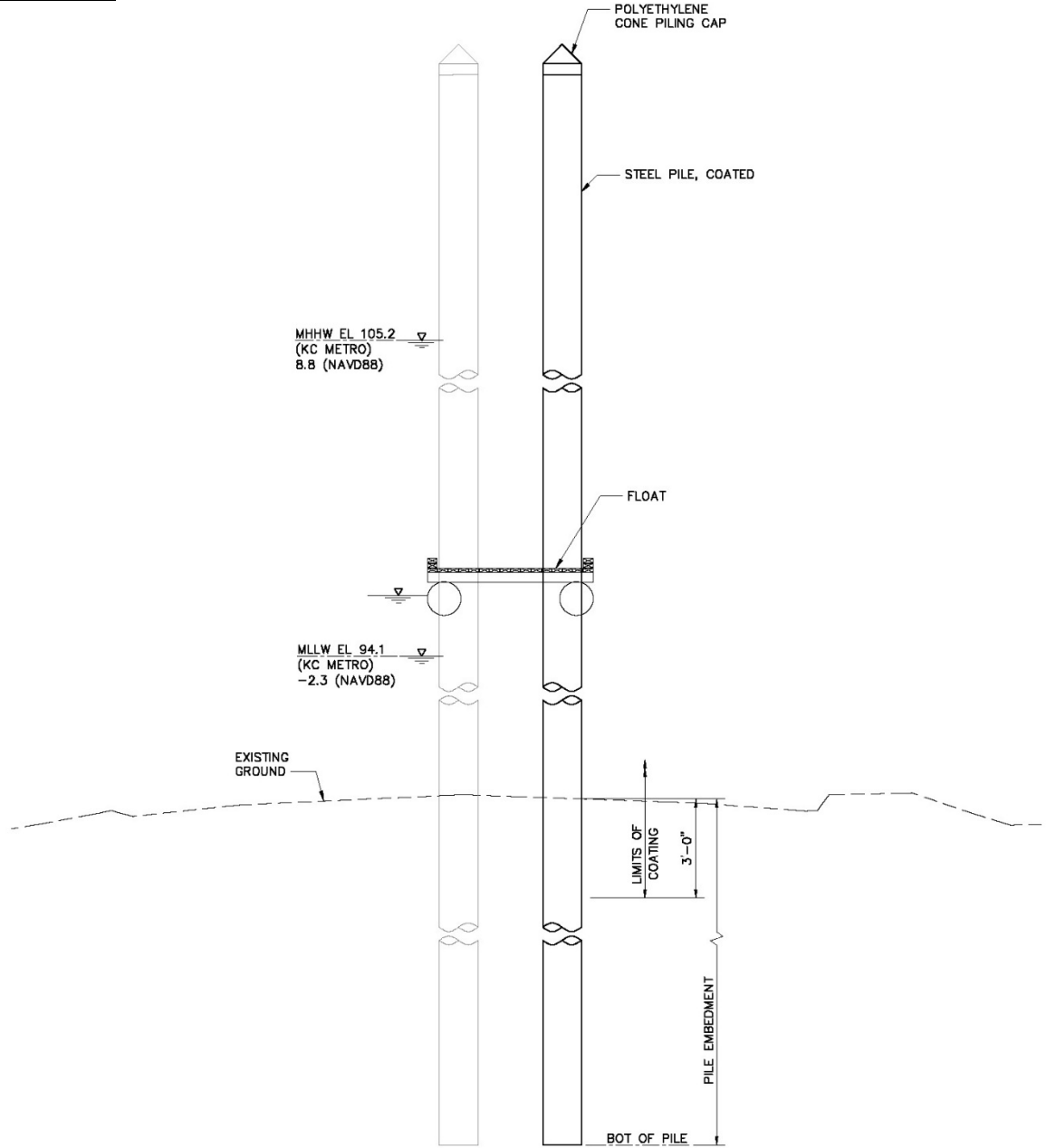
Layer	Effective Unit Weight γ (pcf)	Friction Angle ϕ (°)	Undrained Shear Strength c_u (kip/ft ²)	P-Y Curve Model	Spring Constant; K ($E_s = Kx$) k (pci)	Strain Factor; @50% max E ϵ_{50}
Recent sediment	36	27	0.08	Soft clay (Matlock)	--	0.020
Alluvium	61	32	--	Sand (Reese)	20	--

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F - DESIGN ELEMENTS

1. Guide Piles – South Park Marina (ST20)

Float Section



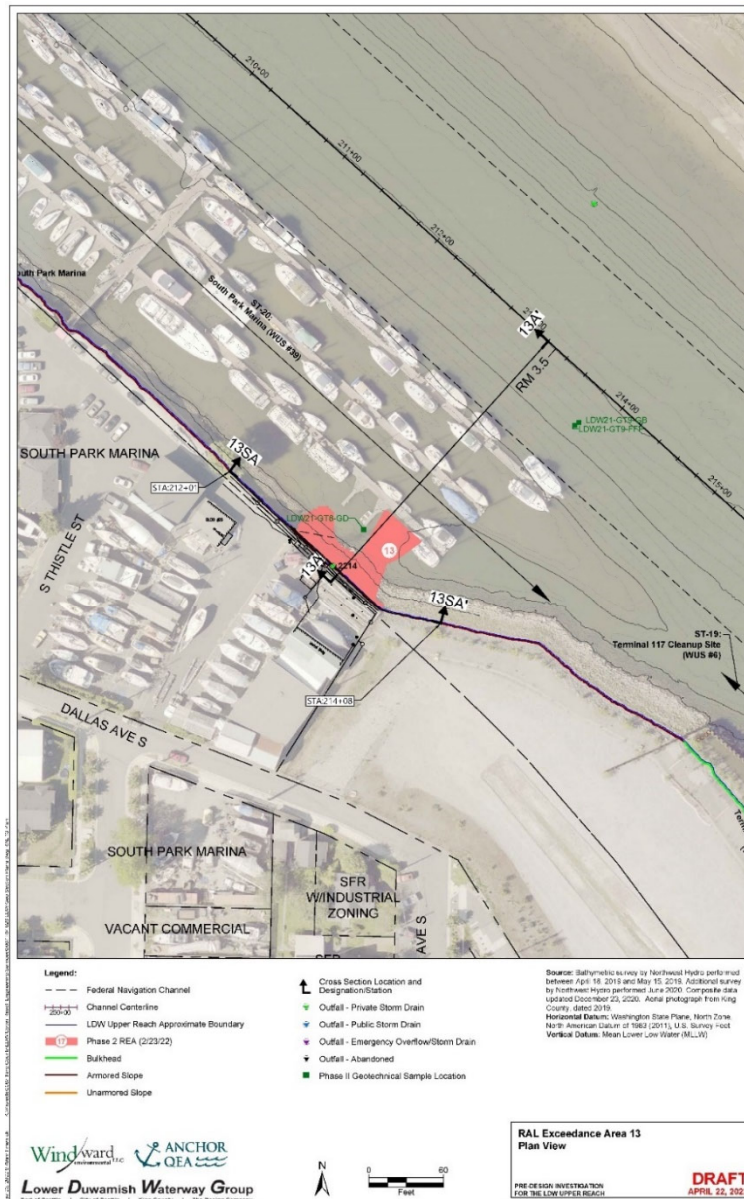
FLOAT SECTION
SCALE: 1/4"=1'-0"

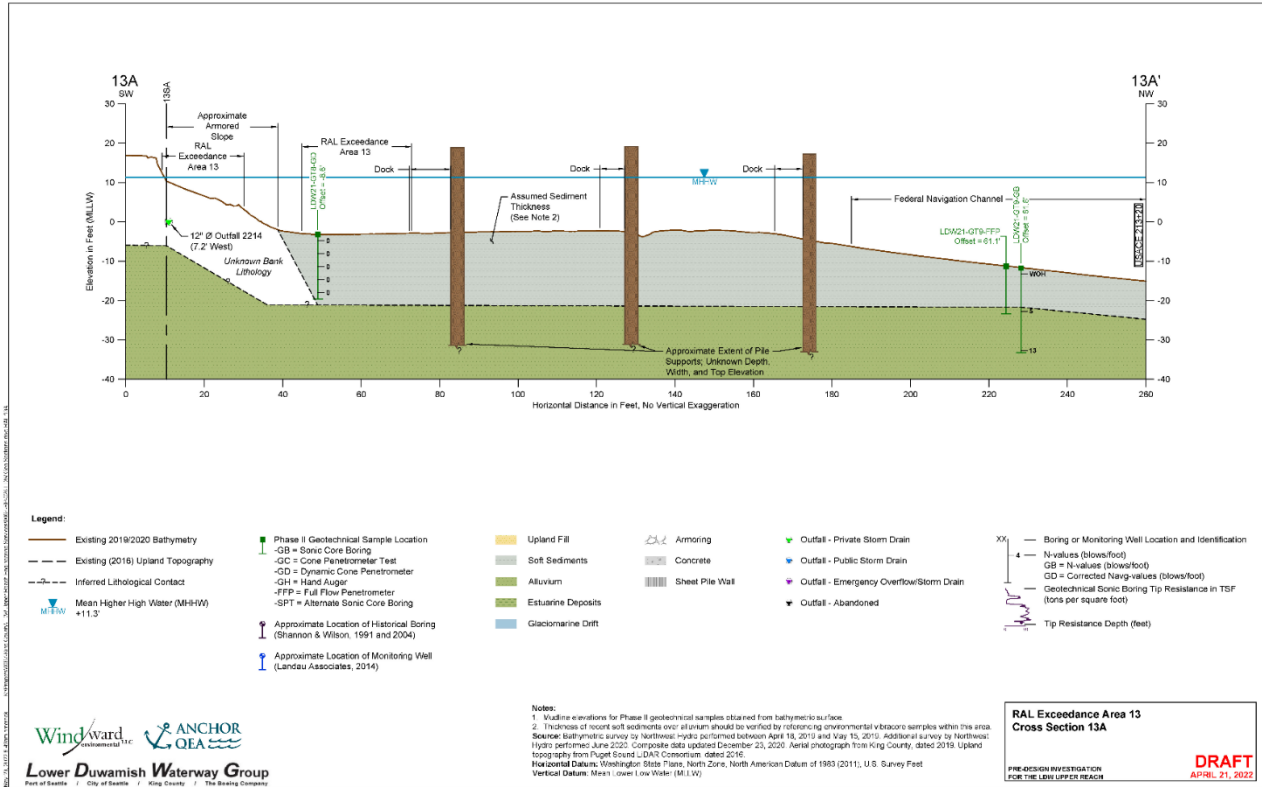
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 Subject: Engineering Services for Sediment Cleanup of Upper Reach of Lower Duwamish Waterway

Design Parameters:

- Freeboard =
- Water Pressure =
- Current Speed =
- Wave Height = 0
- Wake =
- Berthing Force =

South Park Marina





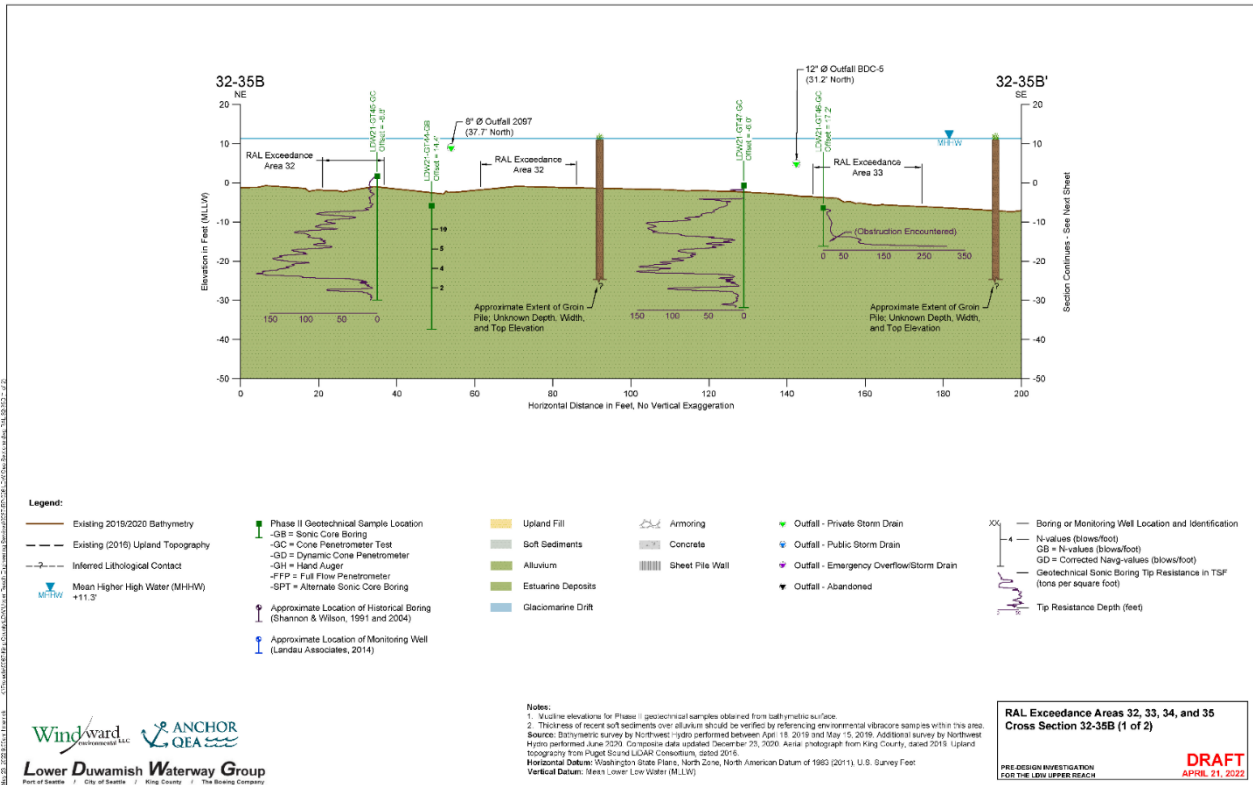
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 Subject: Engineering Services for Sediment Cleanup of Upper Reach of Lower Duwamish Waterway

2. Groin Piles (ST07)

Design Parameters:

Current Speed =
 Wave Height = 0
 Project Log Jam Height =





3. Bulkheads (ST03)

Evaluation Procedure and Assumptions:

1. Apply Lateral Earth Pressure (LEP) to existing bulkhead assuming the original wall design was based on a similar apparent LEP
 Conservatively assume:
 - a. Neglect live load surcharge pressures
 - b. Apply passive resistance on pile width assuming no shaft (unknown)
 - c. Base of wall at existing grade
2. Resulting bending moment and displacement becomes the benchmark for existing wall capacity estimate
3. Apply full LEP on existing wall with prescribed dredging depths and offsets.
 Compare bending moments allowing for 25% overstress for temporary and construction condition.
4. Add temporary or permanent tiebacks, if necessary, to achieve no overstress condition. Consider using temporary tieback if the base of the pile is in good condition and permanent, if not, or provide reinforcing if possible.
5. Assume base of wall will be buttressed with quarry spalls.
6. Earthquake pressures will not be considered.

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Soldier Pile and Lagging

Sheet Pile



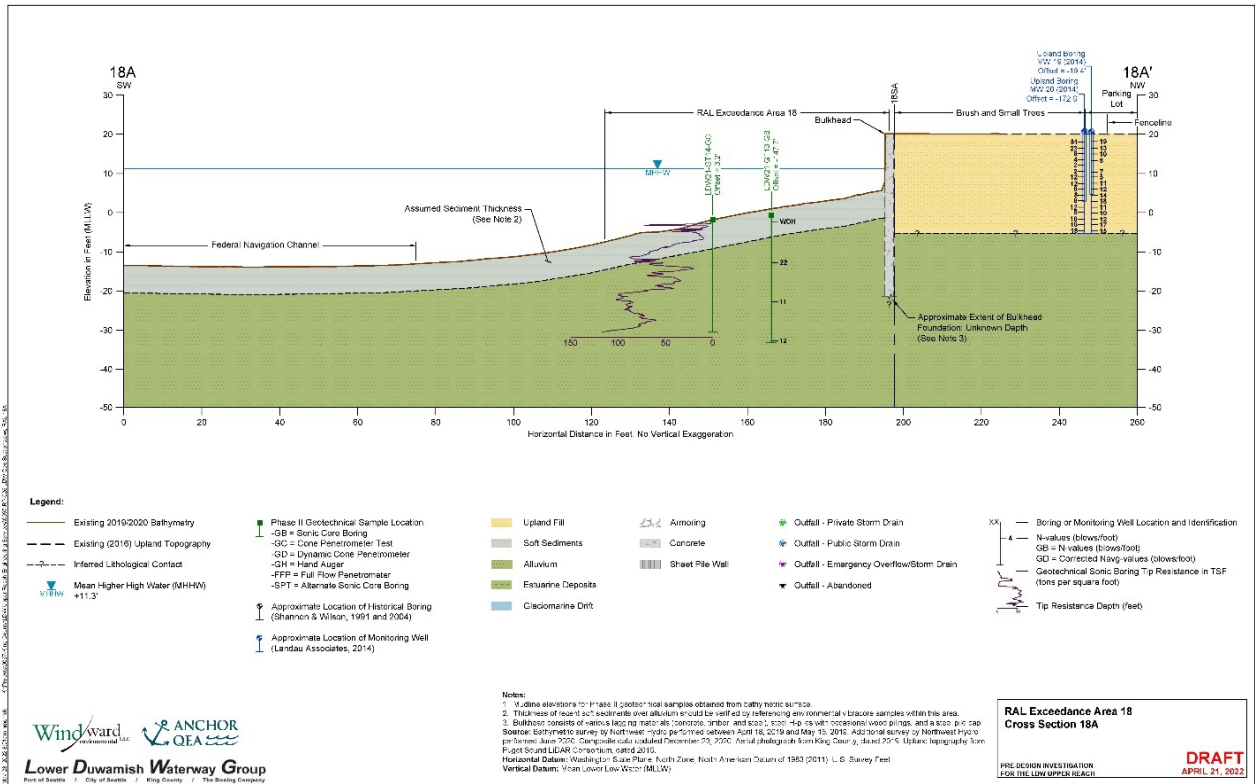
Stub Timber Piles

- Legend:**
- Federal Navigation Channel
 - Channel Centerline
 - LDW Upper Reach Approximate Boundary
 - (18) Phase 2 REA (2/23/22)
 - █ Bulkhead
 - █ Armored Slope
 - █ Unarmored Slope
 - ▲ Cross Section Location and Designation/Station
 - Outfall - Private Storm Drain
 - Outfall - Public Storm Drain
 - Outfall - Emergency Overflow/Storm Drain
 - Outfall - Abandoned
 - Phase II Geotechnical Sample Location
 - Approximate Upland Monitoring Well Location (Landiau Associates, 2014)

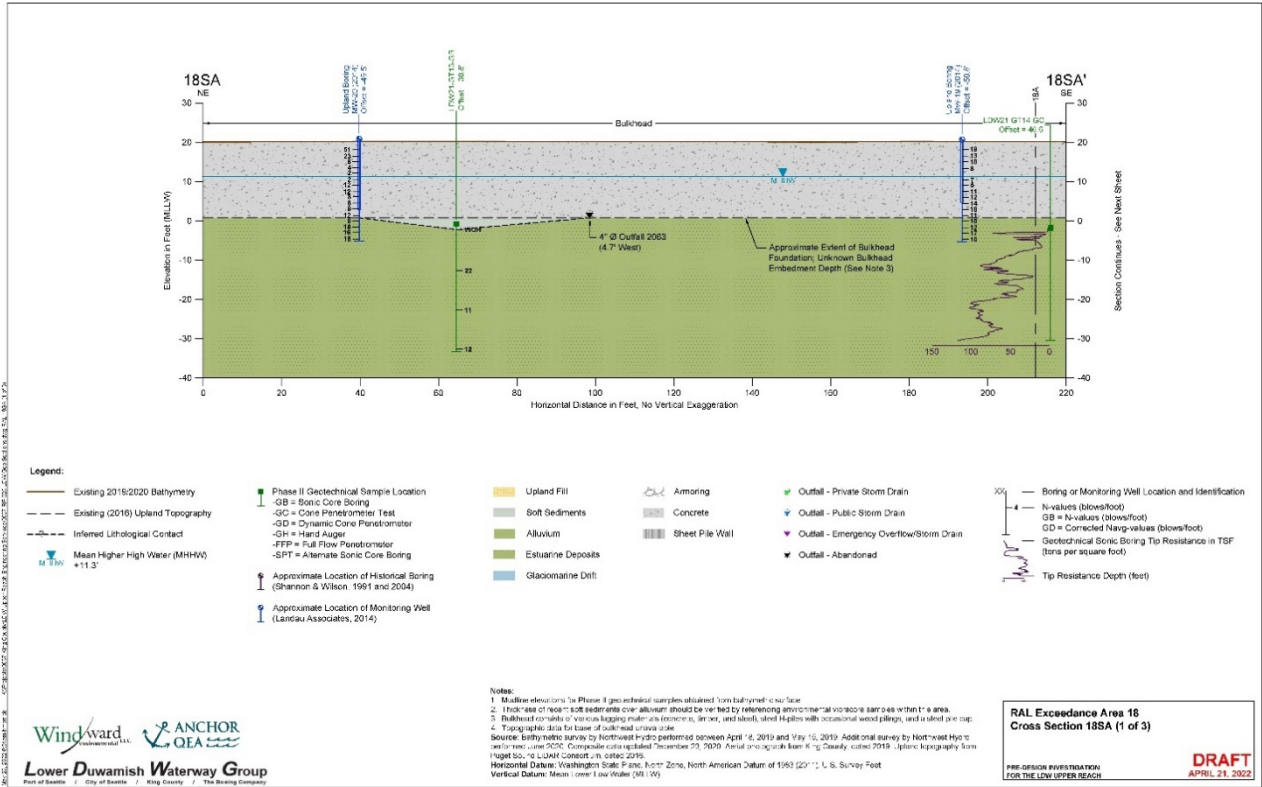
Source: Bathymetric survey by Northwest Hydro performed between April 18, 2019 and May 15, 2019. Additional survey by Northwest Hydro performed June 2020. Composite data updated December 23, 2020. Aerial photograph from King County, dated 2019. Horizontal Datum: Washington State Plane, North Zone, North American Datum of 1983 (2011). U.S. Survey Feet Vertical Datum: Mean Lower Low Water (MLLW)

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a. Soldier Pile and Lagging
 i. Boeing Vacant Land

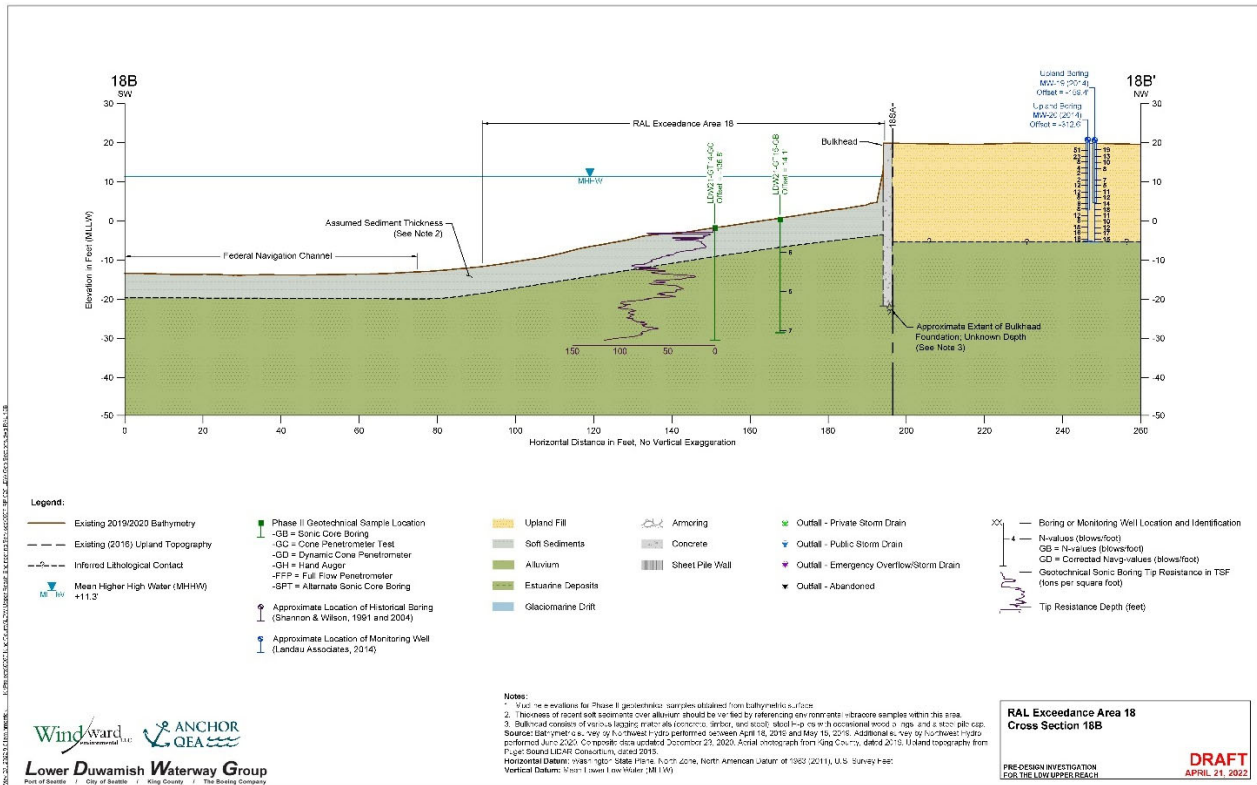


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Date: December 2022 By: SL, AB BEI No. _____ Sheet No. 12 of 20 Sheets
 Subject: Engineering Services for Sediment Cleanup of Upper Reach of Lower Duwamish Waterway

- ii. Boeing Thompson
 - Design Parameters:
 - Retained Wall Height =
 - Pile Size = Unknown
 - (Physical and Material Properties) = Unknown
 - Pile Embedment = Unknown
 - Pile Spacing = Varies
 - Lagging Material = Misc – Combination of timber, steel sheets, and concrete panels



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b. Sheet Piles

i. Boeing Thompson

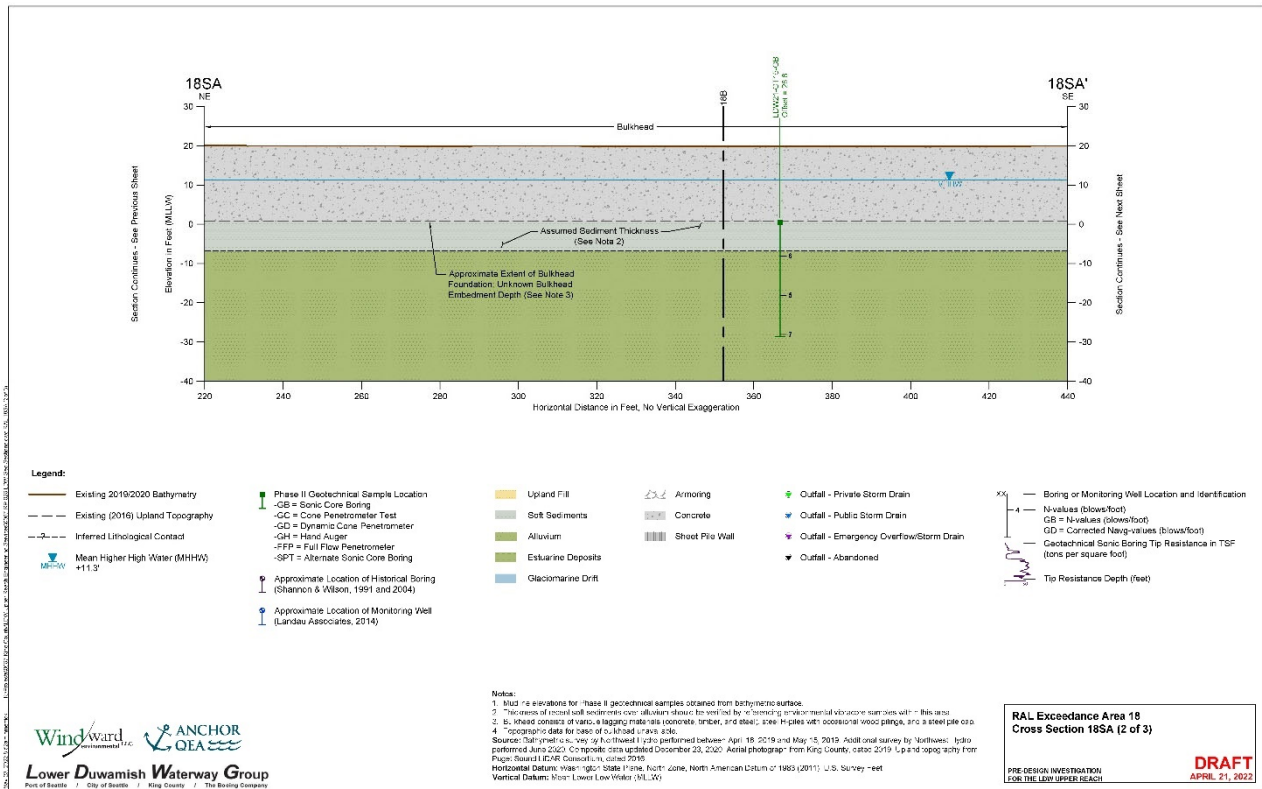
Design Parameters:

Retained Wall Height =

Sheet Pile Size (Physical and Material Properties) = Unknown

Pile Embedment = Unknown

Observations/Condition – Appear to be newer section profile; in relatively good condition



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ii. Center Point (Insurance Auto Auction)

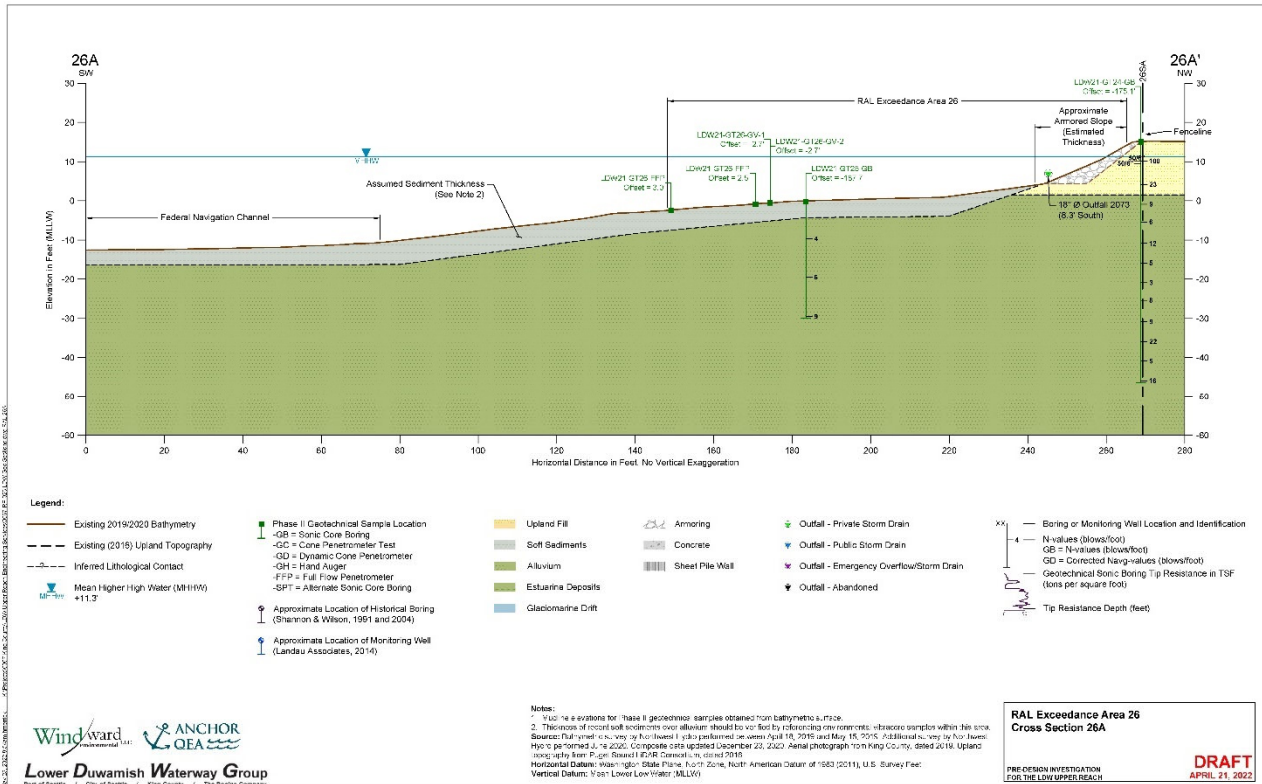
Design Parameters:

Retained Wall Height =

Sheet Pile Size
 (Physical and Material Properties) = Unknown

Pile Embedment = Unknown

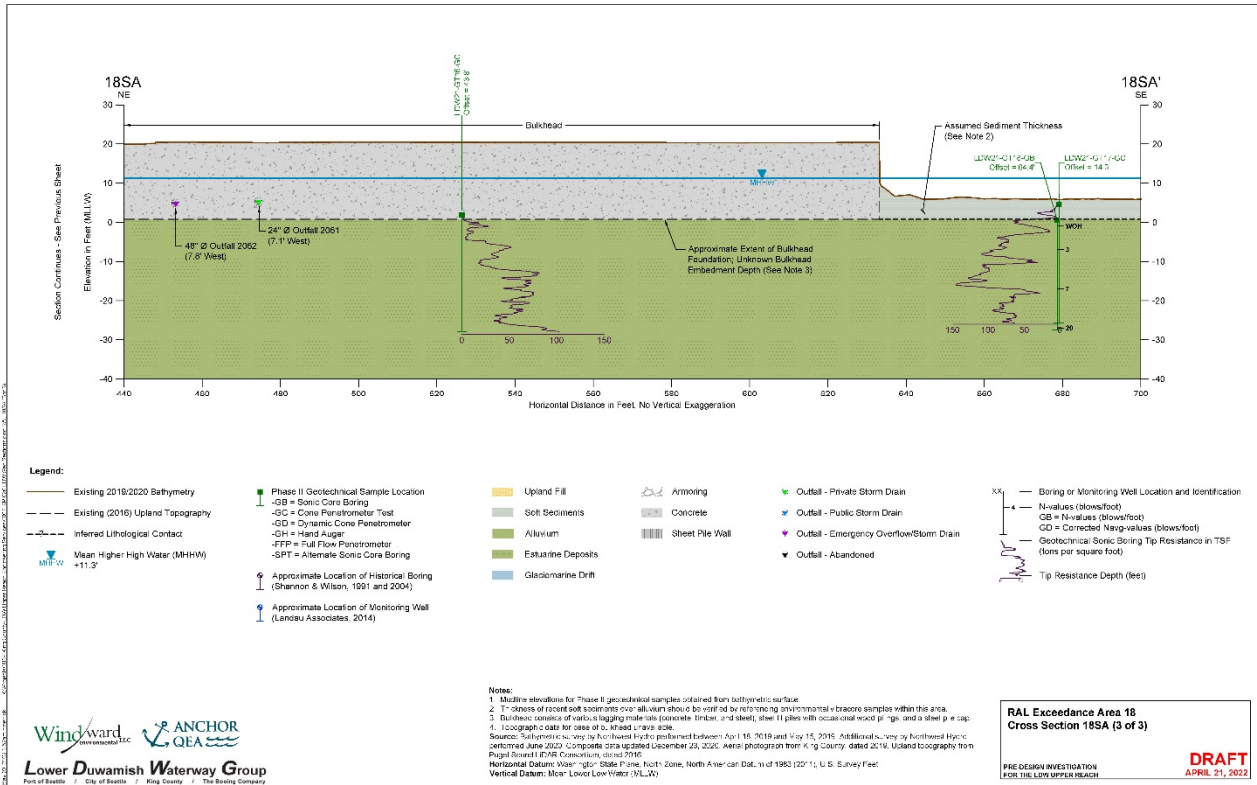
Observations/Condition – Appears to be older section profile; heavy corrosion and loss of section



**RAL Exceedance Area 26
 Cross Section 26A**

PRE DESIGN INVESTIGATION
 FOR THE LOWER REACH

DRAFT
 APRIL 21, 2022



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c. Stub Piles

i. Boeing Thompson

Design Parameters:

Pile Size

(Physical and Material Properties) = Unknown

Pile Embedment

= Unknown

Observations/Condition – Short timber piles with timber lagging and sporadic brace/buttress – severe wear

Stub Timber Piles

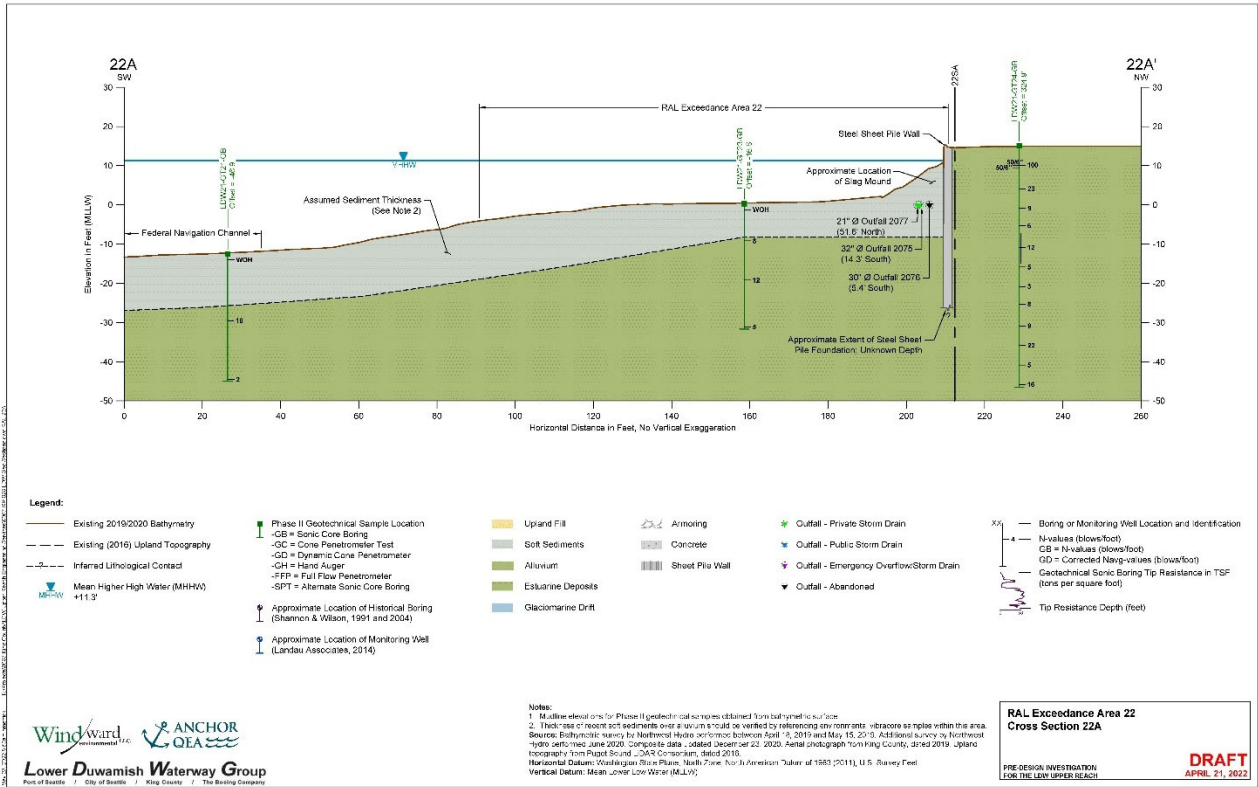
Sheet Piles



- Legend:**
- Federal Navigation Channel
 - Channel Centerline
 - LDW Upper Reach Approximate Boundary
 - Phase 2 REA (2/23/22)
 - Bulkhead
 - Armored Slope
 - Unarmored Slope
 - ▲ Cross Section Location and Designation/Station
 - ▲ Outfall - Private Storm Drain
 - ▲ Outfall - Public Storm Drain
 - ▲ Outfall - Emergency Overflow/Storm Drain
 - ▲ Outfall - Abandoned
 - Phase II Geotechnical Sample Location

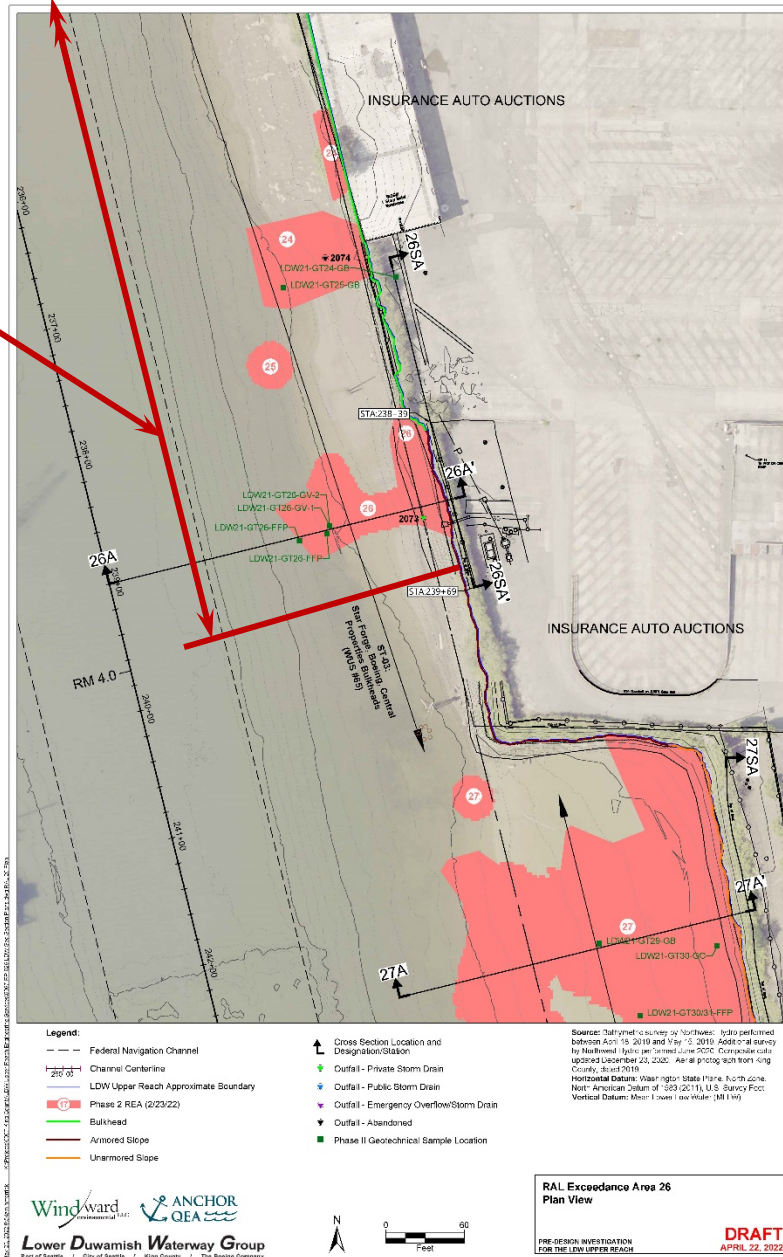
Source: Bathymetric survey by Fortinet Hydro performed between April 18, 2019 and May 15, 2019. Additional survey by Fortinet Hydro performed June 2020. Current data updated December 23, 2020. Aerial Photography from King County, dated 2015. Horizontal Datum: Washington State Plane, North Zone, North American, East of 180° (2011); J.S. Survey Foot Vertical Datum: Mean Lower Low Water (MLLW).

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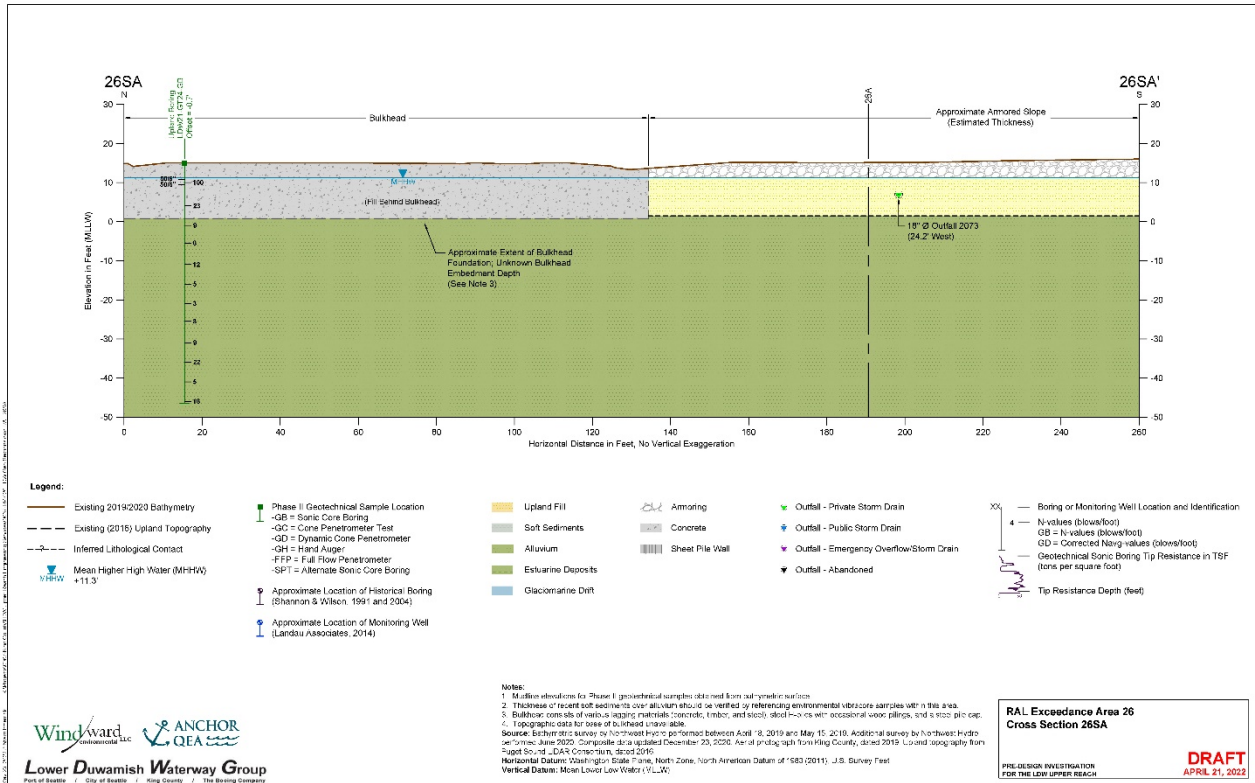


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Sheet Piles



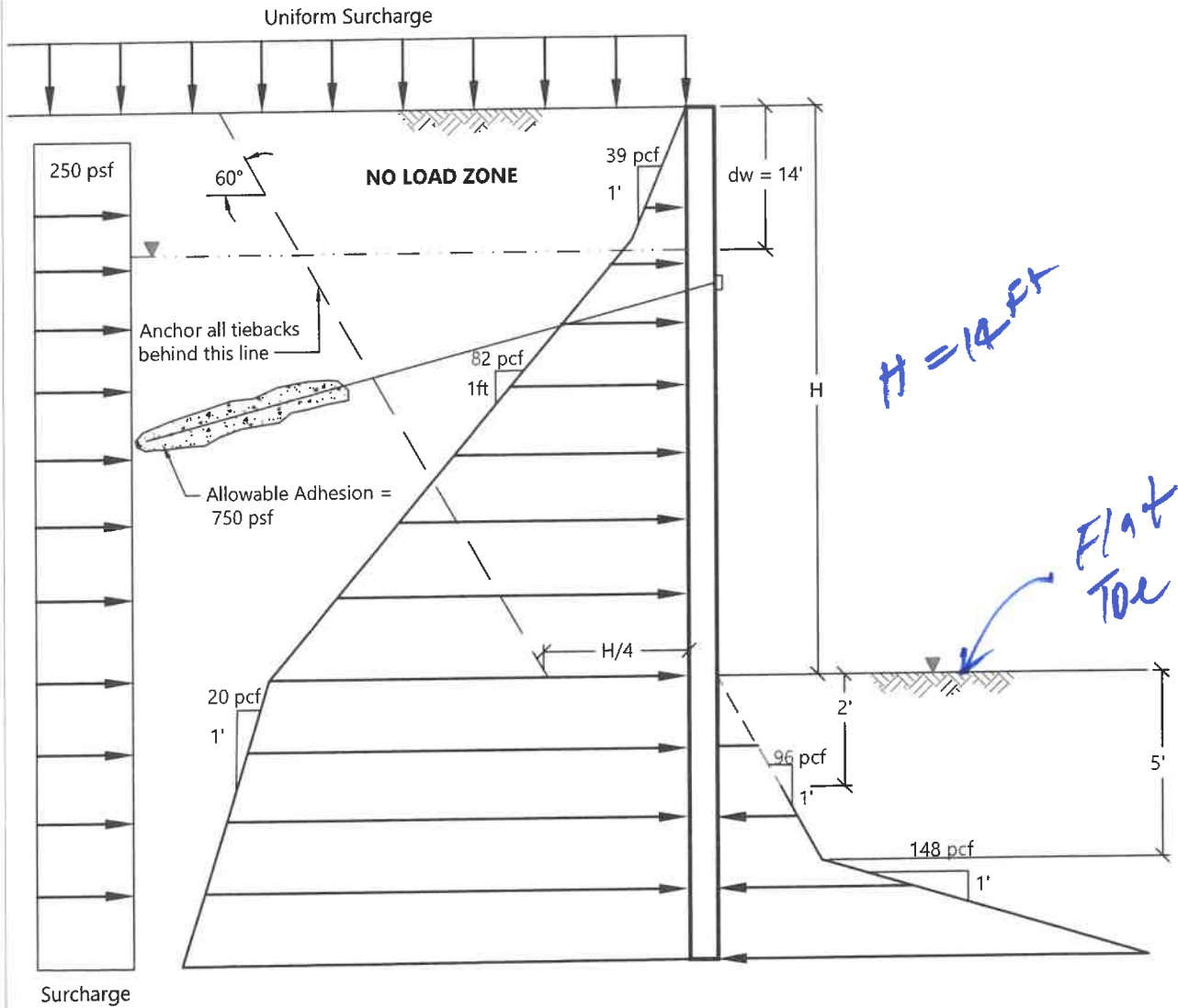
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6

INITIAL CAPACITY CHECK

FOR SOLDIER PILE AND LAGGING AND SHEET PILE WALLS



Not to Scale

NOTES:

1. Yielding walls are those walls that will deform at least 0.001 times the height of the wall.
2. Passive pressures are Ultimate values and do not include a factor of safety. We recommend applying a factor of safety of at least 1.5 when computing static passive pressures.
3. Ignore the contribution of the upper 2 feet of soil at the base of the wall when computing passive pressures.
4. Active and at-rest earth pressures are for cantilever walls or walls supported by a single row of tiebacks.

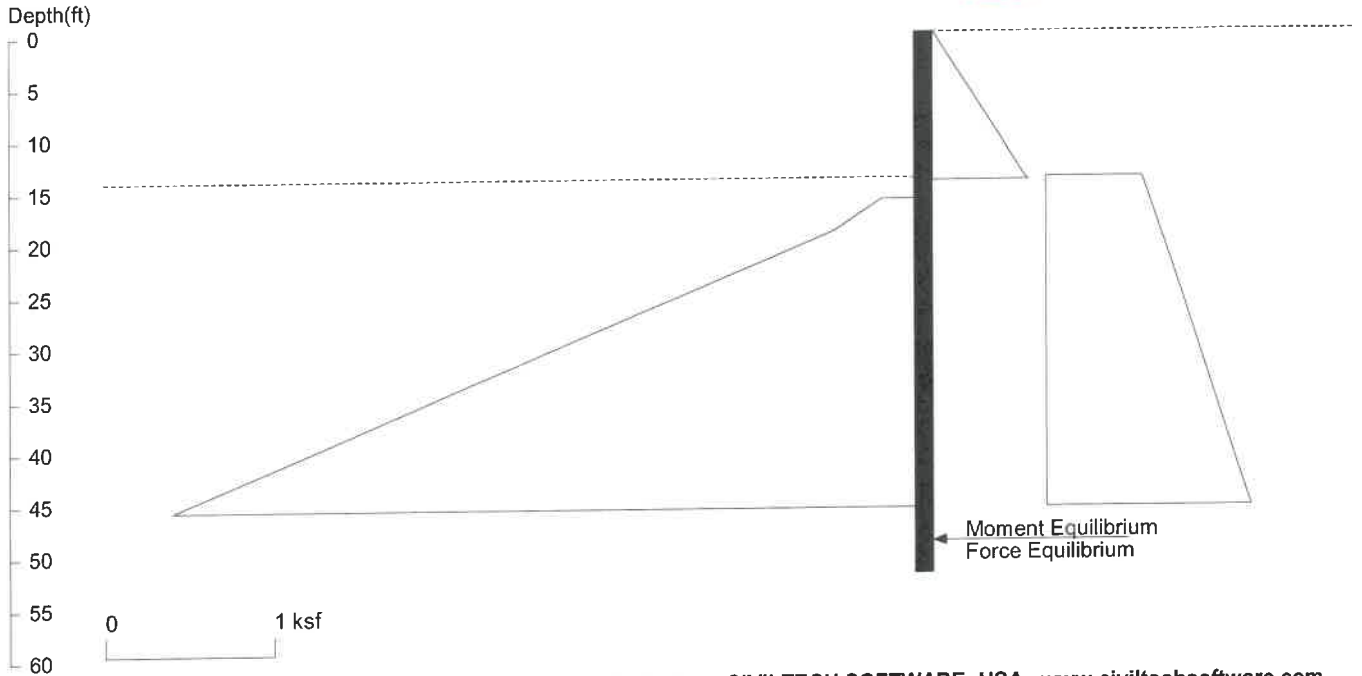
Passive Earth Pressure Reduction Factors			
Offset Distance	Reduction Factor		
	2H:1V	1.5H:1V	1H:1V
0	0.75	0.56	0.38
2	0.85	0.66	0.48
4	0.95	0.76	0.58

3 0.90 0.71 0.53



14ft High@8ft Spacing, Driven, Dw=14ft, Flat Toe

Apparent As-Built Condition



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Date: 12/22/2022

File: T:\252 Series - Anchor QEA\252.01 Eng Svcs for Sediment Cleanup of Upper Reach of Lower Duwamish Waterway

Wall Height=14.0 Pile Diameter=1.8 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=38.00 Min. Pile Length=52.00
 MOMENT IN PILE: Max. Moment=567.18 per Pile Spacing=8.0 at Depth=31.94

PILE SELECTION:

Request Min. Section Modulus = 286.5 in³/pile=4694.16 cm³/pile, Fy= 36 ksi = 248 MPa, Fb/Fy=0.66

-> Piles meet Min. Section Requirements: Top Deflection is shown in (in)
 W12X210J (2.54) W14X193 (2.26) W18X158 (1.78) W21X132 (1.69) W24X117 (1.53)
 W27X114 (1.33) W30X108 (1.22) W33X118 (0.92) W36X135 (0.70) W40X149 (0.55)
 W44X230 (0.26)

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
0	0	14	0.546	.039
14	.546	14.25	0.567	.082
14	.567	99	2.267	.02000

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
16.0	0.19	19.0	0.48	0.096
19.0	0.48	99.0	12.32	0.148

ACTIVE SPACING:

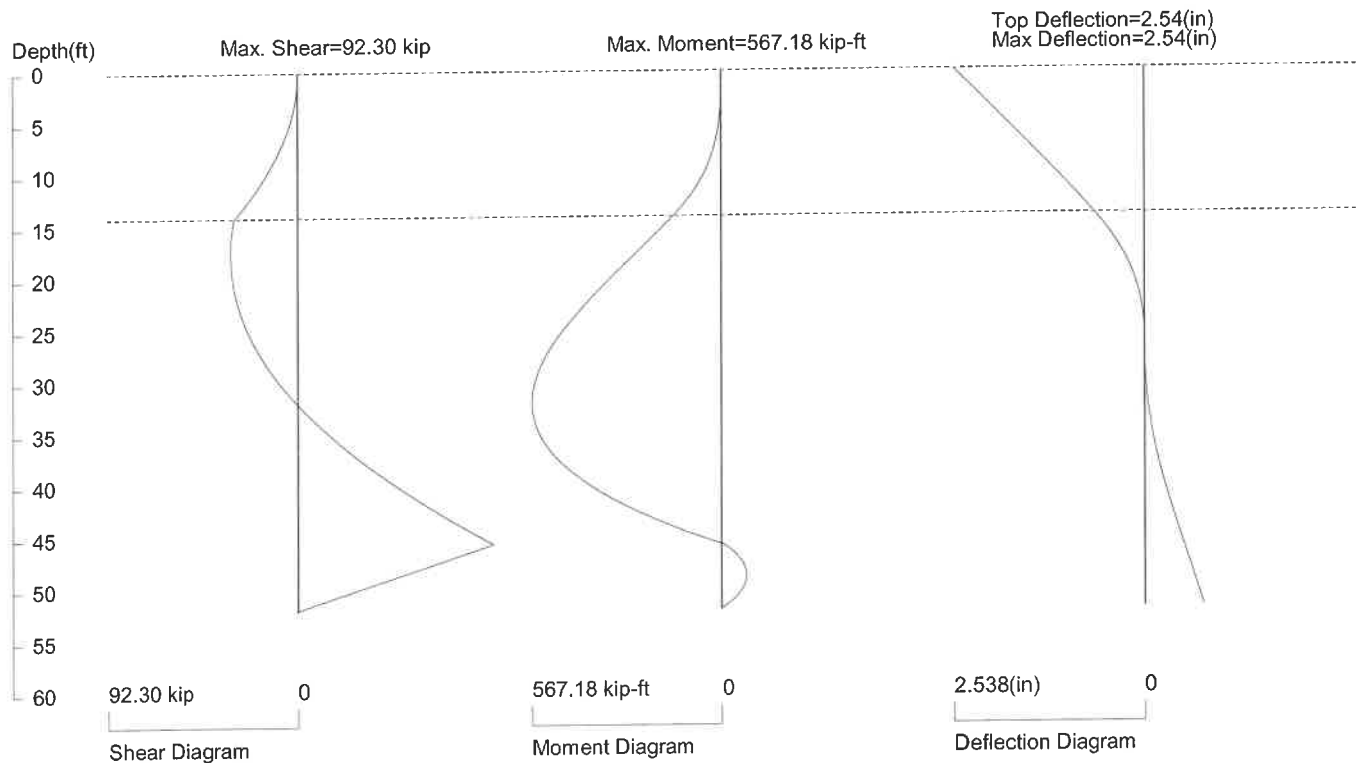
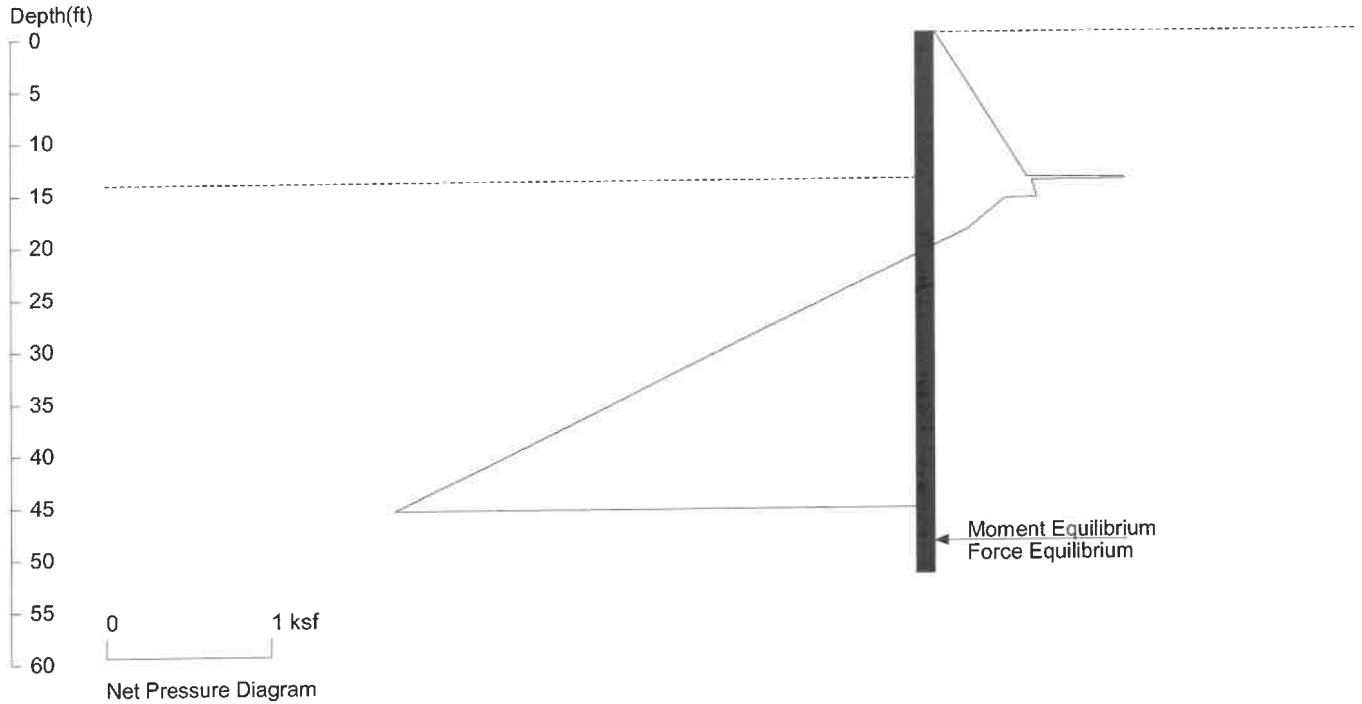
No.	Z depth	Spacing
1	0.00	8.00
2	14.00	8.00
3	14.01	1.12
4	99.00	1.12

PASSIVE SPACING:

No.	Z depth	Spacing
1	16.00	3.50
2	99.00	3.50

UNITS: Width, Spacing, Diameter, Length, and Depth - ft; Force - kip; Moment - kip-ft
Friction, Bearing, and Pressure - ksf; Pres. Slope - kip/ft³; Deflection - in

14ft High@8ft Spacing, Driven, Dw=14ft, Flat Toe Apparent As-Built Condition



PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

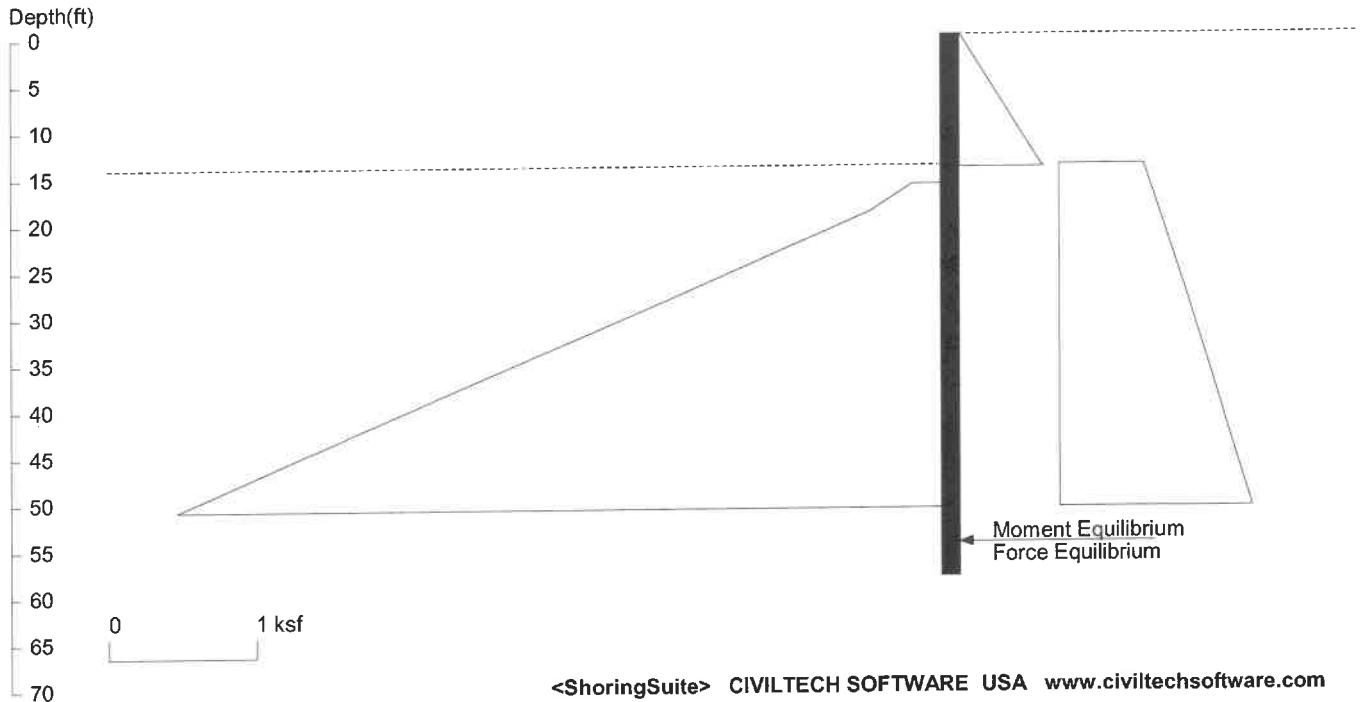
Based on pile spacing: 8.0 foot or meter

First Suitable Pile: W12X210J: E (ksi)=29000.0, I (in⁴)/pile=2140.0

252 Series - Anchor QEA\252.01 Eng Svcs for Sediment Cleanup of Upper Reach of Lower Duwamish Waterway E00559E18\Calculations\AB\WP8_14_0S_00

14ft High Sheet Pile, Dw=14ft, Flat Toe

Apparent As-Built Condition



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Date: 12/22/2022

File: T:\252 Series - Anchor QEA\252.01 Eng Svcs for Sediment Cleanup of Upper Reach of Lower Duwamish Waterway

Wall Height=14.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=44.20 Min. Pile Length=58.20
 MOMENT IN PILE: Max. Moment=138.75 per Pile Spacing=1.0 at Depth=36.86

PILE SELECTION:

Request Min. Section Modulus = 70.1 in³/ft=3767.38 cm³/m, Fy= 36 ksi = 248 MPa, Fb/Fy=0.66

-> Piles meet Min. Section Requirements: Top Deflection is shown in (in)

AZ38 (2.09) FSPZ38 (2.63) AZ38700 (1.92) AZ40700 (1.82) BZ42 (2.45)
 FSPZ45 (2.18) AZ46 (1.65) AZ48 (1.57) AZ50 (1.50)

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
0	0	14	0.546	.039
14	.546	14.25	0.567	.082
14	.567	99	2.267	.02000

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
16.0	0.19	19.0	0.48	0.096
19.0	0.48	99.0	12.32	0.148

ACTIVE SPACING:

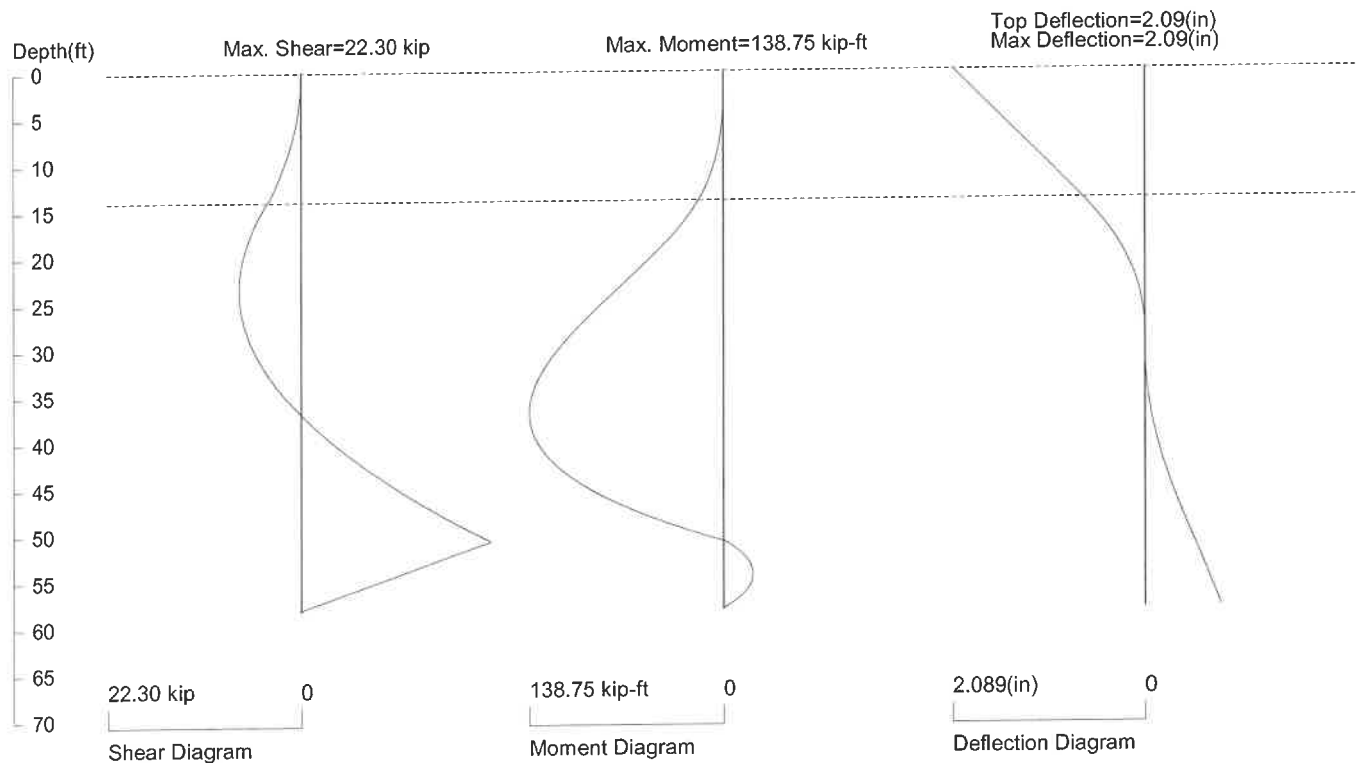
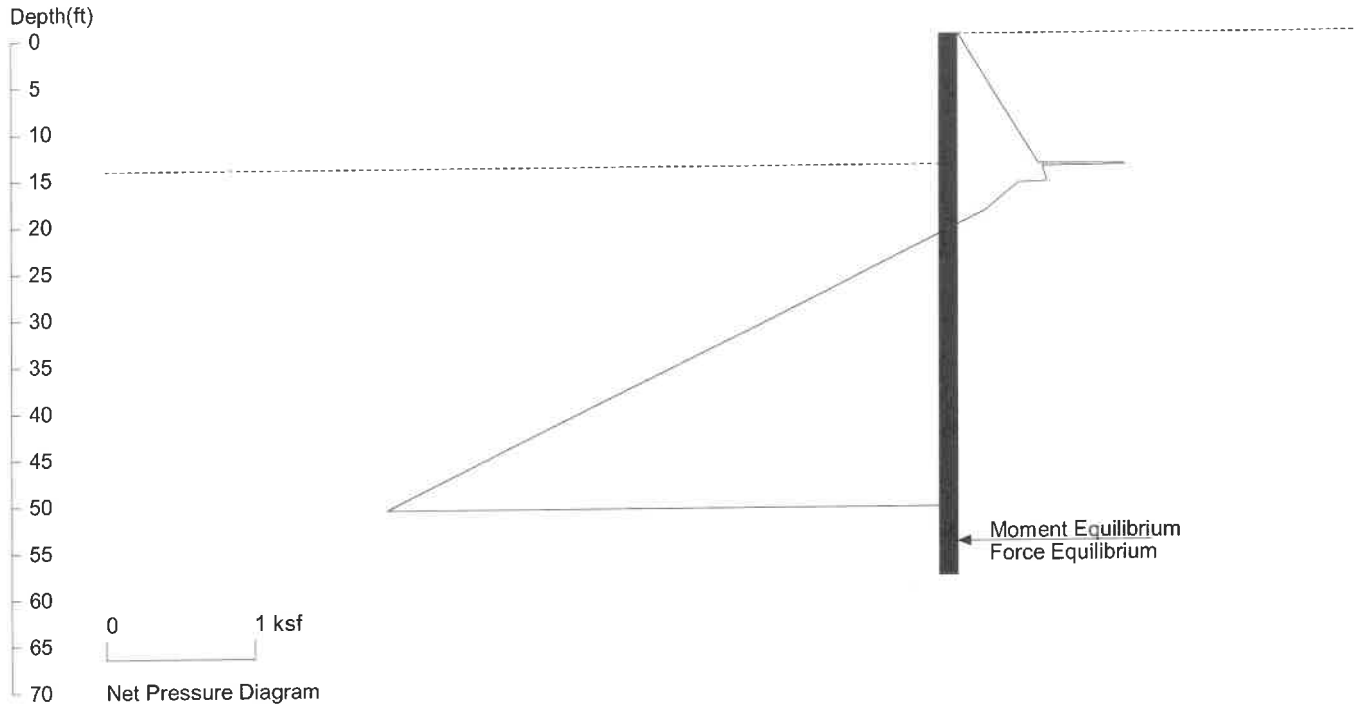
No.	Z depth	Spacing
1	0.00	1.00
2	14.00	1.00
3	14.01	1.00
4	99.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	16.00	1.00
2	99.00	1.00

14ft High Sheet Pile, Dw=14ft, Flat Toe

Apparent As-Built Condition



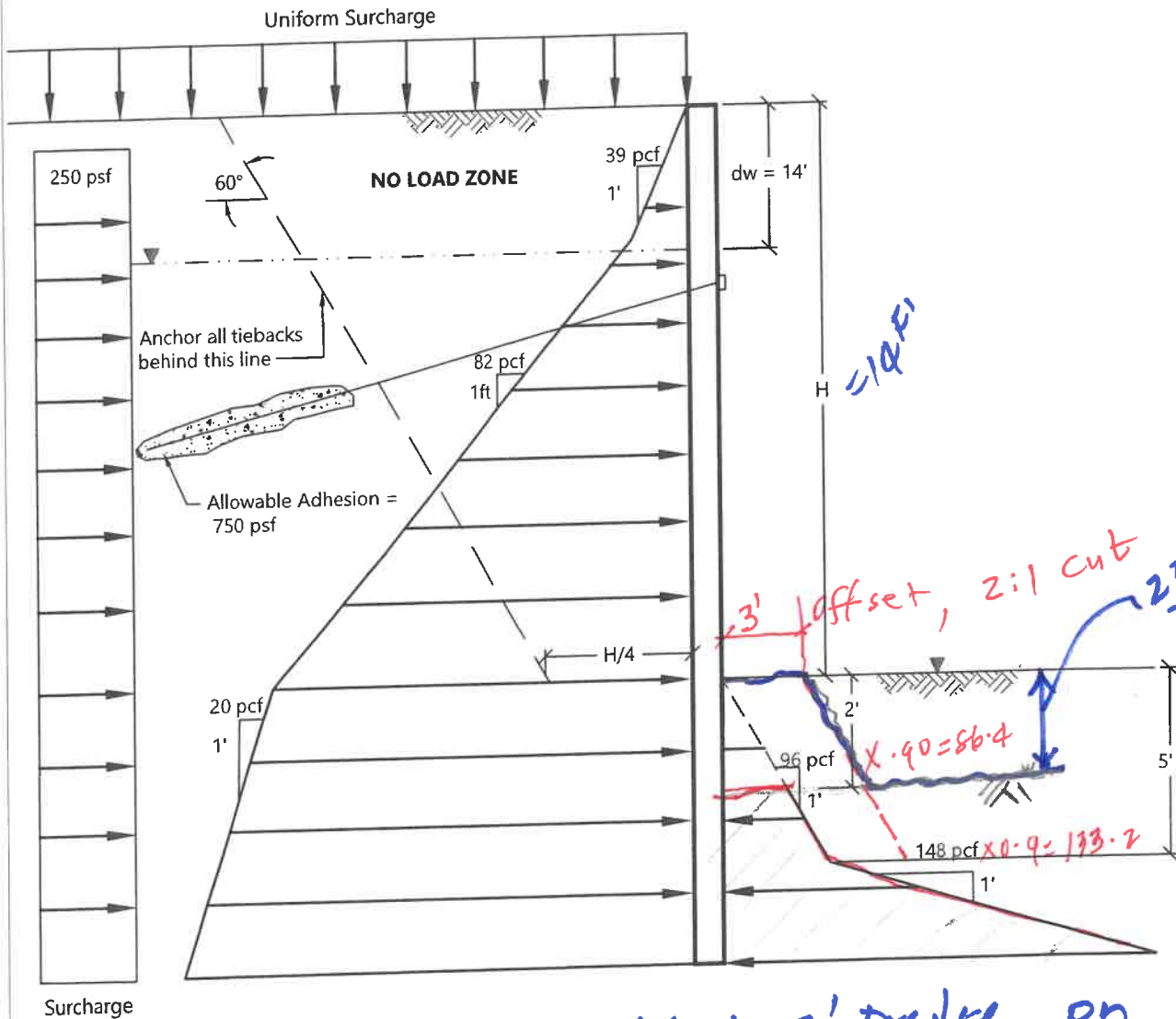
PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 1.0 foot or meter

First Suitable Pile: AZ38: E (ksi)=29000.0, I (in⁴)/foot=637.7

52 Series - Anchor QEA\252.01 Eng Svcs for Sediment Cleanup of Upper Reach of Lower Duwamish Waterway E00559E18\Calculations\AB\WP8_14_0S_0x

DRAFT



Surcharge

3' Dredging
2:1 cut
3' offset, 2' Dredge on
Not to Scale

NOTES:

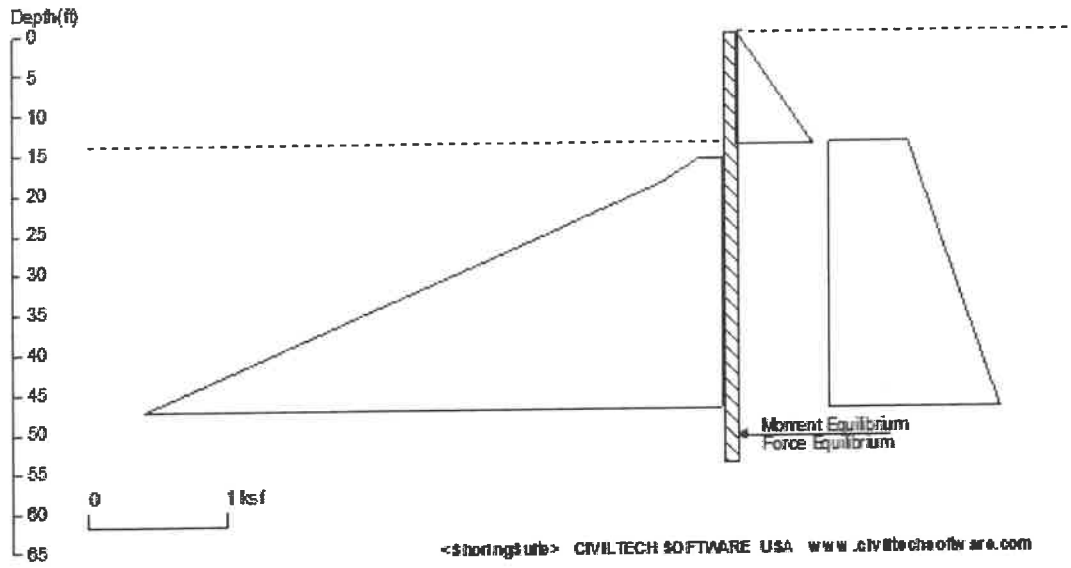
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3. Ignore the contribution of the upper 2 feet of soil at the base of the wall when computing passive pressures.
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Passive Earth Pressure Reduction Factors			
Offset Distance	Reduction Factor		
	2H:1V	1.5H:1V	1H:1V
0	0.75	0.56	0.38
2	0.85	0.66	0.48
4	0.95	0.76	0.58

3 0.90 0.71 0.53



14ft High @ 8ft Spacing, Driven, Dw=14ft, 2:1 Slope, 3' offset Apparent As-Built Condition



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 File: \\brights-er\PROJECTS\252 Series - Anchor QEA\252.01 Eng Svcs for Sediment Cleanup of Upper Reach of Lower Du
 Wall Height=14.0 Pile Diameter=1.8 Pile Spacing=8.0 Wall Type: 3. Soldier Pile, Driving

PILE LENGTH: Min. Embedment=40.20 Min. Pile Length=54.20
 MOMENT IN PILE: Max. Moment=594.98 per Pile Spacing=8.0 at Depth=33.05

PILE SELECTION:
 Request Min. Section Modulus = 300.5 in³/pile=4924.25 cm³/pile, Fy= 38 ksi = 248 MPa, Fb/Fy=0.66
 -> Piles meet Min. Section Requirements: Top Deflection is shown in (in)
 W12X230J (2.49) W14X193 (2.51) W18X158 (1.97) W21X147 (1.66) W24X131 (1.50)
 W27X129 (1.27) W30X116 (1.22) W33X118 (1.02) W36X135 (0.77) W40X149 (0.61)
 W44X230 (0.29)

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
0	0	14	0.546	.039
14	.546	14.25	0.567	.082
14	.567	99	2.267	.02000

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
16.0	0.17	19.0	0.43	0.086
19.0	0.43	99.0	11.09	0.133

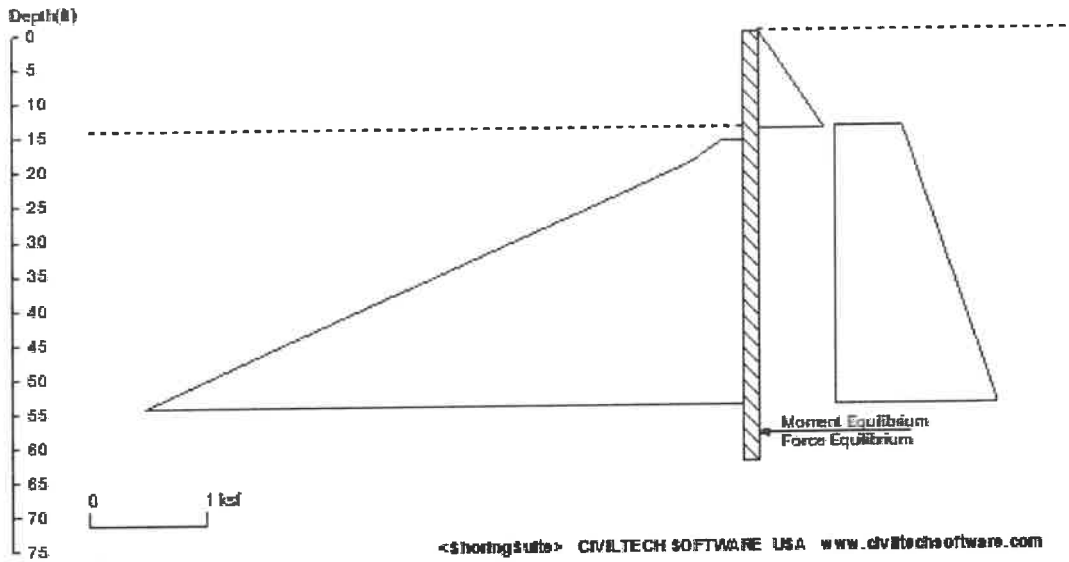
ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	8.00
2	14.00	8.00
3	14.01	1.12
4	99.00	1.12

*2.25ft more embedment
 ~10% more deflection*

14ft High Sheet Pile, Dw=14ft, 2:1 Slope, 3' offset

Apparent As-Built Condition



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 File: \\brightserver\PROJECTS\252 Series - Anchor QEA\252.01 Eng Svcs for Sediment Cleanup of Upper Reach of Lower D
 Wall Height=14.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=48.54 Min. Pile Length=62.54
 MOMENT IN PILE: Max. Moment=157.28 per Pile Spacing=1.0 at Depth=39.28

PILE SELECTION:
 Request Min. Section Modulus = 79.4 in³/ft=4270.29 cm³/m, F_y=36 ksi = 248 MPa, F_b/F_y=0.66
 -> Piles meet Min. Section Requirements: Top Deflection is shown in (in)
 FSPZ45 (2.69) AZ46 (2.03) AZ48 (1.94) AZ50 (1.85)

*~4.5' more embedment
 x 23.5% more deflection*

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
0	0	14	0.546	.039
14	.546	14.25	0.567	.082
14	.567	99	2.267	.0200

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
16.0	0.17	19.0	0.43	0.086
19.0	0.43	99.0	11.09	0.133

ACTIVE SPACING:

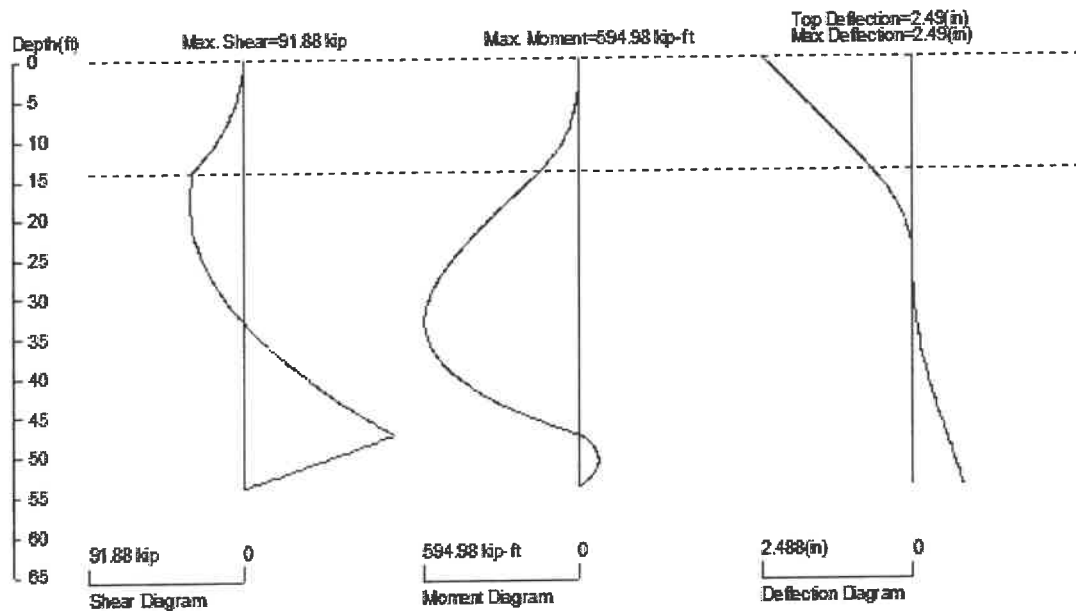
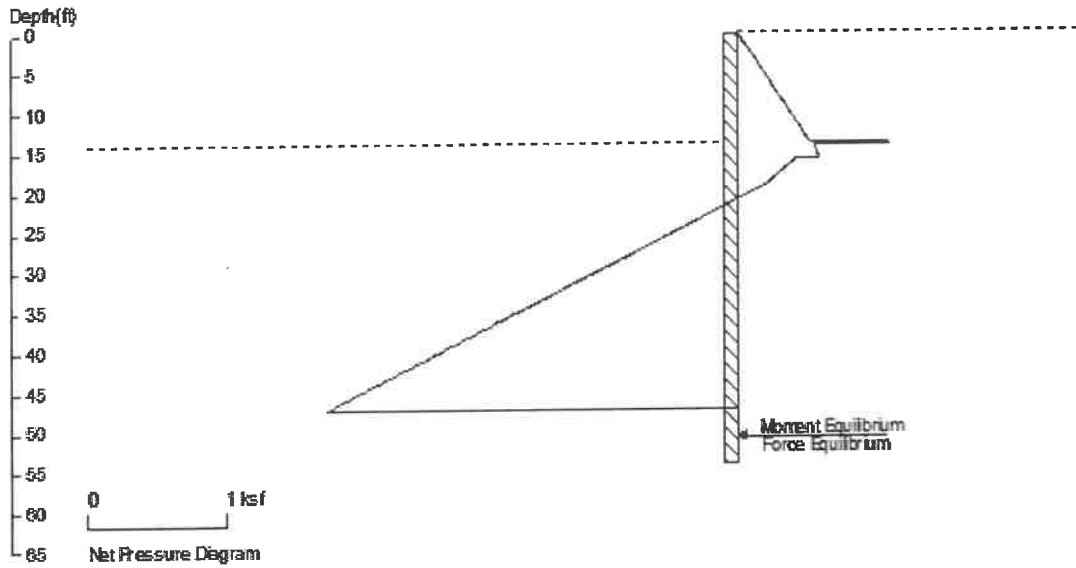
No.	Z depth	Spacing
1	0.00	1.00
2	14.00	1.00
3	14.01	1.00
4	99.00	1.00

PASSIVE SPACING:

No.	Z depth	Spacing
1	16.00	1.00
2	99.00	1.00

UNITS: Width, Spacing, Diameter, Length, and Depth - ft; Force - kip; Moment - kip-ft
 Friction, Bearing, and Pressure - ksf; Pres. Slope - kip/ft³; Deflection - in

14ft High @ 8ft Spacing, Driven, Dw=14ft, 2:1 Slope, 3' offset
Apparent As-Built Condition



PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 8.0 foot or meter

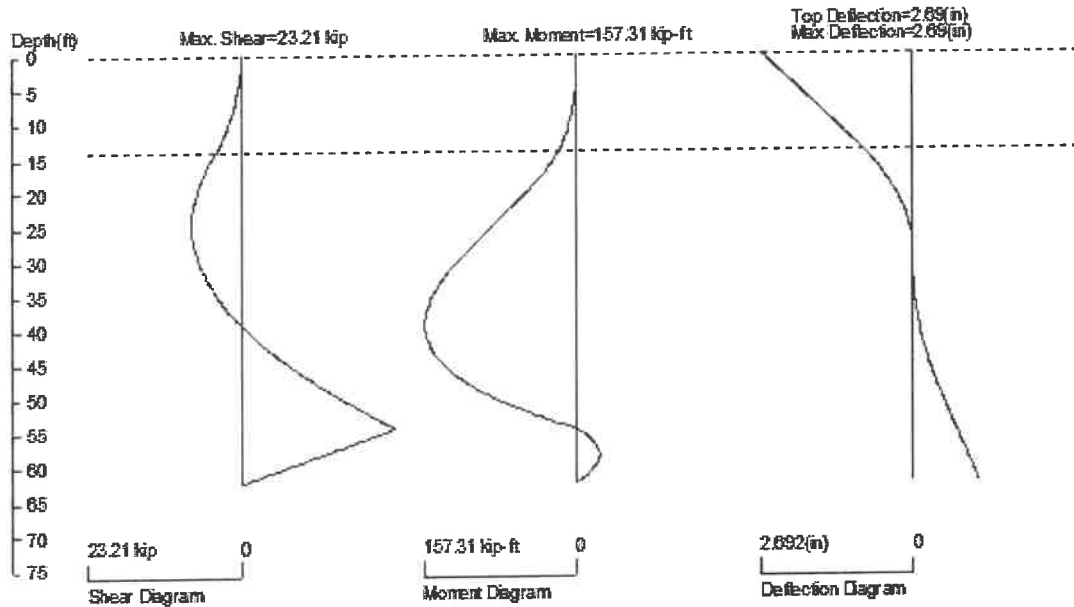
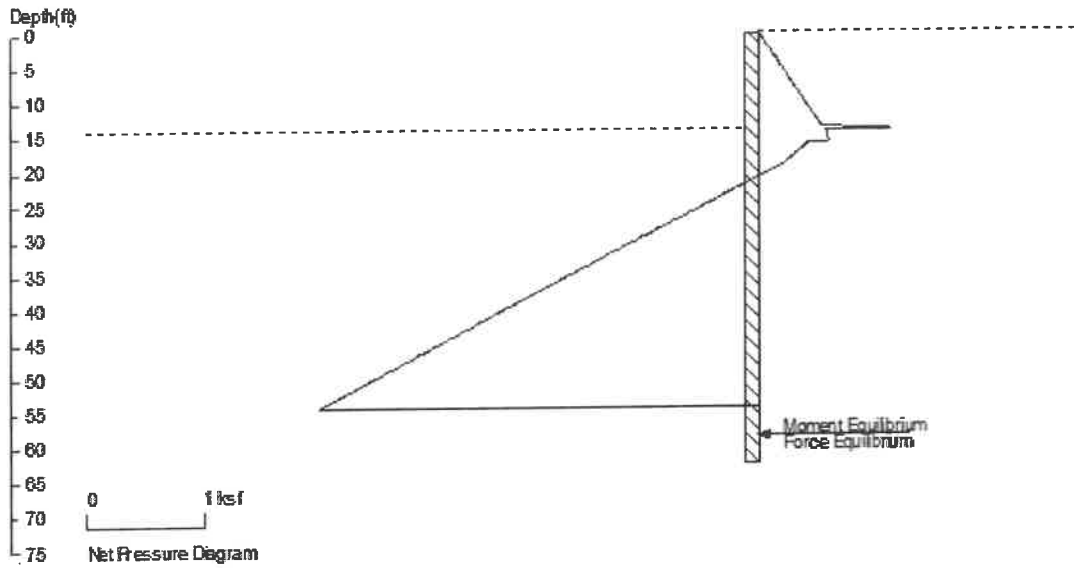
First Suitable File: W12X230J: E (ks)=29000.0, I (in⁴)/pile=2420.0

Project: 252 series - Anchor QEA 252.01 Eng Svcs for Sediment Cleanup of Upper Reach of Lower Duwamish Waterway E00550E18\Calculations\AB\WP8_14

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14ft High Sheet Pile, Dw=14ft, 2:1 Slope, 3' offset Apparent As-Built Condition



PRESSURE, SHEAR, MOMENT, AND DEFLECTION DIAGRAMS

Based on pile spacing: 1.0 foot or meter

First Suitable File: FSPZ45: E (ks)=29000.0, I (in⁴)/foot=611.0

Server\PROJECTS\252 Series - Anchor GEA\252.01 Eng Svcs for Sediment Cleanup of Upper Reach of Lower Duwamish Waterway E0559E18\Calculations\ABSP_14_0

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