
Subject: Conceptual Intake Cofferdam Construction (Final Draft)

Project feature: Intakes

Prepared for: California Department of Water Resources (DWR) / Delta Conveyance Office (DCO)

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1. Purpose

This technical memorandum presents the revised conceptual approach to the installation of temporary cofferdams to facilitate in-river intake construction for the Delta Conveyance Project. The initial, now superseded, conceptual approach is presented in Attachment 1.

Temporary in-river cofferdam structures are planned at Intakes C-E-2, 3, and 5 for the Delta Conveyance Project (project). The purpose of the cofferdams is to create temporary enclosures to isolate the construction areas for the intake structures from the Sacramento River and the riverbank soils. This isolation will allow for dewatered conditions for the intake structures' construction.

1.1 Organization

- Subsurface Conditions
- Approach
- Analysis
- Results
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- Attachment 1 – Pile Driving Analysis for Cofferdam Construction *
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* Note: initial conceptual cofferdam approach, now superseded

2. Subsurface Conditions

This section discusses generalized and conceptual subsurface conditions at the intake sites. At this time, most of the exploration at the sites has been completed on the river-side of the existing State Route 160.

2.1 Intake C-E-2

The Intake C-E-2 structure would be located approximately 1,900 feet south of the intersection of Scribner Road and State Route 160 along the eastern bank of the Sacramento River. Six overwater borings (DCR2-DH-004 to DRC2-DH-009)(DWR, 2013) were drilled to depths ranging from approximately 120 to 142 feet below the mudline at the site in 2010 and 2012.

A review of the six borings indicated the subsurface conditions at Intake C-E-2 may be divided into a softer and looser upper layer and a harder and denser lower soil layer. Boring DCR2-DH-004, which encountered the thinnest upper soil layer, was selected to be representative of the general soil conditions at Intake C-E-2, for conservatism. Based on this borehole, the upper soil layer at Intake C-E-2 is approximately 37 feet thick and consists of very loose to medium dense silt (ML) and sand (SM, SP), followed by a lower soil layer of stiff to very stiff fat clay (CH) and lean clay (CL) and primarily medium to very dense sands (SM, SP, SW-SM). Attachment 1 contains the Boring DCR2-DH-004 log.

2.2 Intake C-E-3

The Intake C-E-3 structure would be located 1.75 miles south of Intake C-E-2, approximately 2,100 feet southwest of the intersection of River Park Drive and State Route 160, along the eastern bank of the Sacramento River. Three overwater borings (DCR3-DH-013 to DRC3-DH-015)(DWR, 2013) were drilled to depths ranging from approximately 140 to 142 feet below the mudline at the site in 2012.

Similar to Intake C-E-2, the subsurface conditions at Intake C-E-3 can be divided into upper and lower soil layers. Boring DCR3-DH-014 was selected to be representative of the general soil conditions at Intake C-E-3, for conservatism. Based on this borehole, the upper soil layer at Intake C-E-3 is approximately 18.1 feet thick and consists of lean clay (CL) and loose to medium dense sand (SM, SP), underlain by a lower soil layer of very stiff to hard lean clay (CL) and fat clay (CH) and dense to very dense silt (ML), sand (SM, SC, SP, SW, SP-SM) and gravel (GM, GP, GW-GM). Attachment 1 contains the Boring DCR3-DH-014 log.

2.3 Intake C-E-5

The Intake C-E-5 structure would be located approximately 1.5 miles southwest of the intersection of Hood-Franklin Road and State Route 160, along the eastern bank of the Sacramento River. Three overwater borings (DCR5-DH-013, DCR5-DH-004, and DRC5-DH-014)(DWR, 2013) were drilled to depths ranging from approximately 138 to 142 feet below the mudline at the site in 2009 and 2012.

Boring DCR5-DH-014, with the thinnest upper soil layer, was selected to be representative of the general soil conditions at Intake C-E-5, for conservatism. Based on this boring, the upper soil layer at Intake C-E-5 is approximately 36.3 feet thick and consists of very soft lean clay (CL) and loose to medium dense sand (SM, SP-SC), followed by a lower layer of very stiff to hard lean clay (CL) and fat clay (CH) and medium to very dense sand (SM, SP, SW, SP-SM) and gravel (GP). Attachment 1 contains the Boring DCR5-DH-014 log.

3. Approach

Initial concepts for the cofferdam construction followed the approach used on the nearby Freeport Intake for the Freeport Regional Water Authority (FRWA) Project. That project used a heavy-duty combination of king piles and sheetpiles to form a 4-sided cofferdam with the necessary stiffness and rigidity to limit the deflection of the landside wall to no more than 1 inch per U.S. Army Corps of Engineers (USACE)

requirements. Because the cofferdam was constructed in the waterside slope of a jurisdictional USACE levee, no inclusions, such as tiebacks, were permitted in the levee prism (Figure 1).



Figure 1. Cofferdam for Freeport Intake

Attachment 1 analyzes the pile installation for the cofferdams at each of the proposed intakes described above using the same concept as employed at the Freeport Intake. The analyses, based on the cited limited initial geotechnical exploration information at each intake site, concluded that an initial portion of each king pile and sheetpile could be vibrated into place and that the remainder of the piles would require impact driving to advance to their full planned depth. The number of anticipated pile strikes was estimated to range between 478,160 blows for the Intake C-E-2 cofferdam and 32,538 blows for the Intake C-E-5 cofferdam. It can be observed from the results presented in Attachment 1 that the number of blows required to drive a king pile (wide-flange beam) is at least 4 times larger than the number of blows required to drive a paired sheetpile. Note that the cumulative blows presented in Attachment 1 are based on an earlier arrangement of the intakes and the number of pile pairs and king piles may not exactly sum to the peripheral lengths of the current intake cofferdam configurations.

3.1 Revised Concept

While developing the current Project intake configuration, the DCA developed a staged approach to public flood protection to facilitate construction. Specifically, the construction sequence involves constructing a setback embankment for the State Route 160 realignment at each intake that would serve as the

temporary flood protection levee. The ring embankment surrounding the sediment basin constructed later would ultimately serve as the permanent flood protection levee. Because the existing State Route 160 levee would not provide temporary or permanent flood protection, it would be possible to install inclusions, such as tiebacks, within the existing levee prism. The revised flood protection sequence also satisfied another goal of the DCA, to reduce the quantity of impact pile driving in the Sacramento River.

The DCA also identified an opportunity to implement a planned groundwater cutoff wall as part of the cofferdam, rather than as a separate facility behind the cofferdam. The revised conceptual cofferdam configuration utilizes a deep mechanically mixed (DMM) cutoff wall, reinforced with wide flange steel beams (similar to the combination sheetpile wall) for the back wall (landside wall). The back wall would be primarily supported by drilled and grouted tiebacks. The remaining three walls would consist of interlocking steel sheetpiles, without the need for king piles, installed to a shallower tip depth. The flexible sheetpile walls are braced against the reinforced DMM wall using 4 levels of pipe struts (Figure 2). The short cofferdam end walls, not shown, would be braced using diagonal corner braces. Note that for this concept, the existing Highway 160 and levee would be partially removed following construction of an approved setback embankment for the Highway 160 realignment (not shown).

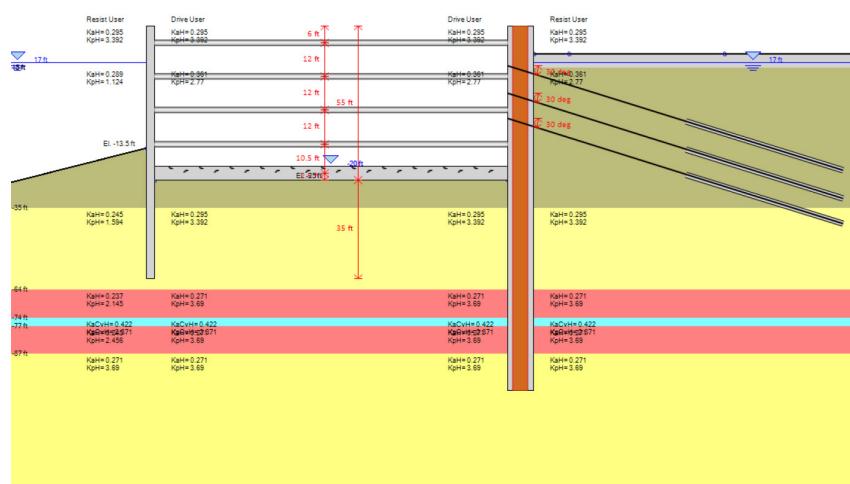


Figure 2. Revised Conceptual Cofferdam Concept

Full depth excavation and embankment removal at Intake C-E-3 for Tee Screen Alternative

The key to the revised concept is to install a self-supporting back wall anchored using three rows of tiebacks. To install the tiebacks and struts, the surface of the water and the soil would be lowered in stages until the two upper struts and two upper tieback levels could be installed. After these two upper strut and support layers were installed, the excavation would continue in the wet to full depth, and a reinforced concrete tremie base slab would be poured. This tremie slab would provide a vital lower brace to prevent over deflection of the walls upon lowering of the water within the cofferdam. The sequence would continue with the alternating installation of strut level 3, tieback level 3, and strut level 4. Once strut level 4 was complete, the cofferdam could be completely dewatered.

3.1.1 Deep Mechanically Mixed Wall

The deep mechanically mixing method is an in-situ soil mixing technology that mixes existing soil with cementitious materials using mixing shafts consisting of auger cutting heads, discontinuous auger flights, cutters, or mixing paddles. The soil-cement produced has much higher strength and lower permeability

than the native soils and can be reinforced with steel inclusions. Where reinforced, the soil-cement functions as lagging between the steel beam, much like a soldier pile wall. Figure 3 shows a DMM rig in operation in Tracy, California.



Figure 3. Deep Mechanical Mixing Rig with Cutters

The cementitious materials are generally delivered in a grout or slurry form from ports in the cutting heads. The construction of the back wall using the DMM method would include a wall panel cutter, slurry mixing tanks, storage tanks for bentonite and cement, and storage for reinforcing steel, likely consisting of wide flange steel beams. Short sheet pile starter walls may be required if the river water level was above the ground surface at the wall location. All equipment and working area, including the mixing tanks, storage tanks, and reinforcing steel laydown areas, would be adjacent to the work trestle and could be moved along the length of the intake structure to maintain proximity to the actual work site.

The wall excavator would construct a panel about 8 feet long to the full depth of the wall. That excavation would be filled with bentonite slurry mixed with the native soil to keep the excavated area from collapsing. After it was fully excavated, cement would be introduced to the full soil bentonite column and mixed into place during a slow withdrawal process. Reinforcing steel would be placed at a predetermined spacing in the uncured panel using vibration where necessary. Wall panels would be placed in an alternating (every other one) pattern. Once the initially constructed panels achieved suitable strength, the intermediate panels (between initial panels) would be placed and the excavation for these panels would overlap into the previous placed panels to provide a continuous wall.

3.1.2 Sheet Pile Walls

For the remaining cofferdam walls, there are two typical methods for installing sheet piles: (1) the traditional impact hammer approach, and (2) the vibratory approach. The impact hammer approach would be challenging for areas near residential properties because of the noise created by the diesel or air hammer. The use of noise walls and acoustic shrouds would reduce the noise. However, noise walls would be difficult to install on the water side, and residences across the river, as well as other sensitive resources, may be affected by noise and the more acute pressure spikes within the water column. Given that the revised cofferdam approach reduces the depth of sheetpile penetration and eliminates the need to install the heavy wide-flange king piles, the use of a vibrating pile head installer would also be expected to be a viable option for the construction of most sheet pile portions of the cofferdam. The vibratory method reduces the acute pressure spikes, and while noise is also an issue for vibratory installation, it is typically considerably lower than noise associated with impact hammer installation.

According to the results of the vibratory installation analysis (Attachment 1), it may be anticipated that up to the last 10 feet of the sheetpiles would require the use of impact driving to install. The need to use impact driving may also be the result of clogged interlocks between sheets, delays in vibratory installation that result in “setup,” or encountering dense or very hard soils or gravels.

3.1.3 Deep foundation system

The prior discussion and Figure 2 do not depict the presence of a deep foundation system for the intake structure. Like the construction sequence used for the Freeport Intake, the DCA intake cofferdam concept requires the installation of the tremie concrete base slab prior to dewatering the cofferdam. Figure 4 shows the steel casings of the drilled shaft foundation extending above the water level in the cofferdam at the Freeport Intake. These casings were installed from a trestle above the water surface following full depth excavation and prior to pouring the tremie slab. It is assumed that a similar sequence would be employed for the DCA cofferdam concept; however, the spacing and arrangement of the deep foundation would need to consider the installation of the third row of tiebacks and two additional rows of struts to ensure there are no physical conflicts between the drilled casings and the struts or tieback installation. The vibratory preinstallation of the steel casings would actually strengthen the intake foundation and provide tie-down for the tremie slab, allowing a thinner slab to resist hydrostatic uplift.



Figure 4. Tremie Concrete Placement at Freeport Intake

Casings for drilled pier foundation shown with provisions to attach work trestle

4. Analysis

The revised cofferdam concept was analyzed at the site of Intake C-E-3 for the Tee Screen Alternative using an elastoplastic analysis with the software package DeepEx 2018 (Deep Excavation LLC, 2018). The Tee Screen Alternative was analyzed because it is generally sited closer to the levee crest and therefore represents the greatest height of retained soil. Attachment 2 provides the results of the analysis.

Two checks of the DeepEx analysis were performed. The first was a check of wall stability using the DeepEx estimates of loads at 3 stages of the cofferdam construction: DMM back wall at final stage, sheet pile front wall final stage, and DMM back wall at interim stage. The second check was an independent calculation of back wall stability using the approach described in the Caltrans Trenching and Shoring Manual (Caltrans, 2011) and referred to as the “hinge method”. This approach also uses an “apparent” earth pressure distribution, but calculated support forces independently, instead of using the support forces from DeepEx.

5. Results

The results of the analysis (Attachment 2), which were confirmed using the check calculations, indicate the use of a stiff anchored back wall is structurally viable, and would significantly reduce the need for impact sheetpile driving in the river.

Table 1 summarizes the revised cofferdam impact driving.

Table 1. Summary of Pile Drivability Evaluations for Intakes C-E-2, 3, and 5

Intake	Estimated Pile Tip Elevation (feet)	Flow (cfs)	Screen Type	Number of sheetpile pairs	Blows ^a	Total Number of Blows		Time ^b (minutes)	Total Time (hours) ^c
						On-land	In-water		
C-E-2	-55	1,500	Tee ^e	269	20	-	5,380	2 ^d	9
C-E-2	-55	1,500	Plate ^f	324	20	-	6,480	2 ^d	11
C-E-3	-60	3,000	Tee ^e	420	19	-	7,980	2 ^d	15
C-E-3	-60	3,000	Plate ^f	492	19	-	9,350	2 ^d	17
C-E-5	-55	1,500	Tee ^e	277	10	-	2,770	2 ^d	10
C-E-5	-55	1,500	Plate ^f	324	10	-	3,240	2 ^d	11
C-E-5	-55	3,000	Tee ^e	410	10	-	4,100	2 ^d	14
C-E-5	-55	3,000	Plate ^f	509	10	-	5,090	2 ^d	17

^a Estimated per sheetpile pair from Figures 1 through 3 of Attachment 1.^b Driving time per sheetpile pair.^c Estimated total driving time has been rounded up. It presents estimate of impact pile driving time only.

Time for the partial vibratory pile installation, equipment setup, periodic alignment check, and downtime are not considered in the estimate.

^d Required driving time is assumed to be 2 minutes.^e Quantities account for the intake structure location that provides water surface level impact compliance.^f Quantities have not been adjusted for relocating the intake structure to account for water surface level impact compliance. If the vertical flat plate intake structure is selected for implementations, these values would need to be revised.

Comparing the results provided in Table 1 to the results in Table 5 of Attachment 1, the elimination of the sheetpile-supported back wall and the elimination of the use of king piles in the front and side walls have reduced the cumulative number of impact pile strikes to between 2- and 15-percent of those of the initial approach.

6. Duration

The driving time identified in Table 1 does not account for the handling of the sheetpile pair, nor the time required to perform the primary vibratory installation. For the purpose of estimating the total duration of pile driving it is assumed that 2 crews will perform the vibratory installation at each intake, and that each intake sheetpile construction period is staggered by approximately 1 year. Setting the pile pair in the template and vibratory driving is anticipated to take 1 hour per pair, on average.

It is therefore estimated that the longest installation period would be 255 hours, or roughly 5 weeks for the 3,000 cfs plate screen alternative at Intake 5. During this 5-week period there would be a total of 1,018 minutes (17 hours) of pile impact driving. This assumes that the impact driving would be completed by a separate 3rd crew who followed after each of the 2 vibratory crews.

If the same 2 vibratory crews were responsible for impact driving, which could be preferable from an installation standpoint, then the crews could spend the last portion of each day completing the installation with impact driving. If it takes 1 hour to swap from the vibratory to impact hammer and back again each

day then the total duration of pile pair installation would be 5 weeks plus 26 hours of hammer-swap, and 17 hours of impact driving for the 3,000 cfs plate screen alternative at Intake 5. This approach would result in 17 hours of impact driving during a roughly 6-week period.

7. Intake Structure Configuration

Similar to the approach used for the Freeport Intake, the current concept for intake cofferdam construction does not anticipate relying on the tiebacks and the DMM back wall for support of the ground in the intake structure's permanent condition. It is anticipated that "windows" in the back wall of the permanent intake would allow access to the tiebacks during construction, which would in turn be detensioned when the intake structure was capable of transferring the lateral loads to the deep foundation. The "windows" would then be sealed, as no further access to the tiebacks would be required.

Tiebacks would be spaced as required to avoid conflicts with the intake discharge piping and ground improvement DMM grid, and portions of the tiebacks may need to be removed, after detensioning.

8. References

State of California Department of Transportation (Caltrans). 2011. Trenching and Shoring Manual. Revision 1. August.

DeepEx 2018. Deep Excavation LLC. New York, NY. Version 18.0.0.61.

Department of Water Resources (DWR). 2013. 2009 – 2012 Geotechnical Data Report, Pipeline/Tunnel Option. Delta Habitat Conservation and Conveyance Program.

9. Document History and Quality Assurance

The listed reviewers have completed an internal quality control (QC) review check and approval process for deliverable documents that is consistent with procedures and directives identified by the Engineering Design Manager (EDM) and the DCA.

Approval Names and Roles			
Prepared by	Internal Quality Control review by	Consistency review by	Approved for Submission by
Andrew Finney / EDM Geotechnical and Field Work Lead	Dean Harris / EDM Geotechnical Engineer	Gwen Buchholz / DCA Environmental Consultant Phil Ryan / EDM Design Manager	Terry Krause / EDM Project Manager

This interim document is considered preliminary and was prepared under the responsible charge of Andrew Finney, California Professional Engineering License GE2759.

Attachment 1
Cofferdam Pile-driving Analyses

FINAL DRAFT

Subject	Pile Driving Analyses for Cofferdam Construction at Intakes 2, 3, and 5 (Draft)
Project feature	Geotechnical
Prepared for	California Department of Water Resources (DWR)/Delta Conveyance Office (DCO)
Prepared by	Delta Conveyance Design and Construction Authority (DCA)
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Date/Version	July 1, 2020 Rev 0
Reference no.	EDM_GE_CE_MEM_Pile Driving Analyses_000504_V01_D_20200414

1. Introduction

The purpose of this technical memorandum is to evaluate the installation of piling to be used to construct temporary cofferdams to facilitate in-river intake construction for the Delta conveyance project.

Temporary in-river cofferdam structures would be planned at Intakes 2, 3, and 5 for the Delta Conveyance Project. The purpose of the cofferdams would be to create a temporary enclosure to isolate the construction area for the intake structure from the Sacramento River water and river bank soil to allow construction of the intake structures in dry conditions.

It is assumed that there would be a large unbalanced lateral load acting on the back cofferdam wall and a lack of soil resistance acting on the front cofferdam wall. Development of the criteria also considered the system employed for the cofferdam used during construction of upstream Freeport Intake. The temporary cofferdams are assumed to be a combined wall system, such as those manufactured by Arcelor-Mittal and consisting of king piles (HZ 680M LT) and paired intermediary sheet piles (AZ 40-700). An interlock connector would be welded at the end of the flange of the king pile (wide-flange pile), and a pair of intermediary sheet piles would be attached to the connectors between two king piles. The intermediary sheet piles would transfer the soil and water pressure to the king piles, which carry most of the load.

It is anticipated that the piles would be installed with vibratory hammers in the upper soil layers, followed by impact hammers in the lower hard and dense soil layers to the pile termination depths. This memorandum summarizes the pile drivability analyses, the number of piles anticipated, the estimated total number of impact hammer blows to install the king and intermediary piles, and the estimated impact hammer driving time for each of the cofferdam structures. It also discusses potential mitigation measures to reduce the need for impact pile driving.

1.1 Organization

- Subsurface Conditions
- Analysis Methodology
- Results
- Conclusion
- Further Studies
- References
- Document History and Quality Assurance

2. Subsurface Conditions

2.1 Intake 2

The Intake 2 structure would be located approximately 1,900 feet south of the intersection of Scribner Road and State Route 160 (River Road) along the east bank of the Sacramento River. Six overwater borings (DCR2-DH-4 to DRC2-DH-009) were drilled to depths ranging from approximately 120 to 142 feet below the mudline at the site in 2010 and 2012.

A review of the six borings indicated that the subsurface conditions at Intake 2 may be divided into a softer and looser upper layer and a harder and denser lower soil layer. Boring DCR2-DH-004, which encountered the thinnest upper soil layer, was selected to be representative of the general soil conditions at Intake 2, for conservatism. Based on this borehole, the upper soil layer at Intake 2 is approximately 37 feet in thickness and consists of very loose to medium silt (ML) and sand (SM, SP), followed by a lower soil layer of stiff to very stiff fat clay (CH) and lean clay (CL) and primarily medium to very dense sands (SM, SP, SW-SM). Attachment 1 contains the boring DCR2-DH-004 log.

2.2 Intake 3

The Intake 3 structure would be located 1.75 miles south of Intake 2 and is approximately 2,100 feet southwest of the intersection of River Park Drive and State Route 160 (River Road) along the east bank of the Sacramento River. Three overwater borings (DCR3-DH-013 to DRC3-DH-015) were drilled to depths ranging from approximately 140 to 142 feet below the mudline at the site in 2012.

Similar to Intake 2, the subsurface conditions at Intake 3 can be divided into upper and lower soil layers. Boring DCR3-DH-014 was selected to be representative of the general soil conditions at Intake 3 in our analyses for conservatism. Based on this borehole, the upper soil layer at Intake 3 is approximately 18.1 feet in thickness and consists of lean clay (CL) and loose to medium sand (SM, SP), underlain by a lower soil layer of very stiff to hard lean clay (CL) and fat clay (CH) and dense to very dense silt (ML), sand (SM, SC, SP, SW, SP-SM) and gravel (GM, GP, GW-GM). Attachment 1 contains the boring DCR3-DH-014 log.

2.3 Intake 5

The Intake 5 structure would be located approximately 1.5 miles southwest of the intersection of Hood-Franklin Road and State Route 160 (River Road) along the east bank of the Sacramento River. Three overwater borings (DCR5-DH-013, DCR5-DH-004, and DRC5-DH-014) were drilled to depths ranging from approximately 138 to 142 feet below the mudline at the site in 2009 and 2012.

Boring DCR5-DH-014, with the thinnest upper soil layer, is selected to be representative of the general soil conditions at Intake 5 in our analyses for conservatism. Based on this boring, the upper soil layer at Intake 5 is approximately 36.3 feet in thickness and consists of very soft lean clay (CL) and loose to medium sand (SM, SP-SC), followed by a lower layer of very stiff to hard lean clay (CL) and fat clay (CH) and medium to very dense sand (SM, SP, SW, SP-SM) and gravel (GP). Attachment 1 contains the boring DCR5-DH-014 log.

3. Analysis Methodology

Table 1 summarizes anticipated lengths and numbers of planned cofferdam piles.

Table 1. Summary of Potential Cofferdam Characteristics

Intake	Linear Footage of Piles ^a		Sheet Pile Tip Elevation (feet)	Mudline Elevation (feet)	Number of Piles Required (by type) ^b					
	On-land	In-water			On-Land		In-Water			
					King Piles	Sheet Pile Pairs	King Piles	Sheet Pile Pairs		
2	1,869	2330	-85	-12.5	306	306	382	382		
3	1563	2151	-60	-32.5	256	256	352	352		
5	1,665	2228	-55	-16.0	273	273	365	365		

^a Includes 3 interior cofferdam partition walls.

^b Each 6.1-foot increment of perimeter includes a single king pile and a paired sheet pile.

It is anticipated that pile installation will use vibratory methods where the strength and density of the soil make it feasible. Where the conditions make vibratory installation impractical, impact pile driving will be required.

3.1 Vibratory Pile Driving

Vibratory pile driving would result in less noise and could reduce the potential damage to adjacent structures. In general, vibro-drivability of a pile is governed by soil resistance along the pile shaft and at the toe of the pile. To estimate the viable depth of vibratory pile penetration at each intake location, an empirical assessment was used (GE Solution Consulting Ltd., 2020). The parameters considered in the drivability assessment included pile embedment (length), blow count (N-value), undrained shear strength (for cohesive soils), relative density (for cohesionless soils), and groundwater conditions (for cohesionless soils). A drivability rating of Easy, Moderate, Difficult, or Refusal was assigned to different pile embedment lengths based on these parameters, as summarized in Attachment 2.

3.2 Impact Pile Driving

Where vibratory installation was rated as “moderate to difficult” or “difficult” (Attachment 2), pile installation could require an impact method, generally using diesel or compressed air to operate the impact hammer. Impact hammer pile drivability analysis was performed using GRLWEAP (Pile Dynamics Inc., 2010), a one-dimensional wave equation analysis program that simulates the pile response to pile driving equipment. GRLWEAP calculations can be used to estimate the relationship between pile bearing capacity, hammer blow count, hammer stroke, pile stress, and penetration depth. The simulation allows the user to evaluate the potential difficulty of driving based on the estimated blow count, stroke, and pile stress.

The following input parameters were required for GRLWEAP analysis:

- Hammer parameters (efficiency, pressure, stroke from GRLWEAP data base)
- Cushion information (assume values or recommended values from GRLWEAP)

- Pile information (from manufacture data sheet)
- Soil quake and damping parameters (recommended values from GRLWEAP based on soil conditions)
- Soil profile (Simple Soil Type Method "ST" in GRLWEAP)

4. Results

Table 2 summarizes the results of the empirical analysis of vibratory pile installation at Intake 2.

Table 2. Summary of Empirical Analysis of Vibratory Pile Installation Considerations at Intake 2

Depth Below Mudline (feet)		Elevation (feet)		Reported Blow Counts (SPT "n" in blows per foot)	Soil Type (USCS)	Vibratory Drivability Assessment ^a
From	To	From	To			
0	14.5	-12.5	-27.0	11	SP	Easy
14.5	23.2	-27.0	-35.7	2, 13	ML	Moderate to difficult
23.2	28.2	-35.7	-40.7	17	SM	Moderate
28.2	37.0	-40.7	-49.5	22	SP	Moderate
37.0	47.0	-49.5	-59.5	6, 19	SP	Difficult

^a Refer to Attachment 1 for additional detail on assessment.

Easy = piles driving within bounds of hammer capacity, pile advancing at a rate greater than 0.1 meter per second (0.328 foot per second).*

Moderate = piles driving close to bounds of hammer capacity, pile advancing at a rate up to 0.05 meter per second (0.164 foot per second).*

Difficult = piles driving at hammer capacity typically, pile advancing at a rate up to 0.01 meter per second (0.033 foot per second).* (Generally achievable with leader rig crowd force; not achievable with excavated-mounted hammers.)

Refusal = pile resistance in excess of hammer capacity, pile advancing at a rate less than 0.01 meter per second (0.033 foot per second).^b

*Driving rates are averaged over 1 meter (3.281 feet) depth of driving.

Note:

USCS = Unified Soil Classification System

Based upon the results of this analysis, as summarized in Table 2, it appears that vibratory methods could achieve a penetration below the mudline of up to approximately 37 feet. Below this depth, impact methods would probably be required.

Table 3 summarizes the results of the empirical analysis of vibratory pile installation at Intake 3.

Table 3. Summary of Empirical Analysis of Vibratory Pile Installation Considerations at Intake 3

Depth Below Mudline (feet)		Elevation (feet)		Reported Blow Counts (SPT "n" in blows per foot)	Soil Type (USCS)	Vibratory Drivability Assessment ^a
From	To	From	To			
0	8.4	-32.6	-41.0	9	SP	Easy
8.4	14.8	-41.0	-47.4	5	SM	Easy
14.8	18.1	-47.4	-50.7	12	CL, SM	Easy
18.1	26.6	-50.7	-59.2	81	GP, GM	Moderate to Difficult
26.6	31.5	-59.2	-64.1	29	SM	Moderate to Difficult

^a Refer to Attachment 1 for additional detail on assessment.

Easy = piles driving within bounds of hammer capacity, pile advancing at a rate greater than 0.1 meter per second (0.328 foot per second).*

Moderate = piles driving close to bounds of hammer capacity, pile advancing at a rate up to 0.05 meter per second (0.164 foot per second).*

Difficult = piles driving at hammer capacity typically, pile advancing at a rate up to 0.01 meter per second (0.033 foot per second).* (Generally achievable with leader rig crowd force; not achievable with excavated-mounted hammers.)

Refusal = pile resistance in excess of hammer capacity, pile advancing at a rate less than 0.01 meter per second (0.033 foot per second).*

*Driving rates are averaged over 1 meter (3.281 feet) depth of driving.

Based upon the results of this analysis, as summarized in Table 3, it appears that vibratory methods could achieve a penetration below mudline of up to approximately 18 feet. Below this depth, impact methods would probably be required.

Table 4 summarizes the results of the empirical analysis of vibratory pile installation at Intake 5.

Table 4. Summary of Empirical Analysis of Vibratory Pile Installation Considerations at Intake 5

Depth Below Mudline (feet)		Elevation (feet)		Reported Blow Counts (SPT "n" in blows per foot)	Soil Type (USCS)	Vibratory Drivability Assessment ^a
From	To	From	To			
0	21.0	-16.2	-37.2	10, 20	SP-SC	Easy
21.0	28	-37.2	-44.2	2	CL	Easy
28	36.3	-44.2	-52.5	7	SM	Easy
36.3	42.5	-52.5	-58.7	20	SP	Moderate to difficult

^a Refer to Attachment 1 for additional detail on assessment.

Easy = piles driving within bounds of hammer capacity, pile advancing at a rate greater than 0.1 meter per second (0.328 foot per second).*

Moderate = piles driving close to bounds of hammer capacity, pile advancing at a rate up to 0.05 meter per second (0.164 foot per second).*

Difficult = piles driving at hammer capacity typically, pile advancing at a rate up to 0.01 meter per second (0.033 foot per second).* (Generally achievable with leader rig crowd force, not achievable with excavated-mounted hammers.)

Refusal = pile resistance in excess of hammer capacity, pile advancing at a rate less than 0.01 meter per second (0.033 foot per second).*

*Driving rates are averaged over 1 meter (3.281 feet) depth of driving.

Based upon the results of this analysis, as summarized in Table 4, it appears that vibratory methods could achieve a penetration below mudline of up to approximately 36 feet. Below this depth, impact methods would probably be required.

4.1 Impact Pile Driving

Impact pile drivability evaluations were conducted using a number of commercially available diesel hammers to assess variability. The intervals for which vibratory methods were judged to be suitable were defined in the previous section. The impact driving analysis included the friction of the pile within these upper layers where vibratory methods were judged to be suitable, but the number of individual pile strikes and the time required to achieve the tip penetration for these upper layers (identified in Section 3) were not considered to be major factors and were discounted. A BERMINGHAMMER Model B6505 hammer was selected as a typical large hammer suitable for use, with a rated energy of 203 kip-feet. For Intakes 2 and 5, the model assumed a full hammer stroke height of 11.5 feet. For Intake 3, the model assumed a full hammer stroke height of 6.8 feet to reduce driving stress on the piles. Figures 1 to 3 include drivability model results with pile tip elevations versus cumulative pile strikes (hammer blows). Table 5 summarizes the results for all of the intake locations. Attachment 3 contains GRLWEAP output reports.

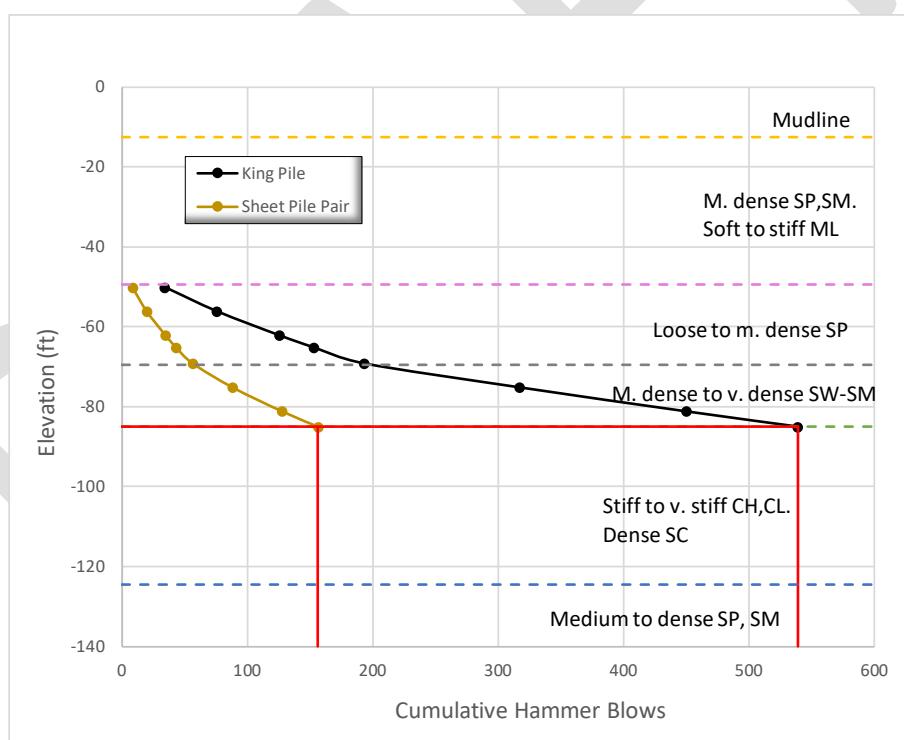


Figure 1. Impact Hammer Pile Drivability Plot for Intake 2

HZ 680 M LT H-Pile & AZ 40-700 Sheet Pile / BERMINGHAMMER B6505

Notes:

m. = medium

v. = very

Soil Types:

CH = Fat Clay

SM = Silty Sand

CL = Clay

SP = Poorly-Graded Sand

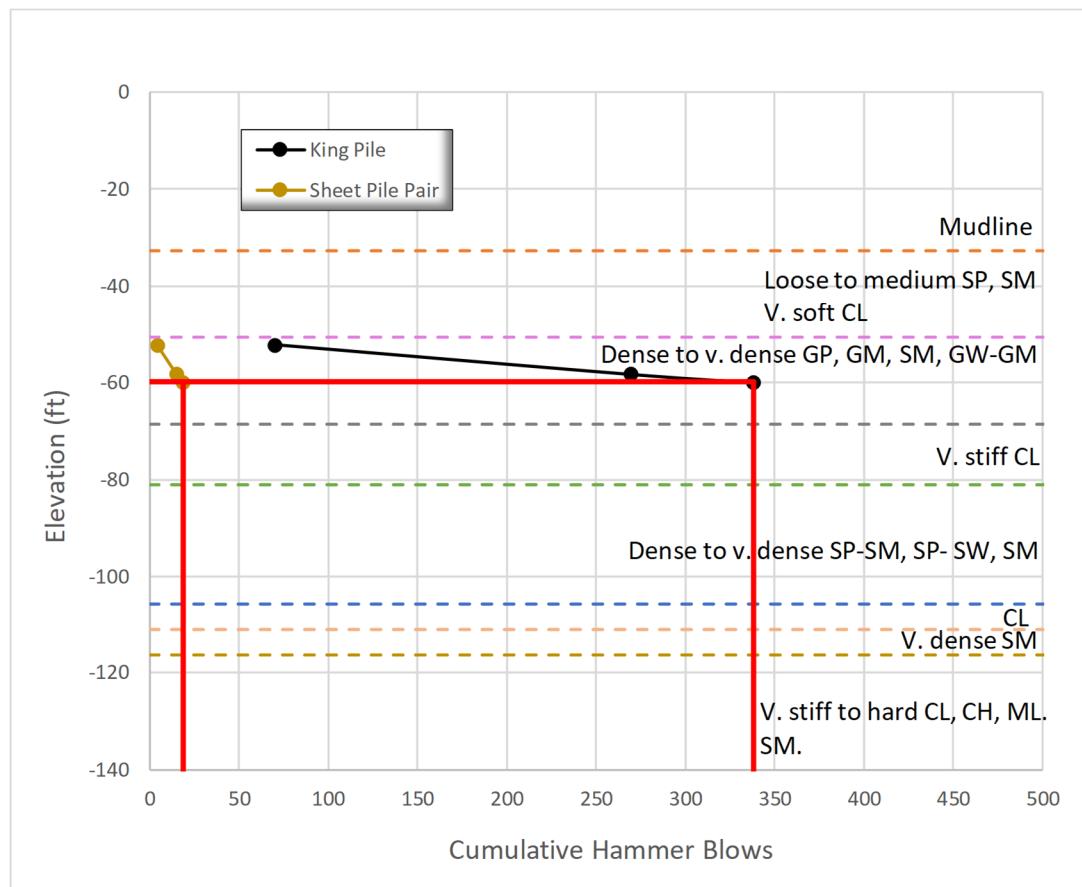


Figure 2 Impact Hammer Pile Drivability Plot for Intake 3
HZ 680 M LT H-Pile & AZ 40-700 Sheet Pile / BERMINGHAMMER B6505

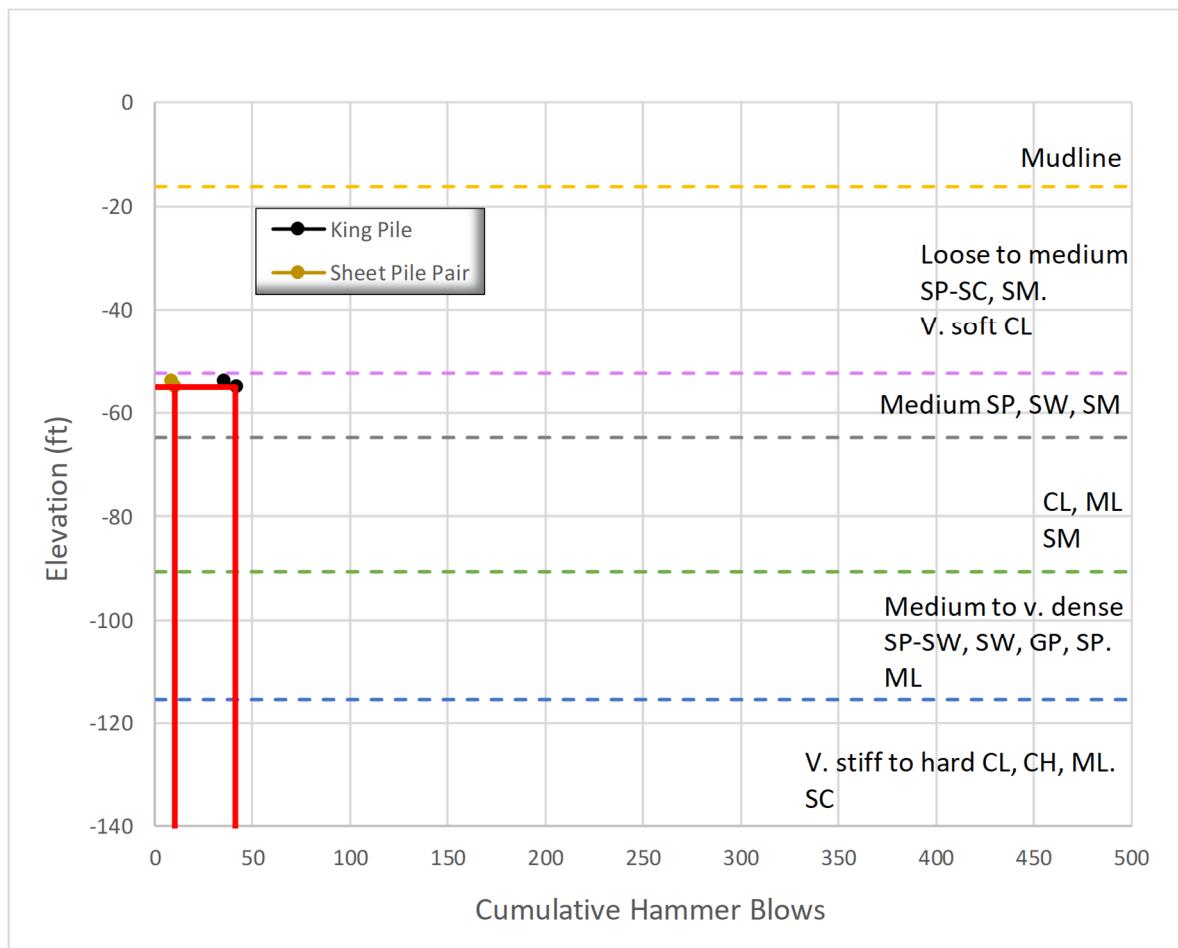


Figure 3 Impact Hammer Pile Drivability Plot for Intake 5
HZ 680 M LT H-Pile & AZ 40-700 Sheet Pile / BERMINGHAMMER B6505

4.1.1 Pile Drivability Summary

Table 5 summarizes the pile drivability evaluation for Intakes 2, 3, and 5. The summary includes estimates of the following:

- Total number of king piles and sheet pile pairs required for each intake
- Cumulative hammer blows to drive all the king piles and sheet pile pairs for each intake
- Driving time

Table 5. Summary of Pile Drivability Evaluations for Intakes 2, 3, and 5

Intake	Estimated Blows per Pile ^a		Total Number of Blows ^b		Driving Time per Pile (minutes)		Total Driving Time (hours) ^c	
	King Pile	Sheet Pile Pair	On-Land	In-Water	King Pile	Sheet Pile Pair	On-Land	In-Water
2	539	156	212,670	265,490	11	3	75	90
3	338	19	91,392	125,664	6	2 ^d	35	50
5	41	10	13,923	18,615	2	2 ^d	20	25

^a From Figures 1 through 3.

^b Refer to Table 1 for total number of piles.

^c Estimated total driving time has been rounded up. It presents estimate of impact pile driving time only. Time for the partial vibratory pile installation, equipment setup, periodic alignment check, and downtime are not considered in the estimate.

^d Required driving time is negligible, assumed 2 minutes.

5. Conclusion

Based on the empirical vibratory pile installation criteria, it appears that piles could be installed using vibratory methods through the upper soil layer at the intakes. The vibratory pile drive lengths at Intakes 2, 3, and 5 would be approximately 37, 18, and 36 feet, respectively. Following vibratory pile driving, impact pile driving would be required based upon this analysis. The impact pile drive lengths from the interface of the upper and lower soil layers to the bottom of the cofferdams as estimated for Intakes 2, 3, and 5 will be approximately 35.5, 9.5, and 2.5 feet, respectively.

6. Further Studies

It is generally preferable for any construction site to limit the duration of impact pile driving for environmental reasons. One approach is to pre-auger the soils using solid-flight augers in order to permit additional penetration using vibratory methods or to reduce the number of impact blows required to achieve full pile penetration. Based on discussions with pile driving contractors, the practical limit of pre-augering is approximately 100 feet, limited by auger length and available motor torque. Given that the cofferdam piles will likely be installed from a temporary work trestle situated above river flood levels (assume top of deck at elevation 30 feet), the depth from the trestle deck to the mudline is anticipated to be 40 to 60 feet. This puts full pre-augering out of depth range at Intake 2, but more importantly, the significant unsupported length is too great for the augers to handle structurally at all of the intakes.

Other methods to reduce driving resistance include water or air jetting at the pile tip, but these actions could increase environmental disturbance in the Sacramento River water column outside of any cofferdam enclosure, including increasing turbidity downstream.

A sound enclosure could be constructed around the cofferdam structure to reduce offsite noise levels by shrouding the pile driving operations. Means to reduce required pile tip penetration and pile section thickness could also be considered.

Pile driving was most frequently required for the king piles along the back wall at the Freeport Intake. If the required bending resistance could be lowered, it may be possible to eliminate the need for the heavy king piles.

Pile penetration for both the front and back cofferdam walls would be driven by structural demands from the large lateral loads acting on the back wall. Potential modifications to the cofferdam could include degrading the levee behind the back wall once a flood control setback levee would be installed on the land side of the intake site and/or implementing tie-backs or ground improvement to further reduce the structural demands on the cofferdam. Scour potential would also be a concern for the front wall penetration, and that penetration should be selected to prevent undermining of the final intake system. Finally, a stiffer secant pile or diaphragm wall could be selected for the back wall to reduce the demands on the front wall, potentially reducing the structural requirements of the front wall.

7. References

GE Solution Consulting Ltd. 2018. *Note on Sheet Pile Drivability with Vibratory Methods*. <https://ge-solutions.co.uk/wp-content/uploads/2016/01/Note-on-sheet-pile-driveability-with-vibratory-methods.pdf>. Accessed March 2020.

Pile Dynamics Inc. 2010. GRLWEAP. Wave equation analysis of pile driving. Version 2010-6.

8. Document History and Quality Assurance

Reviewers listed have completed an internal quality review check and approval process for deliverable documents that is consistent with procedures and directives identified by the Engineering Design Manager and the DCA.

Rev.	Date	Version Description	Approval Names and Roles			
			Prepared by	Internal QC by	Consistency Review by	Approved for Submission by
0	06/25/2020	Initial Submittal	Myra Au	Dean Harris, Andrew Finney/ Geotechnical Lead	Gwen Buchholz/ DCA Environmental Lead	Terry Krause / Integration Lead

DRAFT

Attachment 1
Divider

INTAKE 2
BOREHOLE DCR2-DH-004



Project: Delta Habitat Conservation and Conveyance Program

Feature: Intake 2, Sacramento River

Coordinates: North 2,336,341.48

East 6,270,668.34

Survey Method: Estimate

Datum: NAD83

GPS: Latitude 38.40690

Longitude -121.51550

County: Sacramento

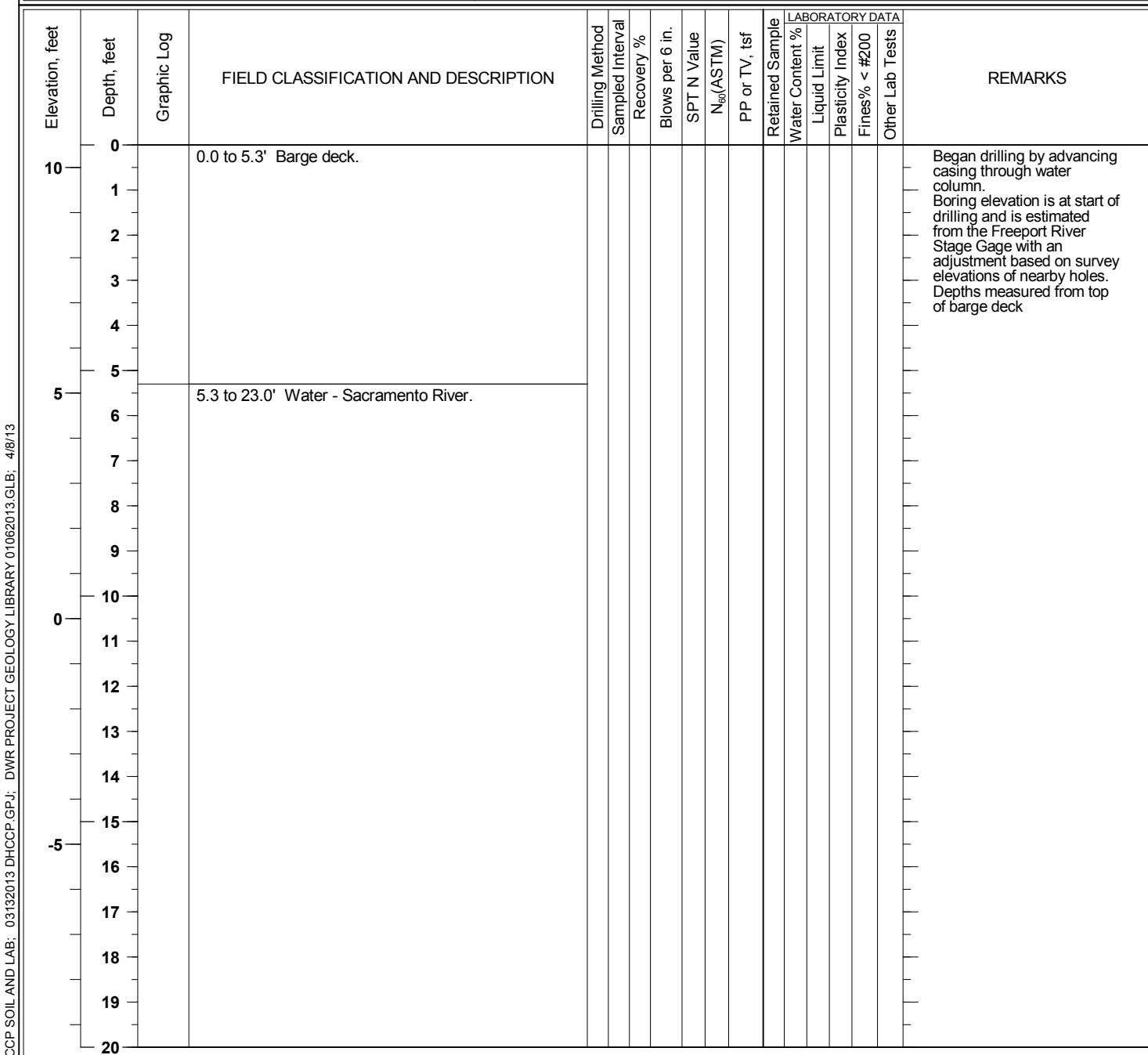
DRILL HOLE LOG

DCR2-DH-004

Sheet 1 of 6

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES

DATE STARTED 10/3/10	DATE COMPLETED 10/4/10	GROUND ELEVATION 10.5 ft	ELEVATION BASIS Gaging Station	TOTAL DEPTH OF BORING 145.0 ft
DRILLING CONTRACTOR Gregg Drilling & Testing, Inc.	DRILLER'S NAME Chris St. Pierre	HELPER'S NAME Oscar/Fine Taufatofua		TOTAL DEPTH OF FILL
DRILLING METHOD 23 - 145 ft: RD	DRILL RIG MAKE AND MODEL Mobile B-80, D-23			DWR/CONSULTANT COMPANY DWR/URS
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 5.5" drag bit	DRILLING ROD TYPE AND DIAMETER 4.5" O.D. HWT & 2.5" NWJ			FIELD LOGGER P. Crispell/D. Perry
<input checked="" type="checkbox"/> VERTICAL <input type="checkbox"/> INCLINED	CASING TYPE, DIAMETER, INSTALLATION DEPTH 8.5" O.D. threaded steel casing to 35'			FIELD LOG REVIEWER P. Crispell/N. Tollefson
SAMPLER TYPE(S) 2.5" MCal, SPT, 134mm Punch Core, 3" Shelby Tube	HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP Automatic, 140 lbs / 30-inch drop			HAMMER EFFICIENCY 78.9%
BOREHOLE BACKFILL OR COMPLETION Tremie backfilled with 95% cement, 5% bentonite by wt.	GROUNDWATER READING: DURING DRILLING Not Applicable			AFTER DRILLING (DATE-TIME)



Draft 3 After All Lab Data Added 4/2/2013



Project: Delta Habitat Conservation and Conveyance Program

Feature: Intake 2, Sacramento River

Coordinates: North 2,336,341.48

East 6,270,668.34

Survey Method: Estimate

Datum: NAD83

GPS: Latitude_38.40690

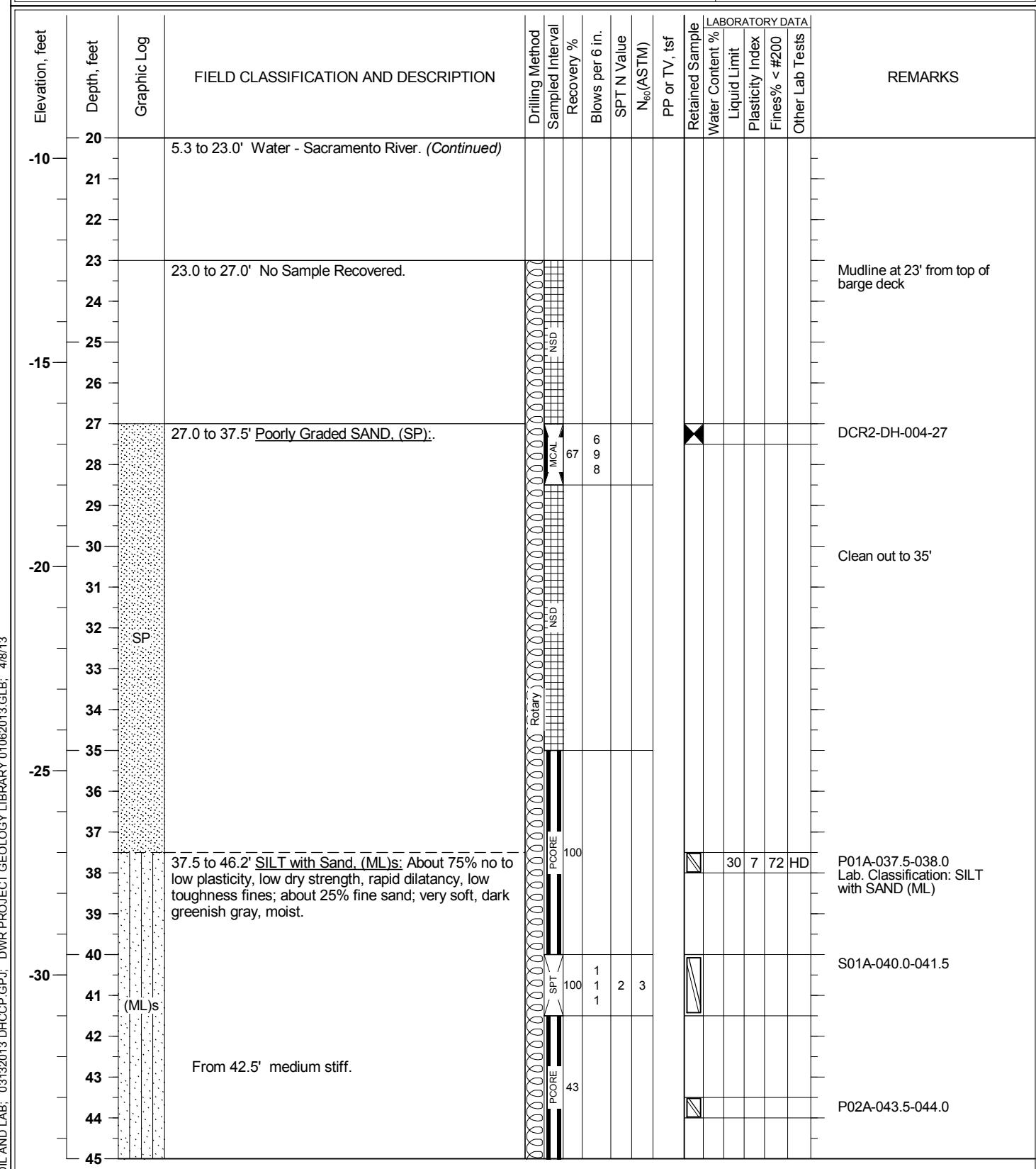
Longitude_-121.51550

County: Sacramento

DRILL HOLE LOG

DCR2-DH-004

Sheet 2 of 6

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES



Project: Delta Habitat Conservation and Conveyance Program

Feature: Intake 2, Sacramento River

Coordinates: North 2,336,341.48

East 6,270,668.34

Survey Method: Estimate

Datum: NAD83

GPS: Latitude_38.40690

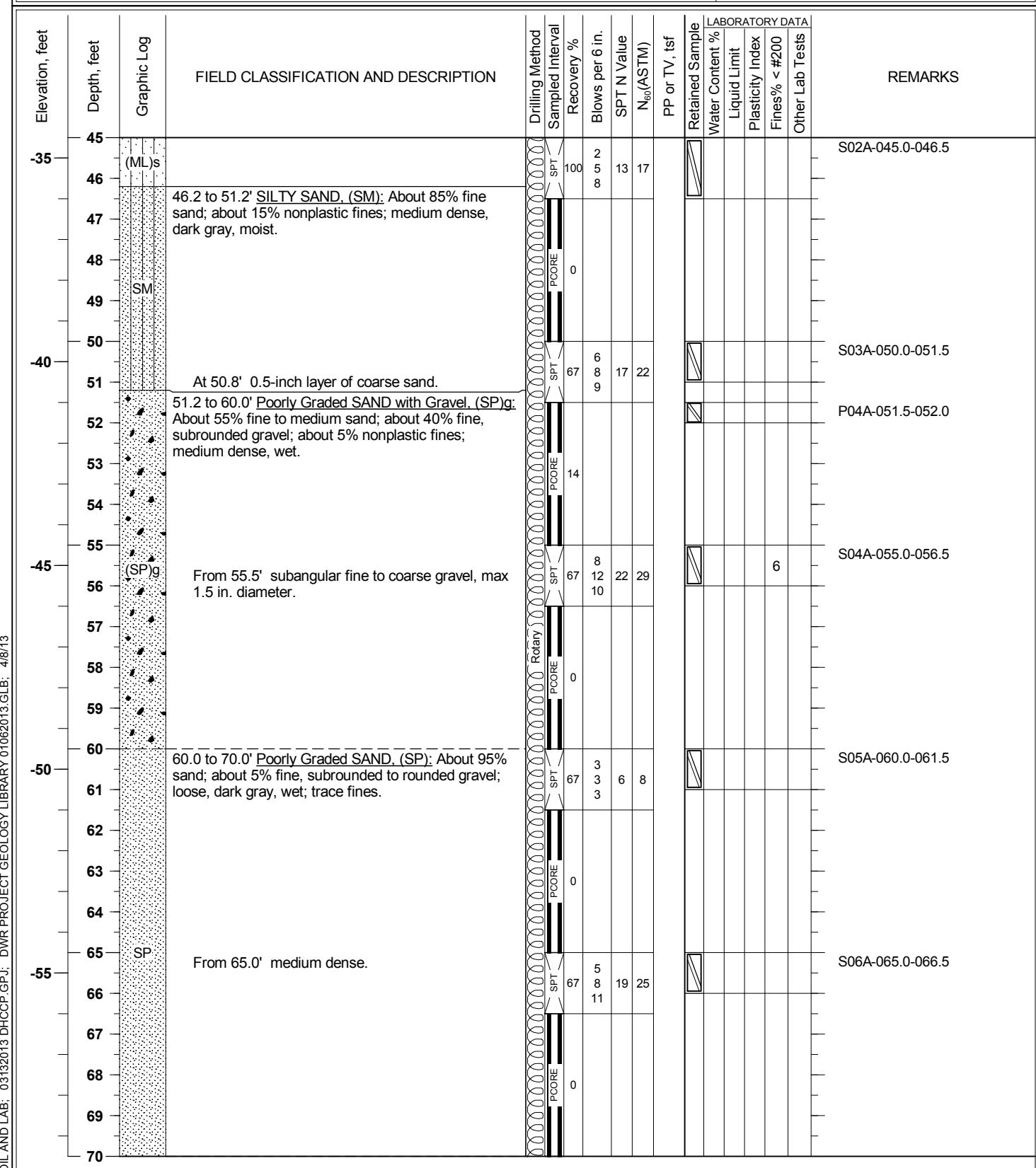
Longitude_-121.51550

County: Sacramento

DRILL HOLE LOG

DCR2-DH-004

Sheet 3 of 6

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES



Project: Delta Habitat Conservation and Conveyance Program

Feature: Intake 2, Sacramento River

Coordinates: North 2,336,341.48

East 6,270,668.34

Survey Method: Estimate

Datum: NAD83

GPS: Latitude 38.40690

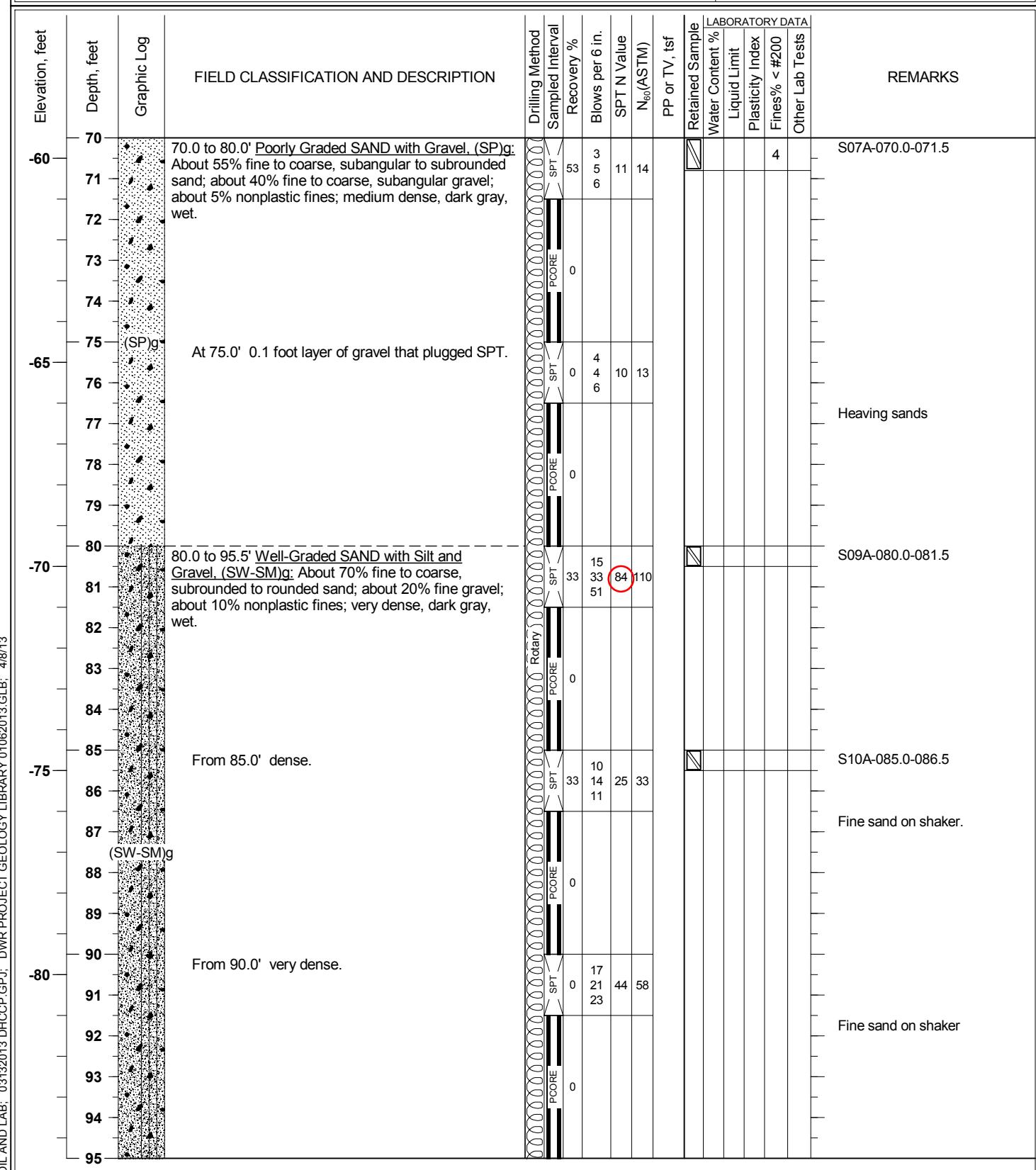
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County: Sacramento

DRILL HOLE LOG

DCR2-DH-004

Sheet 4 of 6

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES



Project: Delta Habitat Conservation and Conveyance Program

Feature: Intake 2, Sacramento River

Coordinates: North 2,336,341.48

East 6,270,668.34

Survey Method: Estimate

Datum: NAD83

GPS: Latitude_38.40690

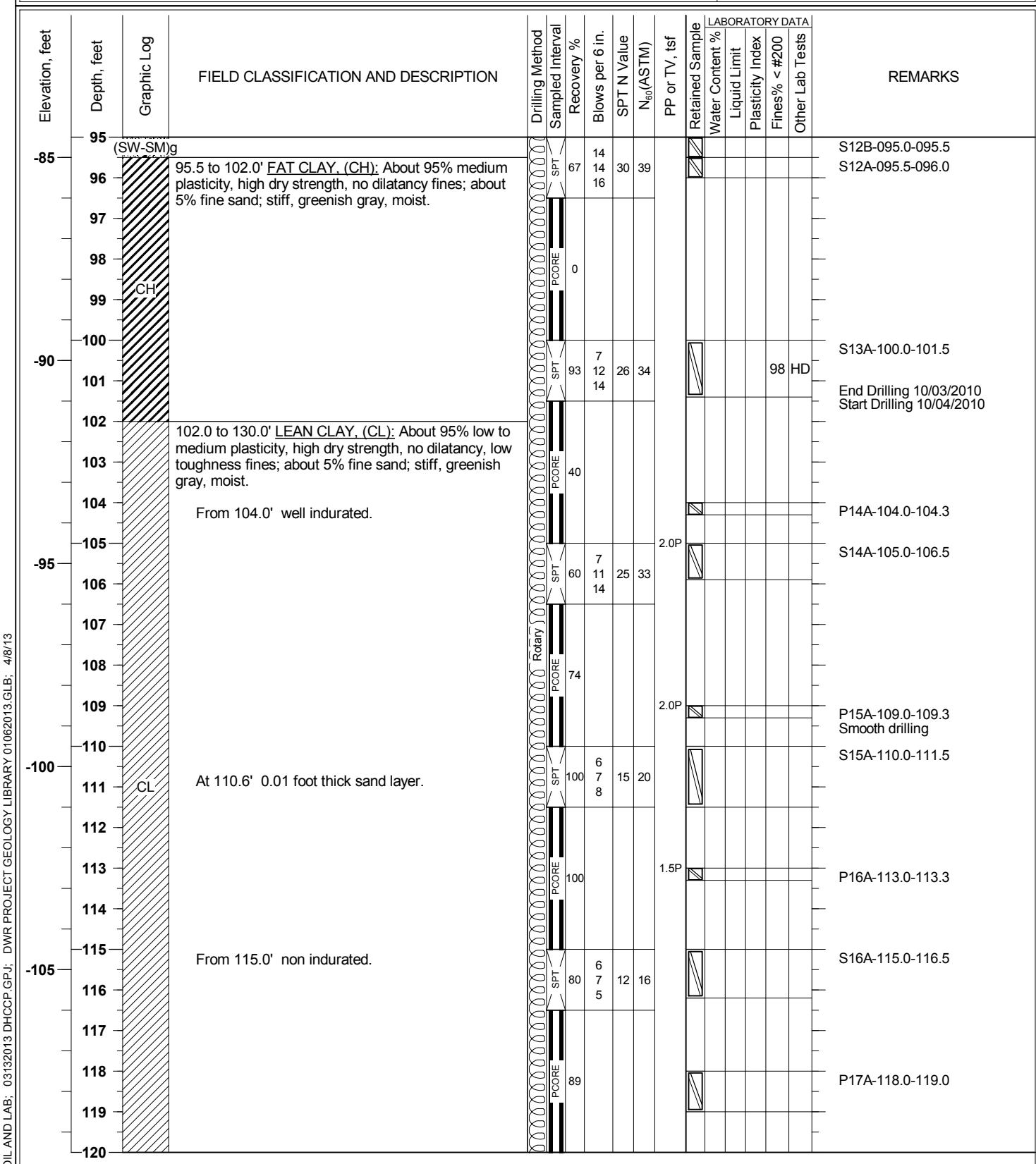
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County: Sacramento

DRILL HOLE LOG

DCR2-DH-004

Sheet 5 of 6

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES



Project: Delta Habitat Conservation and Conveyance Program

Feature: Intake 2, Sacramento River

Coordinates: North 2,336,341.48

East 6,270,668.34

Survey Method: Estimate

Datum: NAD83

GPS: Latitude 38.40690

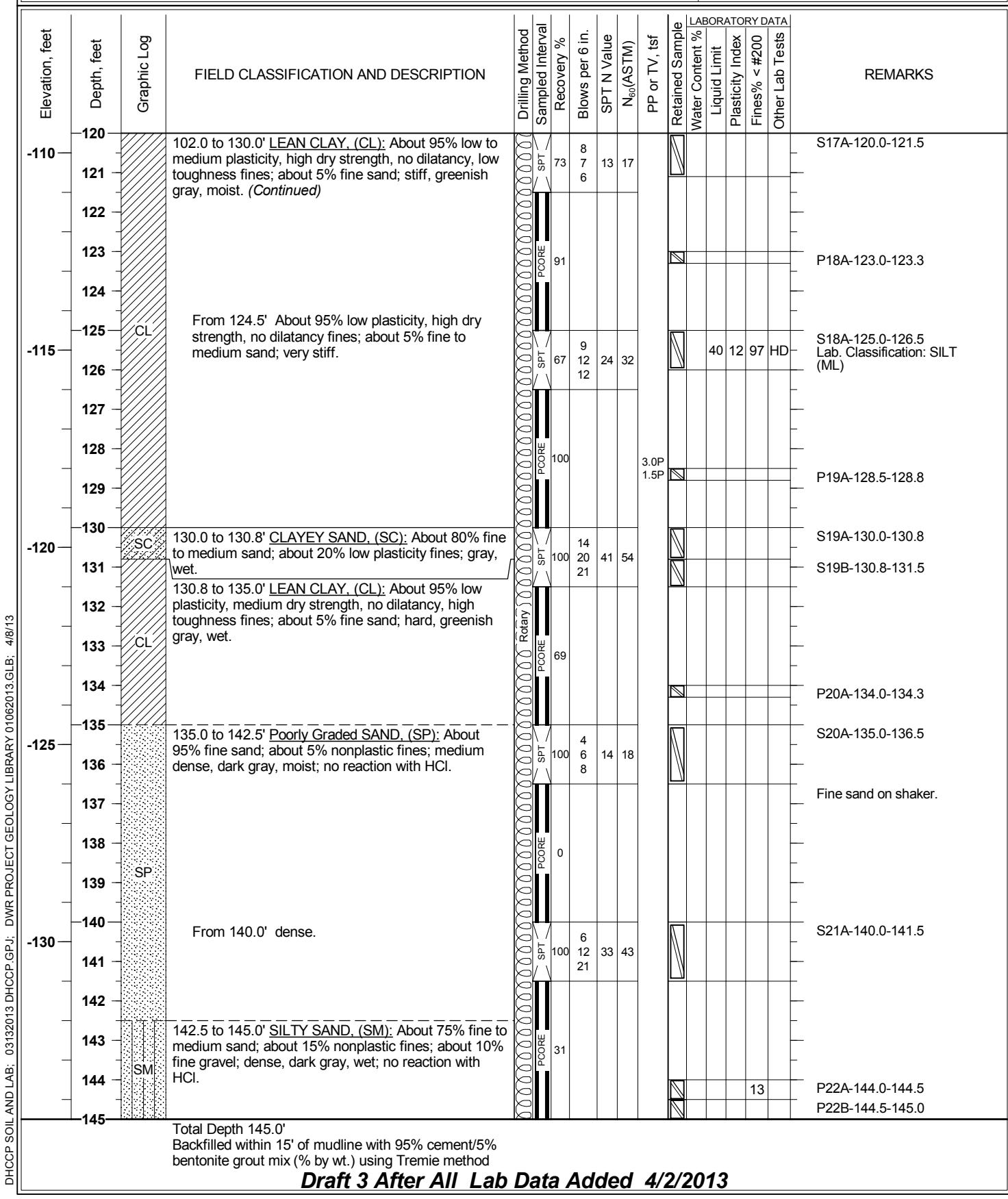
Longitude -121.51550

County: Sacramento

DRILL HOLE LOG

DCR2-DH-004

Sheet 6 of 6

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES

Draft 3 After All Lab Data Added 4/2/2013

INTAKE 3
BOREHOLE DCR3-DH-014



Project: Delta Habitat Conservation and Conveyance Program
 Feature: Intake 3, Sacramento / Sacramento R. near Hood
 Coordinates: North 2,327,416.90 East 6,269,332.35
 Survey Method: Ground Survey Datum: NAD83
 GPS: Latitude Longitude
 County: Sacramento

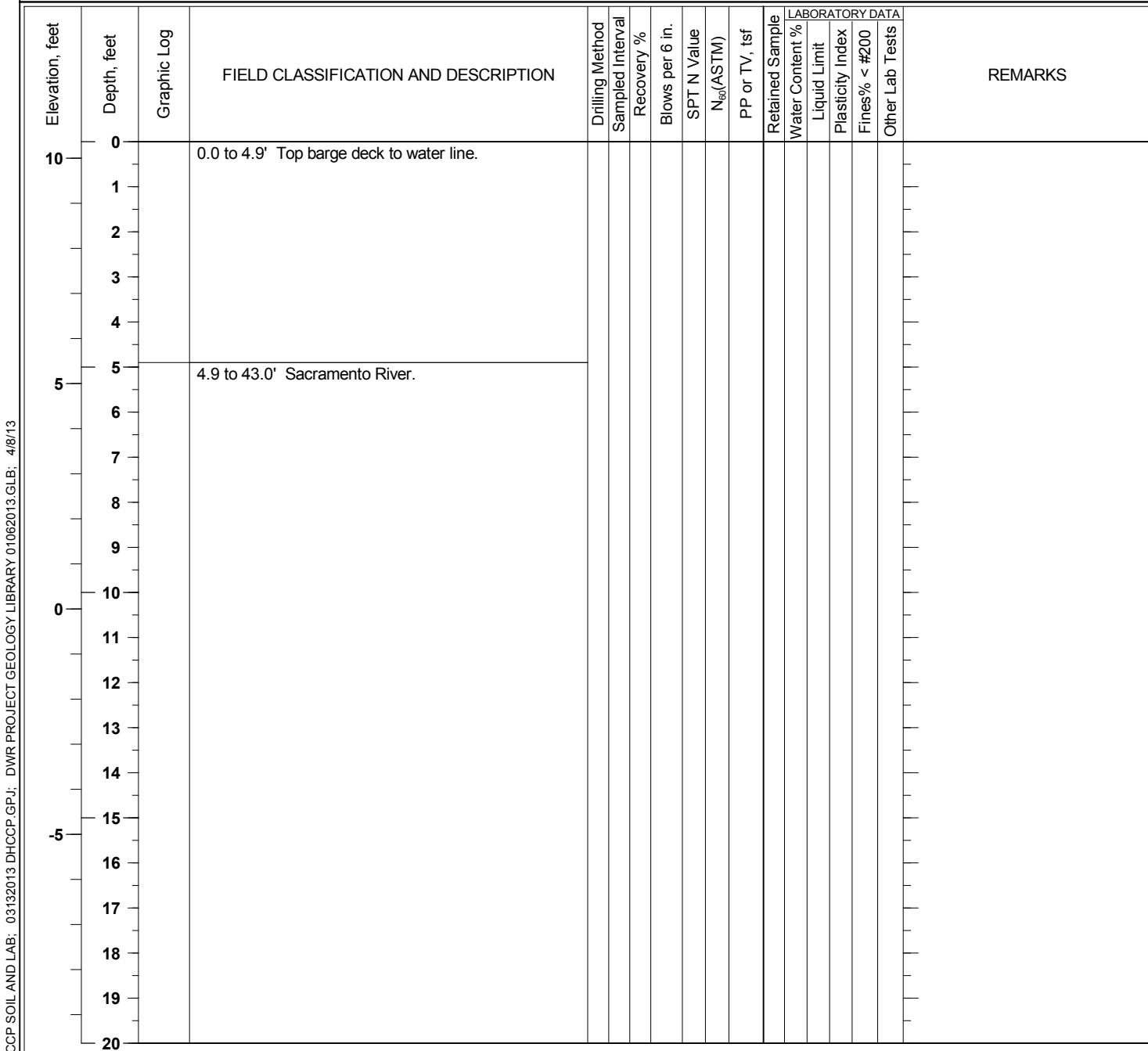
DRILL HOLE LOG

DCR3-DH-014

Sheet 1 of 8

State of California
 California Natural Resources Agency
 DEPARTMENT OF WATER RESOURCES

DATE STARTED 8/22/12	DATE COMPLETED 8/25/12	GROUND ELEVATION 10.37 ft	ELEVATION BASIS Ground Survey	TOTAL DEPTH OF BORING 185.0 ft
DRILLING CONTRACTOR Gregg Drilling & Testing, Inc.	DRILLER'S NAME Chris St. Pierre	HELPER'S NAME Chad Nix		TOTAL DEPTH OF FILL
DRILLING METHOD 43 - 185 ft: RD	DRILL RIG MAKE AND MODEL Mobile B-80, D-21			DWR/CONSULTANT COMPANY DWR/URS
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 5.5" drag bit	DRILLING ROD TYPE AND DIAMETER 4.5" O.D. HWT & 2.5" NWJ			FIELD LOGGER D. Perry
<input checked="" type="checkbox"/> VERTICAL <input type="checkbox"/> INCLINED	CASING TYPE, DIAMETER, INSTALLATION DEPTH 8 5/8" O.D. Threaded to 53'			FIELD LOG REVIEWER D. Pieczynski
SAMPLER TYPE(S) SPT, 3" Pitcher, 134mm punch core	HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP Automatic, 140 lbs / 30-inch drop			HAMMER EFFICIENCY 72.5%
BOREHOLE BACKFILL OR COMPLETION Tremie backfilled with 95% cement, 5% bentonite by wt.	GROUNDWATER READING: DURING DRILLING Not Applicable			AFTER DRILLING (DATE-TIME)



Draft 3 After All Lab Data Added 4/2/2013



Project: Delta Habitat Conservation and Conveyance Program

Feature: Intake 3, Sacramento

Coordinates: North 2,327,416.90

East 6,269,332.35

Survey Method: Ground Survey

Datum: NAD83

GPS: Latitude

Longitude

County: Sacramento

DRILL HOLE LOG

DCR3-DH-014

Sheet 2 of 8

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES

Elevation, feet	Depth, feet	Graphic Log	FIELD CLASSIFICATION AND DESCRIPTION	Drilling Method	Sampled Interval	Recovery %	Blows per 6 in.	SPT N Value	N ₆₀ (ASTM)	PP or TV, tsf	Retained Sample	LABORATORY DATA
20			4.9 to 43.0' Sacramento River. (Continued)									
10												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
20												
31												
32												
33												
34												
35												
36												
37												
38												
39												
40												
41												
42												
43			43.0 to 50.0' Soft river bottom muck. No Sample Taken.	Rotary	NSD							Pushed Casing 53', cleaned out to 50' before first sample
44												
45												



Project: Delta Habitat Conservation and Conveyance Program

Feature: Intake 3, Sacramento

Coordinates: North 2,327,416.90

East 6,269,332.35

Survey Method: Ground Survey

Datum: NAD83

GPS: Latitude

Longitude

County: Sacramento

DRILL HOLE LOG

DCR3-DH-014

Sheet 3 of 8

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES

Elevation, feet	Depth, feet	Graphic Log	FIELD CLASSIFICATION AND DESCRIPTION	Drilling Method	Sampled Interval	Recovery %	Blows per 6 in.	SPT N Value	N ₆₀ (ASTM)	PP or TV, tsf	Retained Sample	LABORATORY DATA	REMARKS
-35	45		43.0 to 50.0' Soft river bottom muck. No Sample Taken. (Continued)										
-40	50	SP	50.0 to 51.4' Poorly Graded SAND, (SP): About 95% fine to medium sand; about 5% nonplastic fines; medium dense, light reddish brown, wet; no reaction with HCl; shells and clams in sample.	Rotary	NSD	73	2 5 4	9	11				S01A-050.0-051.5
-40	51		51.4 to 57.8' SILTY SAND, (SM): About 60% fine sand; about 40% no to low plasticity fines; loose, dark gray, moist; no reaction with HCl.	PCORE	SPT	43							P01A-052.5-053.0
-45	55	SM		PCORE	SPT	67	1 1 4	5	6				S02A-055.0-056.5
-45	58	s(CL)	57.8 to 59.5' SANDY LEAN CLAY, s(CL): About 60% low plasticity, low dry strength, rapid dilatancy, low toughness fines; about 40% fine sand; soft, dark gray, moist; no reaction with HCl.	PCORE	SPT	80							P02A-057.8-058.2
-50	60	SM	59.5 to 61.1' SILTY SAND, (SM): About 65% fine sand; about 35% no to low plasticity fines; medium dense, dark gray, moist; no reaction with HCl.	PCORE	SPT	87	2 4 8	12	15				S03A-060.0-061.5
-50	61	GP	61.1 to 66.1' Poorly Graded GRAVEL with Sand, (GP): About 80% fine, subrounded gravel, maximum size 2 in.; about 15% fine to coarse sand; about 5% nonplastic fines; very dense, gray, wet; no reaction with HCl; trace coarse gravel.	PCORE	SPT	14							End Drilling 8/22/2012 Start Drilling 8/23/2012
-55	66	(GM)s	66.1 to 69.6' SILTY GRAVEL with Sand, (GM)s: About 45% fine, subrounded gravel, maximum size 1.5 in.; about 40% fine to medium sand; about 15% nonplastic fines; very dense, gray, wet; no reaction with HCl; trace coarse subrounded gravel; gravel content variable with depth, from about 15 to 45%.	PCORE	SPT	100	29 45 36	81	98				S04A-065.2-066.1
-55	68	(GM)s		PCORE	SPT	100							S04B-066.1-066.5
-55	69	(SM)g											P04A-068.0-068.5
-55	70	(SM)g	Description on next page.										



Project: Delta Habitat Conservation and Conveyance Program

Feature: Intake 3, Sacramento

Coordinates: North 2,327,416.90

East 6,269,332.35

Survey Method: Ground Survey

Datum: NAD83

GPS: Latitude

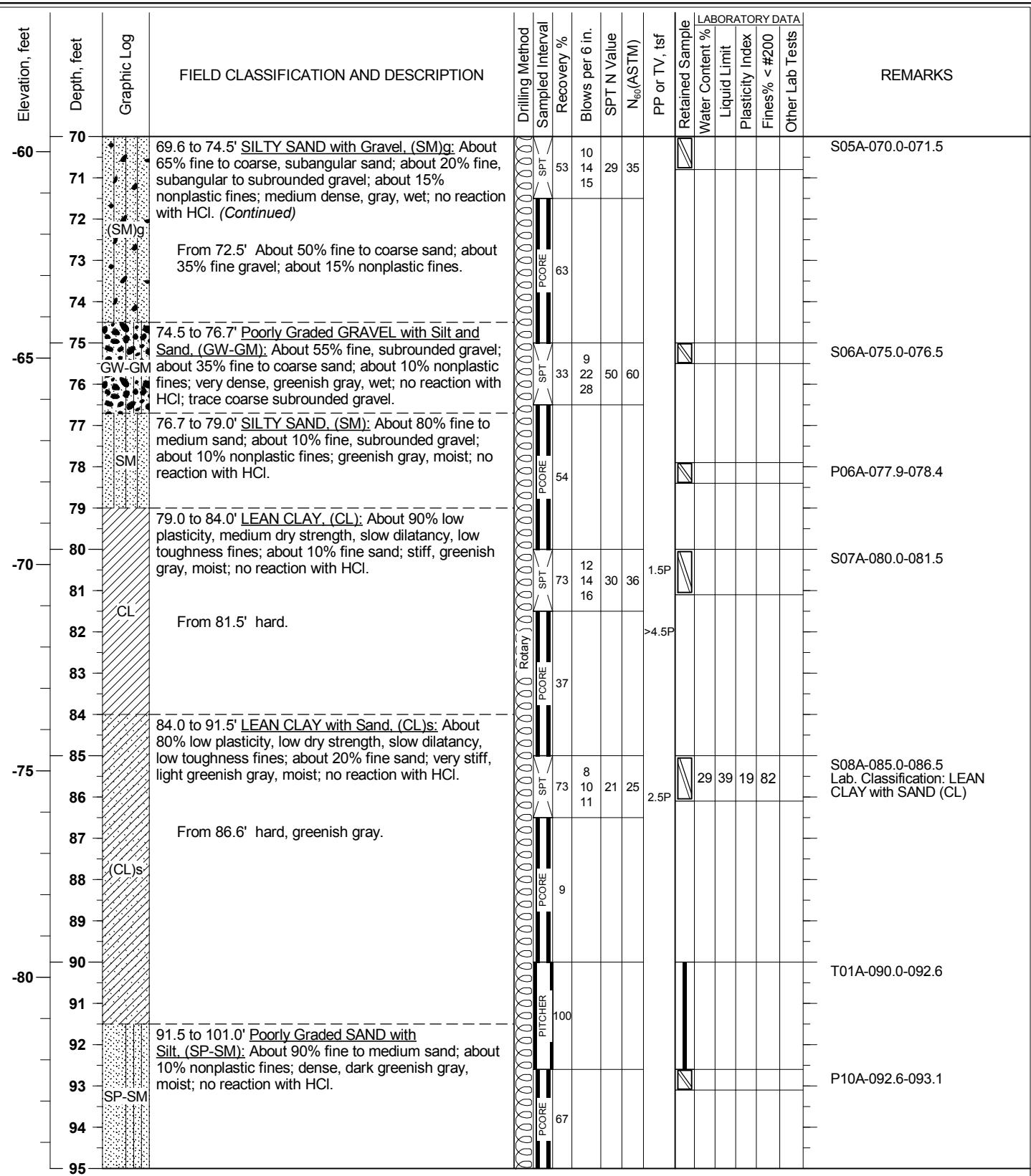
Longitude

County: Sacramento

DRILL HOLE LOG

DCR3-DH-014

Sheet 4 of 8

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES



Project: Delta Habitat Conservation and Conveyance Program

Feature: Intake 3, Sacramento

Coordinates: North 2,327,416.90

East 6,269,332.35

Survey Method: Ground Survey

Datum: NAD83

GPS: Latitude

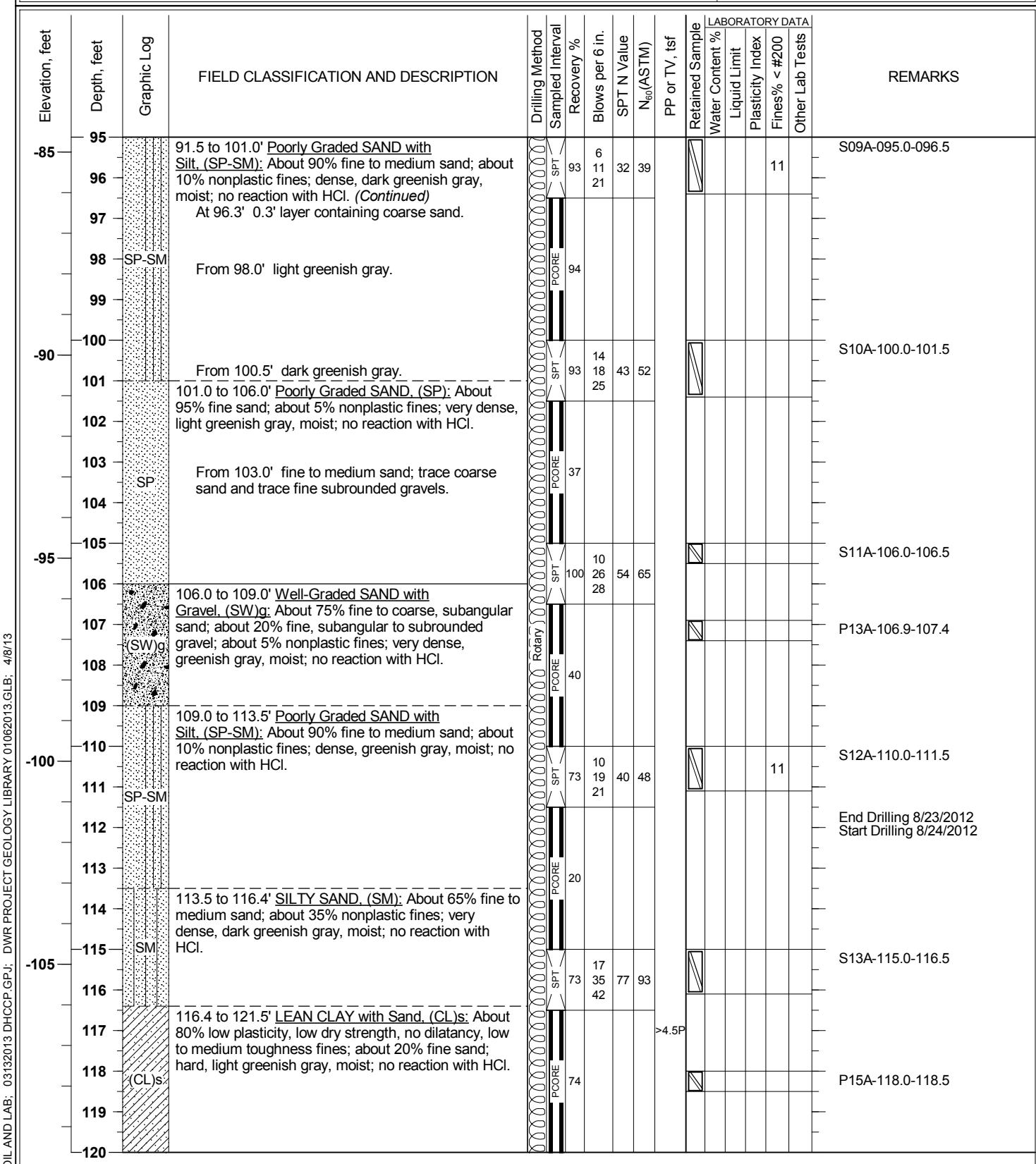
Longitude

County: Sacramento

DRILL HOLE LOG

DCR3-DH-014

Sheet 5 of 8

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES



Project: Delta Habitat Conservation and Conveyance Program

Feature: Intake 3, Sacramento

Coordinates: North 2,327,416.90

East 6,269,332.35

Survey Method: Ground Survey

Datum: NAD83

GPS: Latitude

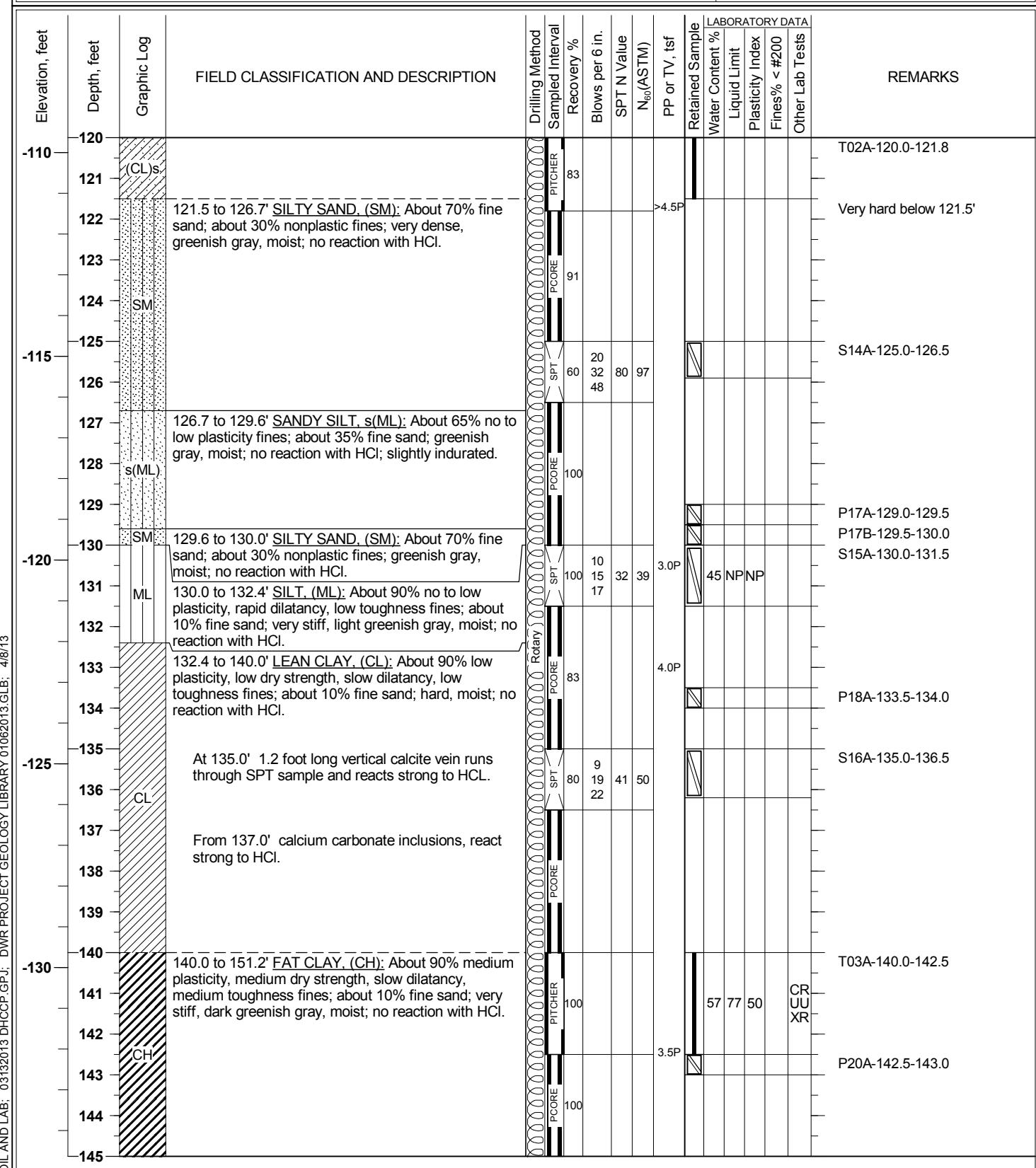
Longitude

County: Sacramento

DRILL HOLE LOG

DCR3-DH-014

Sheet 6 of 8

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES



Project: Delta Habitat Conservation and Conveyance Program

Feature: Intake 3, Sacramento

Coordinates: North 2,327,416.90

East 6,269,332.35

Survey Method: Ground Survey

Datum: NAD83

GPS: Latitude

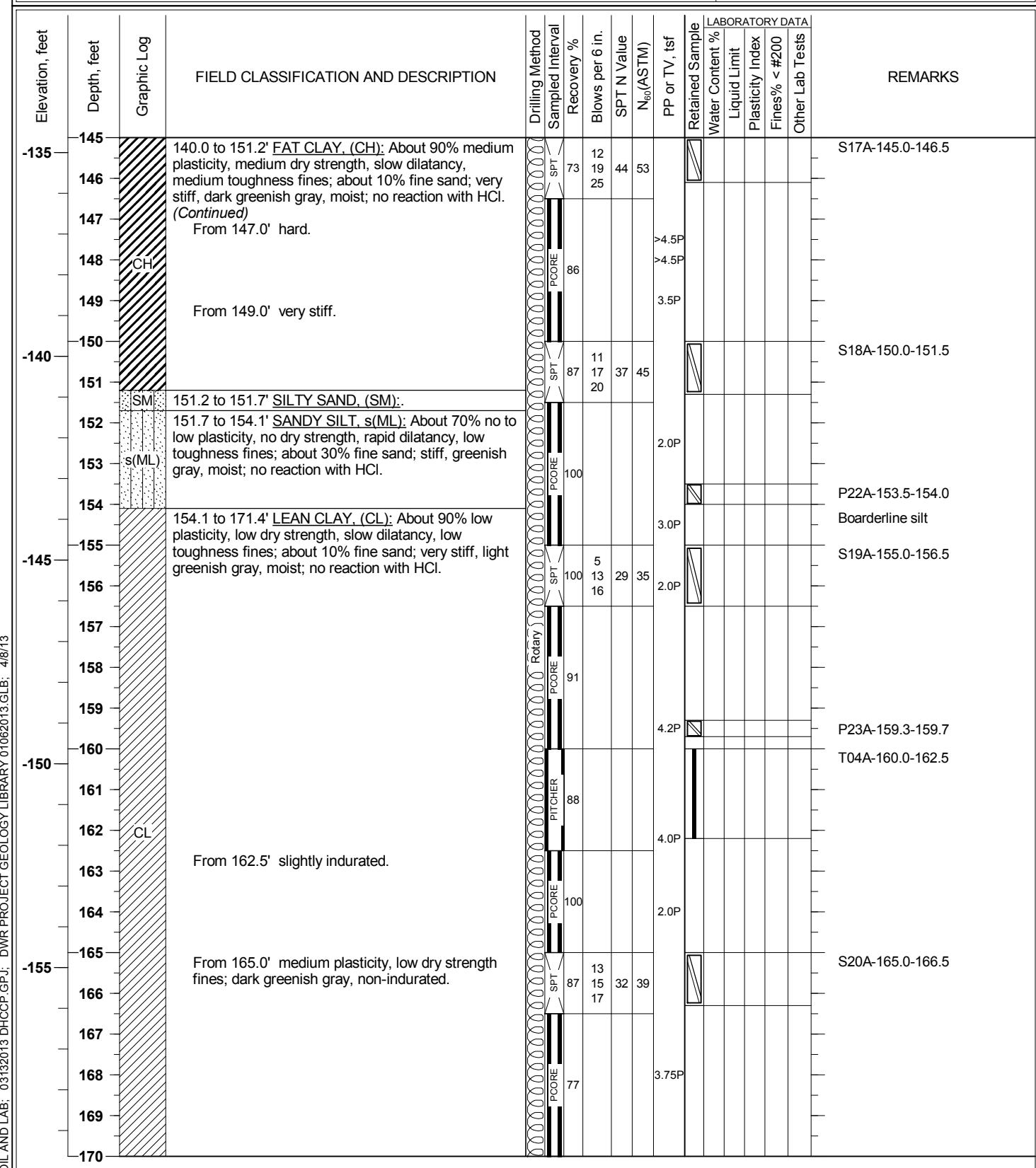
Longitude

County: Sacramento

DRILL HOLE LOG

DCR3-DH-014

Sheet 7 of 8

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES



Project: Delta Habitat Conservation and Conveyance Program

Feature: Intake 3, Sacramento

Coordinates: North 2,327,416.90

East 6,269,332.35

Survey Method: Ground Survey

Datum: NAD83

GPS: Latitude

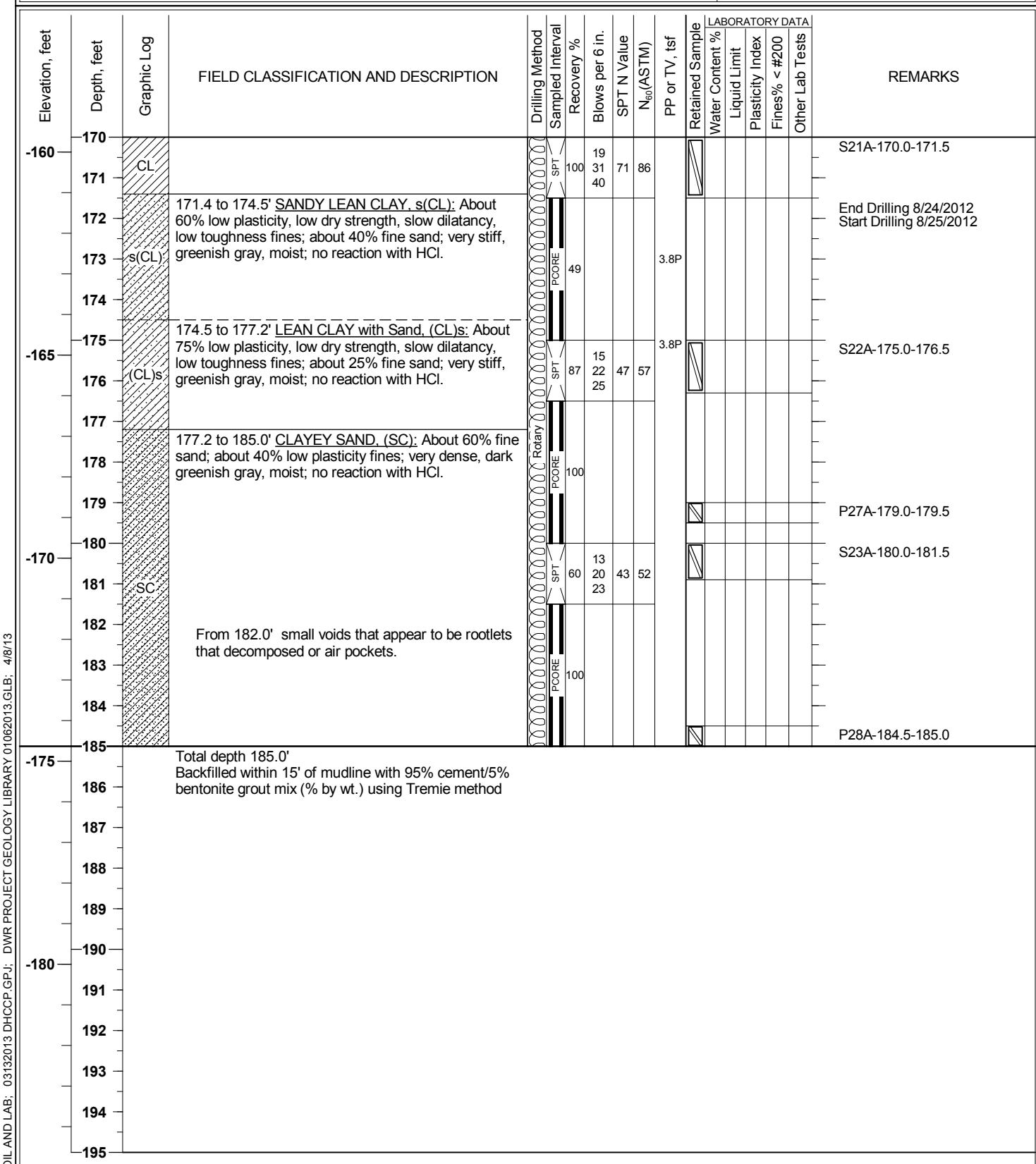
Longitude

County: Sacramento

DRILL HOLE LOG

DCR3-DH-014

Sheet 8 of 8

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES

INTAKE 5
BOREHOLE DCR5-DH-014



Project: Delta Habitat Conservation and Conveyance Program

Feature: Sacramento River / Sacramento River

Coordinates: North 2,316,299.48

East 6,265,705.94

Survey Method: Ground Survey

Datum: NAD83

GPS: Latitude

Longitude

County: Sacramento

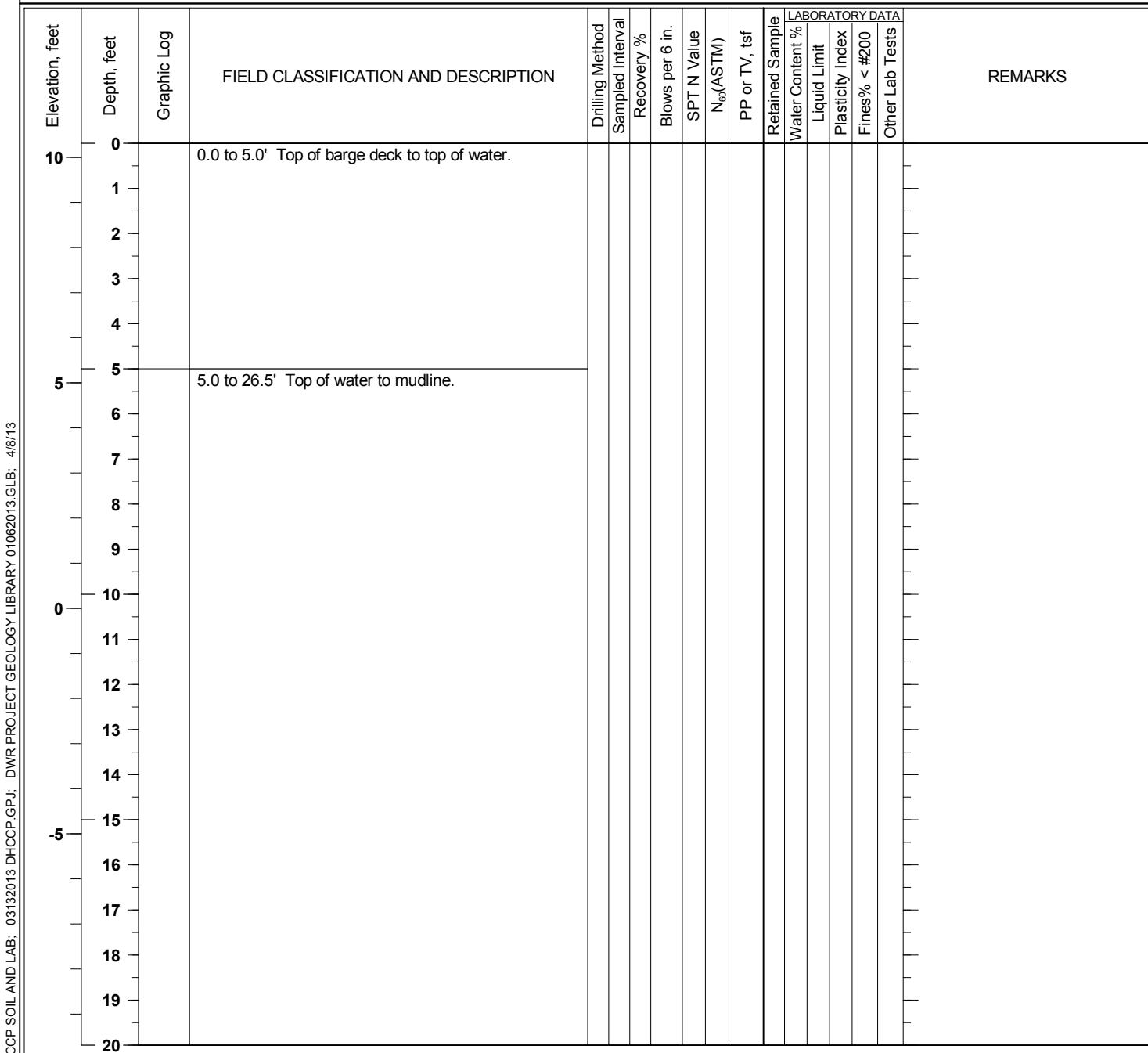
DRILL HOLE LOG

DCR5-DH-014

Sheet 1 of 7

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES

DATE STARTED 9/4/12	DATE COMPLETED 9/6/12	GROUND ELEVATION 10.31 ft	ELEVATION BASIS Ground Survey	TOTAL DEPTH OF BORING 168.0 ft
DRILLING CONTRACTOR Gregg Drilling & Testing, Inc.		DRILLER'S NAME Chris St. Pierre	HELPER'S NAME Robert Greguras	TOTAL DEPTH OF FILL
DRILLING METHOD 36 - 168 ft: RD		DRILL RIG MAKE AND MODEL Mobile B-80, D-21		DWR/CONSULTANT COMPANY DWR/URS
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 5 1/2" O.D. Punchcore bit		DRILLING ROD TYPE AND DIAMETER 4.5" O.D. HWT & 2.5" NWJ		FIELD LOGGER D. Perry
<input checked="" type="checkbox"/> VERTICAL <input type="checkbox"/> INCLINED		CASING TYPE, DIAMETER, INSTALLATION DEPTH Steel threaded, 6 5/8-in., 63 ft		FIELD LOG REVIEWER M. Pagenkopp
SAMPLER TYPE(S) SPT, 3" Shelby and Pitcher, 134mm punch core		HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP Marl, automatic, 140 lbs / 30-inch drop		HAMMER EFFICIENCY 72.5%
BOREHOLE BACKFILL OR COMPLETION Tremie backfilled with 95% cement, 5% bentonite by wt.		GROUNDWATER READING: DURING DRILLING Not Applicable		AFTER DRILLING (DATE-TIME)



Draft 3 After All Lab Data Added 4/2/2013



Project: Delta Habitat Conservation and Conveyance Program

Feature: Sacramento River

Coordinates: North 2,316,299.48

East 6,265,705.94

Survey Method: Ground Survey

Datum: NAD83

GPS: Latitude

Longitude

County: Sacramento

DRILL HOLE LOG

DCR5-DH-014

Sheet 2 of 7

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES

Elevation, feet	Depth, feet	Graphic Log	FIELD CLASSIFICATION AND DESCRIPTION										REMARKS
			Drilling Method	Sampled Interval	Recovery %	Blows per 6 in.	SPT N Value	N ₆₀ (ASTM)	PP or TV, tsf	Retained Sample	LABORATORY DATA		
20													
-10		5.0 to 26.5' Top of water to mudline. (Continued)											
21													
22													
23													
24													
25													
-15													
26													
27		26.5 to 36.0' Mud.											
28													
29													
30													
31													
32													
33													
34													
35													
36		36.0 to 47.5' Poorly Graded SAND with Clay. (SP-SC): About 90% fine to medium sand; about 10% low plasticity fines; loose, dark bluish gray, wet; no reaction with HCl.	Rotary	NSD	100	3 5 5	10	12				S01A-036.0-037.5	
37			SPT	NSD									
38													
39													
40													
41		SP-SC											
42													
43		From 43.0' medium dense, trace fine gravel.	SPT	NSD	53	6 9 11	20	24				Cleaned out run to 43 feet	
44													
45													



Project: Delta Habitat Conservation and Conveyance Program

Feature: Sacramento River

Coordinates: North 2,316,299.48

East 6,265,705.94

Survey Method: Ground Survey

Datum: NAD83

GPS: Latitude

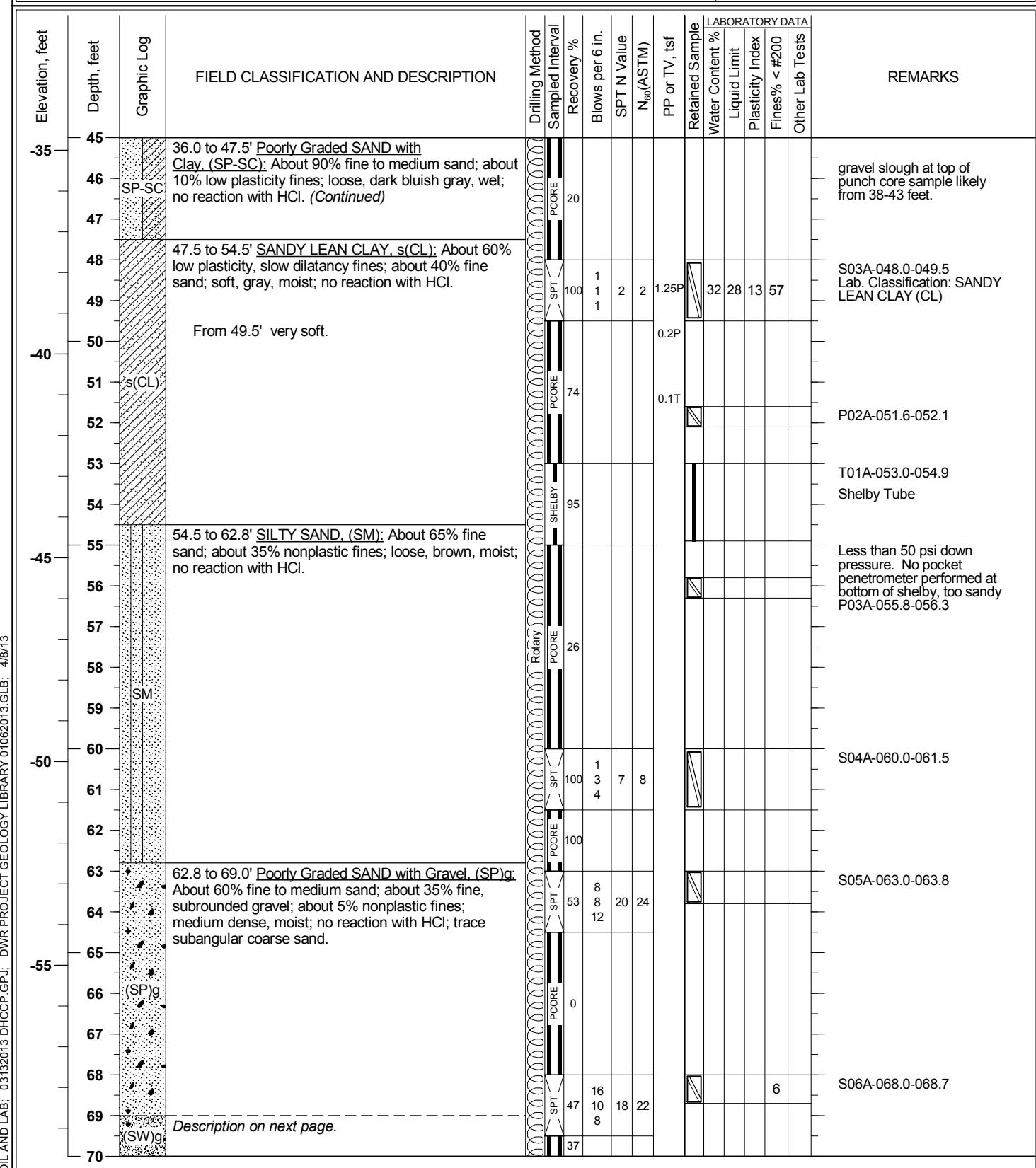
Longitude

County: Sacramento

DRILL HOLE LOG

DCR5-DH-014

Sheet 3 of 7

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES



Project: Delta Habitat Conservation and Conveyance Program

Feature: Sacramento River

Coordinates: North 2,316,299.48

East 6,265,705.94

Survey Method: Ground Survey

Datum: NAD83

GPS: Latitude

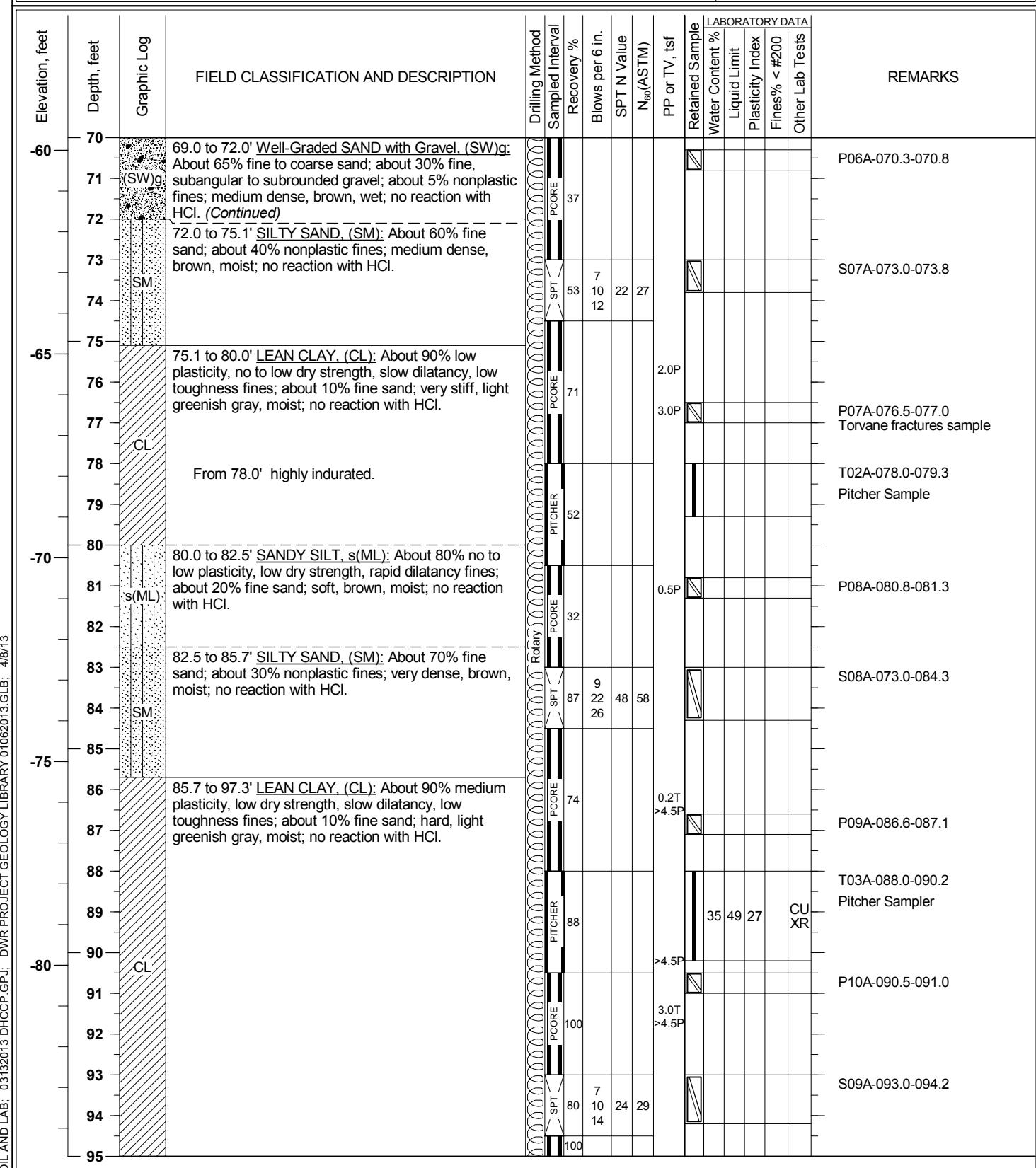
Longitude

County: Sacramento

DRILL HOLE LOG

DCR5-DH-014

Sheet 4 of 7

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES



Project: Delta Habitat Conservation and Conveyance Program

Feature: Sacramento River

Coordinates: North 2,316,299.48

East 6,265,705.94

Survey Method: Ground Survey

Datum: NAD83

GPS: Latitude

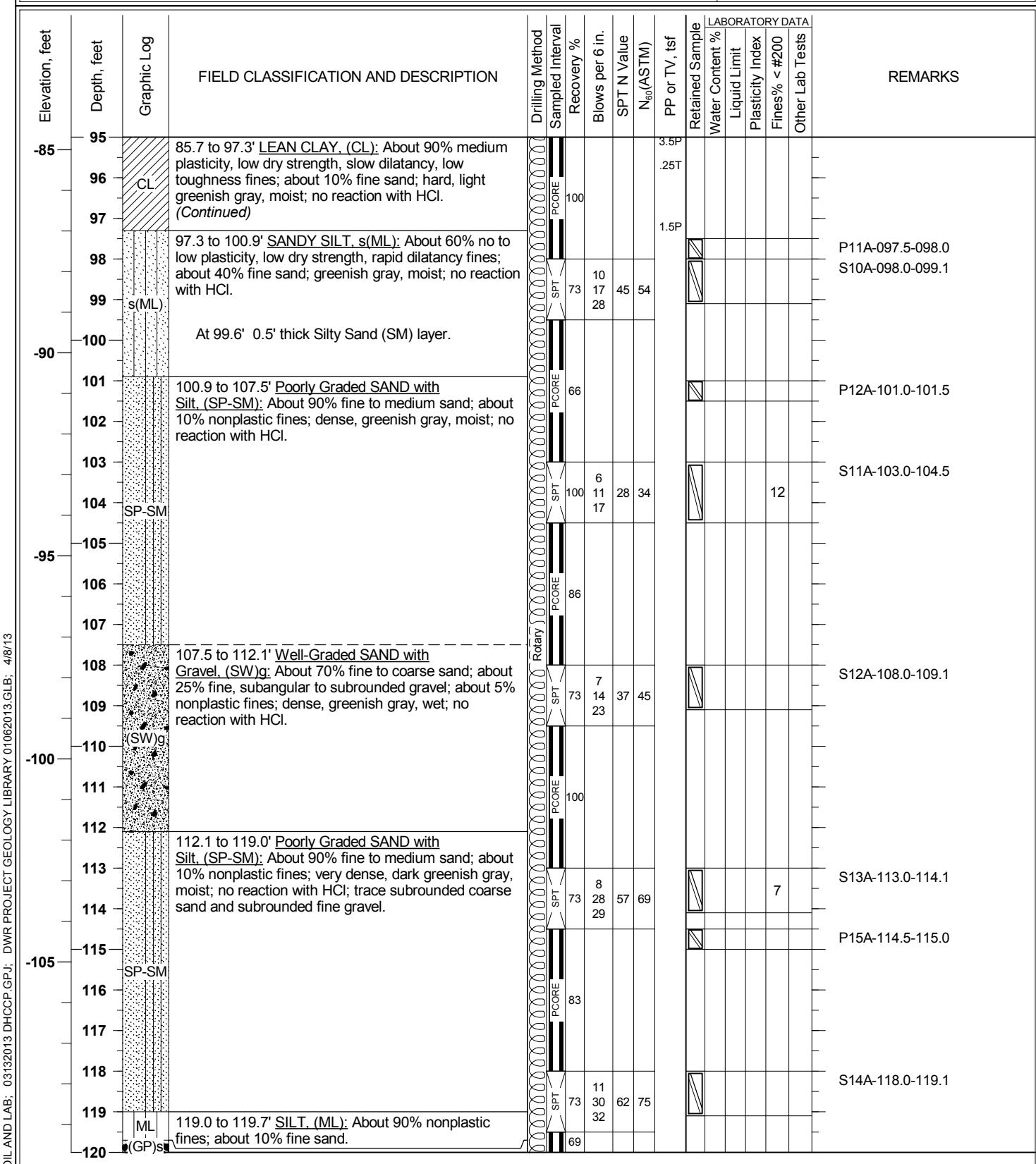
Longitude

County: Sacramento

DRILL HOLE LOG

DCR5-DH-014

Sheet 5 of 7

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES



Project: Delta Habitat Conservation and Conveyance Program

Feature: Sacramento River

Coordinates: North 2,316,299.48 East 6,265,705.94

Survey Method: Ground Survey Datum: NAD83

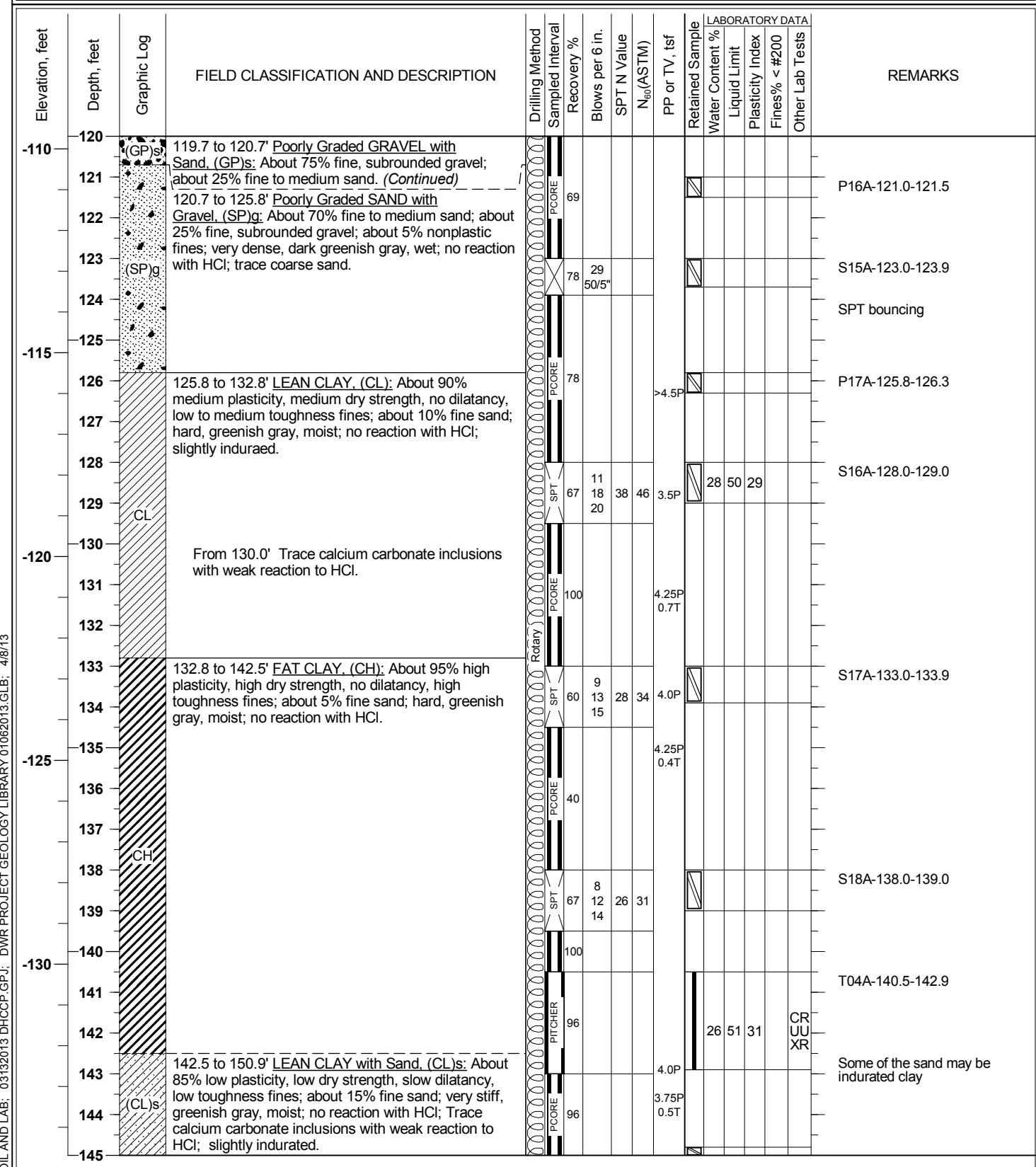
GPS: Latitude Longitude

County: Sacramento

DRILL HOLE LOG

DCR5-DH-014

Sheet 6 of 7

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES



Project: Delta Habitat Conservation and Conveyance Program

Feature: Sacramento River

Coordinates: North 2,316,299.48 East 6,265,705.94

Survey Method: Ground Survey Datum: NAD83

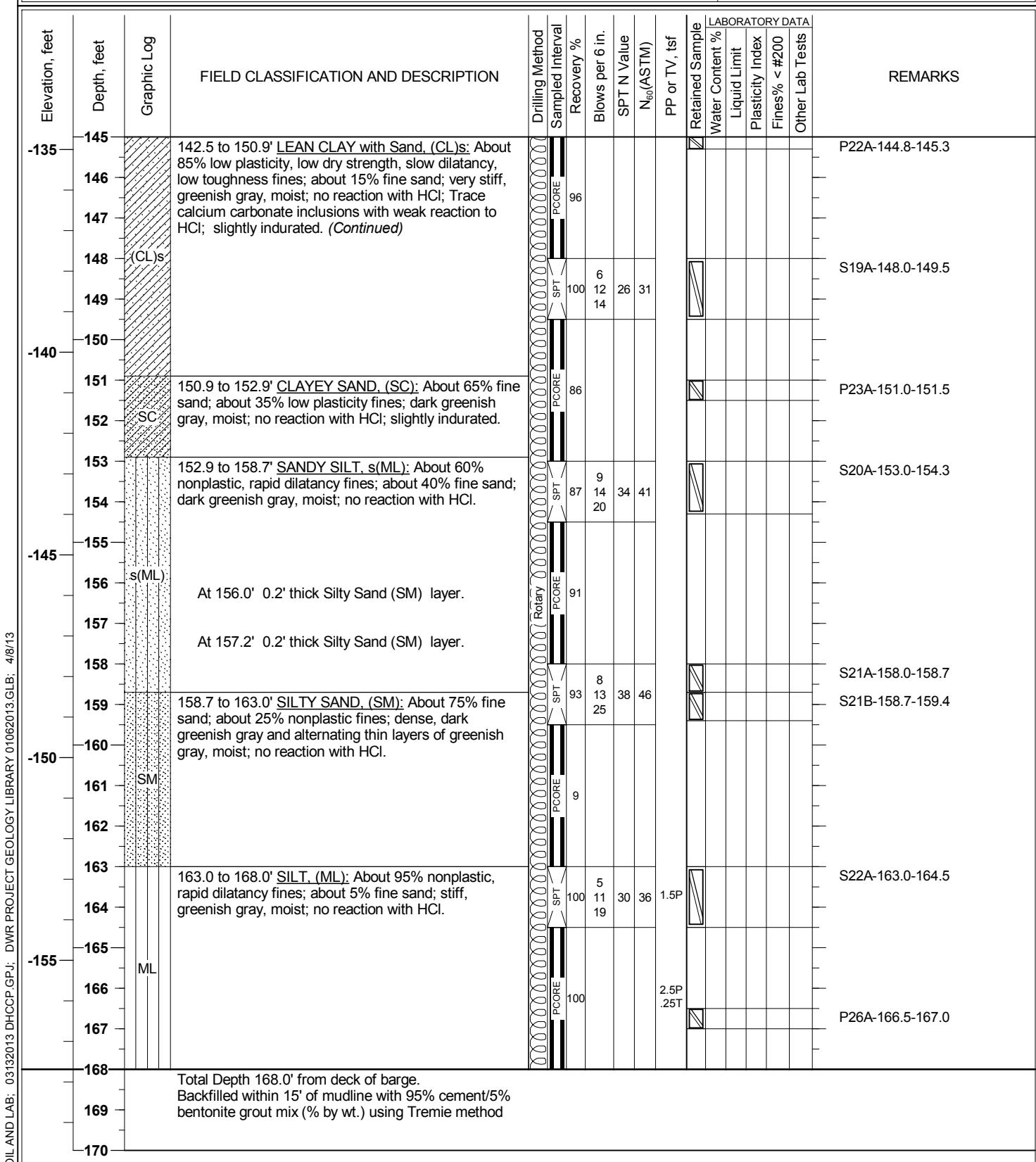
GPS: Latitude Longitude

County: Sacramento

DRILL HOLE LOG

DCR5-DH-014

Sheet 7 of 7

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES



GES

NOTE ON SHEET PILE DRIVEABILITY WITH VIBRATORY METHODS

Table 1 – Summary of GES experience of sheet pile installation using vibratory methods (Fine-grained materials)

SPT Range	Undrained shear strength range (kN/m ²)	Sheet pile length range (m)		
		0-6	6-12	12+
0-8*	0-40	Easy	Easy	Easy becoming moderate with increasing depth at upper range
8-15	40-75	Easy	Moderate at upper range	Difficult at upper range beyond 15m consider pre-auger
15-30	75-150	Moderate at upper range	Difficult at upper range	Refusal beyond 12m without pre-auger, difficult with pre-auger beyond 15m
30-50	150-250	Difficult	Refusal without pre-auger. Difficult with pre-auger.	Impacting recommended
50+	250+	Pre-auger required. Difficult / impacting may be required	Impacting recommended	Impacting recommended

Notes:

Easy – piles driving within bounds of hammer capacity, pile advancing at a rate greater than 0.1m/s**

Moderate – piles driving close to bounds of hammer capacity, pile advancing at a rate to 0.05m/s**

Difficult – piles driving at hammer capacity typically, pile advancing at a rate of up to 0.01m/s**

Refusal – pile resistance in excess of hammer capacity, pile advancing at a rate less than 0.01m/s**

Where difficult driving is encountered the vibration attenuation coefficient will increase but will be much less than soft ground

* The suitability of sheet piles in very soft and soft ground should be considered by a specialist geotechnical or temporary works engineer

**Driving rates are averaged over 1m depth of driving

Table 2 – Summary of GES experience of sheet pile installation using vibratory methods (Coarse-grained materials)

SPT Range	Relative Density	Sheet pile length range (m)					
		0-6		6-12		12+	
		Dry	Wet	Dry	Wet	Dry	Wet
0-4	Very loose 0-15%	Moderate	Easy	Moderate to 6m. Refusal without pre-auger beyond 6m	Easy	Impacting of sheet piles is recommended	Moderate. Experience is limited.
4-10	Loose 15-35%	Moderate	Easy	Moderate becoming difficult with depth to 6m. Refusal without pre-auger beyond 6m	Easy	Impacting of sheet piles is recommended	Moderate. Experience is limited.
10-30	Medium dense 35-65%	Moderate becoming difficult with depth	Easy	Moderate becoming difficult with depth to 6m. Refusal without pre-auger beyond 6m	Moderate	Impacting of sheet piles is recommended	Difficult. Experience is limited.
30-50	Dense 65-85%	Difficult	Moderate	Difficult to 6m. Refusal without pre-auger beyond 6m	Difficult	Impacting of sheet piles is recommended	Difficult. Experience is limited.
>50	Very dense 85-100%	Refusal without pre-auger	Difficult	Refusal without pre-auger. Difficult with pre-auger.	Difficult	Impacting of sheet piles is recommended	Refusal beyond 15m without pre-auger. Experience is limited.

Notes:

Easy – piles driving within bounds of hammer capacity, pile advancing at a rate greater than 0.1m/s**

Moderate – piles driving close to bounds of hammer capacity, pile advancing at a rate to 0.05m/s**

Difficult – piles driving at hammer capacity typically, pile advancing at a rate of up to 0.01m/s**

Refusal – pile resistance in excess of hammer capacity, pile advancing at a rate less than 0.01m/s**

Inter-clutch activity is much more pertinent in granular soils and the most common cause of refusal is material migrating into the clutch causing the adjacent pile to bind. Isolated elements (e.g. H-piles) may drive to greater depth with much less difficulty.

*Driving rates are averaged over 1m depth of driving

DRAFT

Attachment 3
Divider

GRLWEAP ANALYSIS - INTAKE 2
BERMINGHAMMER B6505 (STROKE HEIGHT 11.5 FEET)

INTAKE2_004_HPILE_BERMB6505_TIME_ALL.GWO

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: C:\USERS\MAU\Desktop\WATERFIX\INTAKE PILE DRIVABILITY\PILE_DRIVING\GRLWEAP\DRIVING TIME\BERMINGHAM B6505\INTAKE 2\INTAKE2_004_HPILE_BERMB6505_TIME_ALL.GW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (12/4/2015)

Input File Contents
WaterFix_2019-CER_Intake2_004_HPile

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
-100	0	433	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000
Pile g	Hammer g	Toe	Area	Pile	Size													
32.185	32.185	450.400	18.110															
W Cp	A Cp	E Cp	T Cp															
6.000	424.000	30000.0	6.000															
A Cu	E Cu	T Cu	CoR															
0.000	0.0	0.000	0.000															
LPle	APle	EPle	WPle															
90.200	39.96	30000.0	492.000															
FFatigue	F0	0-Bottom																
0	0.000	0.000																
Manufac	Hmr	Name	HmrType	No Seg-s														
BERMINGH	B6505			1	4													
Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy													
17.64	142.90	23.50	11.50	11.50	0.80													
IB. Wt	IB. L	IB.Dia	IB CoR	IB RO														

INTAKE2_004_HPILE_BERMB6505_TIME_ALL.GWO

3.75	43.00	19.00	0.900	0.010					
CompStrk	A	Chamber	V	Chamber					
20.30	452.40	658.00	0.0000	0.0000					
P atm	P1	P2	P3	P4					
14.70	1375.00	0.00	0.00	0.00					
Stroke	Effic.	Pressure	R-Weight	T-Delay					
11.5000	0.8000	1375.0000	0.0000	0.0000					
Qs	Qt	Js	Jt	Qx					
0.100	0.100	0.100	0.150	0.000					
Research	Soil Model:	Atoe, Plug, Gap, Q-fac							
		0.000	0.000	0.000					
Research	Soil Model:	RD-skn: m, d, toe: m, d							
		0.000	0.000	0.000					
Res. Distribution									
Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimD	SU T
0.00	0.00	0.00	0.10	0.35	0.05	0.15	1.20	6.56	1.0
37.00	0.68	224.97	0.10	0.35	0.05	0.15	1.20	6.56	1.0
37.00	0.68	224.97	0.10	0.35	0.05	0.15	1.20	6.56	1.0
57.00	1.04	346.57	0.10	0.35	0.05	0.15	1.20	6.56	1.0
57.00	1.61	625.56	0.10	0.35	0.05	0.15	1.20	6.56	1.0
72.50	2.00	625.56	0.10	0.35	0.05	0.15	1.20	6.56	1.0
90.20	2.00	625.56	0.10	0.35	0.05	0.15	1.20	6.56	1.0
Gain/Loss factors: shaft and toe									
0.50000	0.00000	0.00000	0.00000	0.00000					
1.00000	0.00000	0.00000	0.00000	0.00000					
Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR		
6.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
12.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
15.71	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
19.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
25.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
31.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
37.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
43.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
49.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
52.71	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
56.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
62.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
68.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
72.50	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000		

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

Version 2010

English Units

WaterFix_2019-CER_Intake2_004_Hpile

Hammer Model:		B6505	Made by:			BERMINGH
No.	Weight	Stiffn	CoR	C-Slk	Dampg	
1	4.410					
2	4.410	352088.1	1.000	0.0100		
3	4.410	352088.1	1.000	0.0100		
4	4.410	352088.1	1.000	0.0100		
Imp Block	3.750	123917.9	0.900	0.0100		
Helmet	6.000	2120000.0	0.700	0.0098	18.1	
Combined Pile Top		29903.5				

HAMMER OPTIONS:

Hammer File ID No.	433	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	17.64	Ram Length	(inch)	142.90
Maximum Stroke	(ft)	11.50			
Rated Stroke	(ft)	11.50	Efficiency		0.800

Maximum Pressure (psi) 1375.00 Actual Pressure (psi) 1375.00

INTAKE2_004_HPILE_BERMB6505_TIME_ALL.GWO

Compression Exponent	1.350	Expansion Exponent	1.250
Ram Diameter (inch)	23.50		
Comb. Start Volume (in ³)	724.00	Comb. End Volume (in ³)	768.00

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION		PILE CUSHION	
Cross Sect. Area (in ²)	424.00	Cross Sect. Area (in ²)	0.00
Elastic-Modulus (ksi)	30000.0	Elastic-Modulus (ksi)	0.0
Thickness (inch)	6.00	Thickness (inch)	0.00
Coeff of Restitution	0.7	Coeff of Restitution	1.0
RoundOut (ft)	0.0	RoundOut (ft)	0.0
Stiffness (kips/in)	2120000.0	Stiffness (kips/in)	0.0

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth (ft)	6.0		
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area (in ²)	450.400	Pile Type	H Pile
Pile Size (inch)	18.110		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s
0.0	39.96	30000.	39.96	492.0	7.2	0	16807.	71.3	
90.2	39.96	30000.	39.96	492.0	7.2	0	16807.	71.3	

Wave Travel Time 2L/c (ms) 10.734

Pile and Soil Model				Total Capacity (kips)	Rut (in)	37.7					
No. Weight	Stiffn	C-Slk	T-Slk	Soil-S	Soil-D	Quake	LbTop	Perim	Area		
	kips	k/in	ft	ft	kips	s/ft	inch	ft	in ²		
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0
26	0.456	29904	0.000	0.000	1.00	0.2	0.050	0.100	86.86	7.2	40.0
27	0.456	29904	0.000	0.000	1.00	0.9	0.050	0.100	90.20	7.2	40.0
Toe					36.5	0.150	0.354				

12.315 kips total unreduced pile weight (g= 32.17 ft/s²)
12.321 kips total reduced pile weight (g= 32.19 ft/s²)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile	Pile Segments: Automatic		
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	1.427

Driveability Analysis

Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	3	Analysis Time-Input (ms)	0
Output Level: Normal			
Gravity Mass, Pile, Hammer:	32.170	32.185	32.185
Output Segment Generation:	Automatic		

Depth ft	Stroke ft	Pressure Ratio	Efficy
6.00	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut kips	B1 b/ft	Ct down	Stroke (ft) up	Ten ksi	Str i	t Comp	Str i	t ENTHRU kip-ft	B1 Rt b/min
37.7	Hammer did not run								

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
Page 3

CH2M HILL

INTAKE2_004_HPILE_BERMB6505_TIME_ALL.GWO
GRLWEAP Version 2010

Depth	(ft)	12.0		
Shaft Gain/Loss Factor		0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in ²)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c	
ft			in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s	
0.0		39.96	30000.		492.0		7.2	0	16807.	71.3
90.2		39.96	30000.		492.0		7.2	0	16807.	71.3

Wave Travel Time 2L/c (ms) 10.734

Pile and Soil Model					Total Capacity	Rut	(kips)	77.7			
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in ²
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0
24	0.456	29904	0.000	0.000	1.00	0.1	0.050	0.100	80.18	7.2	40.0
25	0.456	29904	0.000	0.000	1.00	0.8	0.050	0.100	83.52	7.2	40.0
26	0.456	29904	0.000	0.000	1.00	1.5	0.050	0.100	86.86	7.2	40.0
27	0.456	29904	0.000	0.000	1.00	2.3	0.050	0.100	90.20	7.2	40.0
Toe						73.0	0.150	0.354			

12.315 kips total unreduced pile weight (g= 32.17 ft/s²)12.321 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
12.00	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi		0		ksi		kip-ft		b/min	
77.7	1.3		4.41	4.38	0.00	1	0	13.15	1	6	123.3		56.3	

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	15.7		
Shaft Gain/Loss Factor		0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in ²)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c	
ft			in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s	
0.0		39.96	30000.		492.0		7.2	0	16807.	71.3
90.2		39.96	30000.		492.0		7.2	0	16807.	71.3

Wave Travel Time 2L/c (ms) 10.734

Pile and Soil Model					Total Capacity	Rut	(kips)	103.6			
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in ²
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0
23	0.456	29904	0.000	0.000	1.00	0.2	0.050	0.100	76.84	7.2	40.0
24	0.456	29904	0.000	0.000	1.00	0.9	0.050	0.100	80.18	7.2	40.0
25	0.456	29904	0.000	0.000	1.00	1.6	0.050	0.100	83.52	7.2	40.0
26	0.456	29904	0.000	0.000	1.00	2.3	0.050	0.100	86.86	7.2	40.0
27	0.456	29904	0.000	0.000	1.00	3.1	0.050	0.100	90.20	7.2	40.0
Toe						95.5	0.150	0.354			

INTAKE2_004_HPILE_BERMB6505_TIME_ALL.GWO
 12.315 kips total unreduced pile weight ($g = 32.17 \text{ ft/s}^2$)
 12.321 kips total reduced pile weight ($g = 32.19 \text{ ft/s}^2$)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	
15.71	11.50	1.00	0.800

↑ WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft	down	up	ksi	ksi	1	0	14.11	ksi	1	6	kip-ft	b/min	
103.6	1.7	4.79	4.75	0.00	0.00	1	0	14.11	1	6	119.4	54.0		

↑ WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth	(ft)	19.7
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor
		1.000

PILE PROFILE:

Toe Area	(in ²)	450.400 Pile Type
Pile Size	(inch)	18.110

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in ²	ksi	lb/ft ³	ft	ft	ft	ft/s	k/ft/s	
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3		
90.2	39.96	30000.	492.0	7.2	0	16807.	71.3		

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model			Total Capacity	Rut	(kips)	132.4			
		Stiffn	C-Slk	T-Slk	Soil-S	Soil-D	Quake	LbTop	Perim	Area	
	kips	k/in	ft	ft	kips	s/ft	inch	ft	ft	in ²	
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0
22	0.456	29904	0.000	0.000	1.00	0.3	0.050	0.100	73.50	7.2	40.0
23	0.456	29904	0.000	0.000	1.00	1.0	0.050	0.100	76.84	7.2	40.0
24	0.456	29904	0.000	0.000	1.00	1.8	0.050	0.100	80.18	7.2	40.0
25	0.456	29904	0.000	0.000	1.00	2.5	0.050	0.100	83.52	7.2	40.0
26	0.456	29904	0.000	0.000	1.00	3.2	0.050	0.100	86.86	7.2	40.0
27	0.456	29904	0.000	0.000	1.00	3.9	0.050	0.100	90.20	7.2	40.0
Toe					119.7	0.150	0.354				

12.315 kips total unreduced pile weight ($g = 32.17 \text{ ft/s}^2$)
 12.321 kips total reduced pile weight ($g = 32.19 \text{ ft/s}^2$)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	

19.69	11.50	1.00 0.800
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↑ WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft	down	up	ksi	ksi	1	0	15.61	ksi	9	7	kip-ft	b/min	
132.4	2.4	5.07	5.08	0.00	0.00	1	0	15.61	1	7	114.8	52.3		

↑ WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth	(ft)	25.7
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor
		1.000

PILE PROFILE:

Toe Area	(in ²)	450.400 Pile Type
Pile Size	(inch)	18.110

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in ²	ksi	lb/ft ³	ft	ft	ft	ft	ft/s	

INTAKE2_004_HPILE_BERMB6505_TIME_ALL.GWO

ft	in ²	ksi	lb/ft ³	ft	ft/s	k/ft/s	
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3
90.2	39.96	30000.	492.0	7.2	0	16807.	71.3

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model				Soil-S	Soil-D	Quake	Total Capacity (kips)	Rut (in)	LbTop ft	Perim ft	Area in ²
		Stiffn kips	C-Slk k/in	T-Slk ft	CoR ft								
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0		
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0		
20	0.456	29904	0.000	0.000	1.00	0.2	0.050	0.100	66.81	7.2	40.0		
21	0.456	29904	0.000	0.000	1.00	0.9	0.050	0.100	70.16	7.2	40.0		
22	0.456	29904	0.000	0.000	1.00	1.6	0.050	0.100	73.50	7.2	40.0		
23	0.456	29904	0.000	0.000	1.00	2.3	0.050	0.100	76.84	7.2	40.0		
24	0.456	29904	0.000	0.000	1.00	3.1	0.050	0.100	80.18	7.2	40.0		
25	0.456	29904	0.000	0.000	1.00	3.8	0.050	0.100	83.52	7.2	40.0		
26	0.456	29904	0.000	0.000	1.00	4.5	0.050	0.100	86.86	7.2	40.0		
27	0.456	29904	0.000	0.000	1.00	5.3	0.050	0.100	90.20	7.2	40.0		
Toe						156.2	0.150	0.354					

12.315 kips total unreduced pile weight (g= 32.17 ft/s²)

12.321 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Effacy
25.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut kips	Bl b/ft	Ct down	Stroke (ft) up	Ten ksi	Str i	t	Comp ksi	Str i	t	ENTHRU kip-ft	Bl b/min	Rt
177.8	3.3	5.51	5.49	0.00	1	0	18.96	18	6	110.9	50.0	

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth (ft)	Shaft Gain/Loss Factor	31.7	Toe Gain/Loss Factor	0.500	1.000
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PILE PROFILE:

Toe Area (in ²)	Pile Type
450.400	H Pile
Pile Size (inch)	18.110

L ft	b in ²	Top Area	E-Mod ksi	Spec Wt lb/ft ³	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3	
90.2	39.96	30000.	492.0	7.2	0	16807.	71.3	

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model				Soil-S	Soil-D	Quake	Total Capacity (kips)	Rut (in)	LbTop ft	Perim ft	Area in ²
		Stiffn kips	C-Slk k/in	T-Slk ft	CoR ft								
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0		
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0		
18	0.456	29904	0.000	0.000	1.00	0.1	0.050	0.100	60.13	7.2	40.0		
19	0.456	29904	0.000	0.000	1.00	0.7	0.050	0.100	63.47	7.2	40.0		
20	0.456	29904	0.000	0.000	1.00	1.5	0.050	0.100	66.81	7.2	40.0		
21	0.456	29904	0.000	0.000	1.00	2.2	0.050	0.100	70.16	7.2	40.0		
22	0.456	29904	0.000	0.000	1.00	2.9	0.050	0.100	73.50	7.2	40.0		
23	0.456	29904	0.000	0.000	1.00	3.7	0.050	0.100	76.84	7.2	40.0		
24	0.456	29904	0.000	0.000	1.00	4.4	0.050	0.100	80.18	7.2	40.0		
25	0.456	29904	0.000	0.000	1.00	5.1	0.050	0.100	83.52	7.2	40.0		
26	0.456	29904	0.000	0.000	1.00	5.8	0.050	0.100	86.86	7.2	40.0		
27	0.456	29904	0.000	0.000	1.00	6.6	0.050	0.100	90.20	7.2	40.0		
Toe						192.7	0.150	0.354					

12.315 kips total unreduced pile weight (g= 32.17 ft/s²)

INTAKE2_004_HPILE_BERMB6505_TIME_ALL.GWO
 12.321 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficacy
31.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Rut kips	B1 b/ft	Ct down	Stroke (ft) up	Ten ksi	Str ksi	i 1	t 0	Comp 21.62	Str 19	i 6	t 107.9	ENTHRU kip-ft	B1 b/min	Rt 48.3
225.6	4.4	5.90	5.87	0.00										

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth Shaft Gain/Loss Factor	(ft) 0.500	37.7 Toe Gain/Loss Factor	1.000
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PILE PROFILE:
 Toe Area (in²) 450.400 Pile Type H Pile
 Pile Size (inch) 18.110

L ft	b in ²	Top ksi	Area lb/ft ³	E-Mod ft	Spec Wt ft	Perim ft	C Index ft/s	Wave Sp k/ft/s	EA/c
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3		
90.2	39.96	30000.	492.0	7.2	0	16807.	71.3		

Wave Travel Time 2L/c (ms) 10.734

Pile and Soil Model				Total Capacity (kips)	Rut (kips)	275.8					
No.	Weight kips	Stiffn k/in	C-Slk ft	Soil-S kips	Capacity Soil-D s/ft	Rut Quake inch	LbTop ft	Perim ft	Area in ²		
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0
16	0.456	29904	0.000	0.000	1.00	0.0	0.050	0.100	53.45	7.2	40.0
17	0.456	29904	0.000	0.000	1.00	0.6	0.050	0.100	56.79	7.2	40.0
18	0.456	29904	0.000	0.000	1.00	1.3	0.050	0.100	60.13	7.2	40.0
19	0.456	29904	0.000	0.000	1.00	2.0	0.050	0.100	63.47	7.2	40.0
20	0.456	29904	0.000	0.000	1.00	2.8	0.050	0.100	66.81	7.2	40.0
21	0.456	29904	0.000	0.000	1.00	3.5	0.050	0.100	70.16	7.2	40.0
22	0.456	29904	0.000	0.000	1.00	4.2	0.050	0.100	73.50	7.2	40.0
23	0.456	29904	0.000	0.000	1.00	5.0	0.050	0.100	76.84	7.2	40.0
24	0.456	29904	0.000	0.000	1.00	5.7	0.050	0.100	80.18	7.2	40.0
25	0.456	29904	0.000	0.000	1.00	6.4	0.050	0.100	83.52	7.2	40.0
26	0.456	29904	0.000	0.000	1.00	7.2	0.050	0.100	86.86	7.2	40.0
27	0.456	29904	0.000	0.000	1.00	7.9	0.050	0.100	90.20	7.2	40.0
Toe				229.2	0.150	0.354					

12.315 kips total unreduced pile weight (g= 32.17 ft/s²)
 12.321 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficacy
37.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Rut kips	B1 b/ft	Ct down	Stroke (ft) up	Ten ksi	Str ksi	i 1	t 0	Comp 23.43	Str 18	i 6	t 104.7	ENTHRU kip-ft	B1 b/min	Rt 46.9
275.8	5.7	6.20	6.25	0.00										

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth Shaft Gain/Loss Factor	(ft) 0.500	43.7 Toe Gain/Loss Factor	1.000
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INTAKE2_004_HPILE_BERMB6505_TIME_ALL.GWO

PILE PROFILE:

Toe Area	(in2)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3
90.2	39.96	30000.	492.0	7.2	0	16807.	71.3

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model			Soil-S	Soil-D	Quake	LbTop	Capacity (kips)	Rut ft	Perim in2	Area
		Stiffn kips	C-Slk ft/in	T-Slk ft								
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0	
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0	
14	0.456	29904	0.000	0.000	1.00	0.0	0.050	0.100	46.77	7.2	40.0	
15	0.456	29904	0.000	0.000	1.00	0.4	0.050	0.100	50.11	7.2	40.0	
16	0.456	29904	0.000	0.000	1.00	1.2	0.050	0.100	53.45	7.2	40.0	
17	0.456	29904	0.000	0.000	1.00	1.9	0.050	0.100	56.79	7.2	40.0	
18	0.456	29904	0.000	0.000	1.00	2.6	0.050	0.100	60.13	7.2	40.0	
19	0.456	29904	0.000	0.000	1.00	3.4	0.050	0.100	63.47	7.2	40.0	
20	0.456	29904	0.000	0.000	1.00	4.1	0.050	0.100	66.81	7.2	40.0	
21	0.456	29904	0.000	0.000	1.00	4.8	0.050	0.100	70.16	7.2	40.0	
22	0.456	29904	0.000	0.000	1.00	5.5	0.050	0.100	73.50	7.2	40.0	
23	0.456	29904	0.000	0.000	1.00	6.3	0.050	0.100	76.84	7.2	40.0	
24	0.456	29904	0.000	0.000	1.00	7.0	0.050	0.100	80.18	7.2	40.0	
25	0.456	29904	0.000	0.000	1.00	7.7	0.050	0.100	83.52	7.2	40.0	
26	0.456	29904	0.000	0.000	1.00	8.5	0.050	0.100	86.86	7.2	40.0	
27	0.456	29904	0.000	0.000	1.00	9.2	0.050	0.100	90.20	7.2	40.0	
Toe					265.6	0.150	0.354					

12.315 kips total unreduced pile weight (g= 32.17 ft/s²)

12.321 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	
43.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	B1	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	B1	Rt
kips	b/ft	down	up	ksi		1	0	25.36	ksi	kip-ft		b/min		
328.3	6.9	6.55	6.58	0.00		1	0	25.36	7	3	103.6		45.6	

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	49.7		
Shaft Gain/Loss Factor		0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3
90.2	39.96	30000.	492.0	7.2	0	16807.	71.3

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model			Soil-S	Soil-D	Quake	LbTop	Capacity (kips)	Rut ft	Perim in2	Area
		Stiffn kips	C-Slk ft/in	T-Slk ft								
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0	
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0	
13	0.456	29904	0.000	0.000	1.00	0.3	0.050	0.100	43.43	7.2	40.0	
14	0.456	29904	0.000	0.000	1.00	1.0	0.050	0.100	46.77	7.2	40.0	

INTAKE2_004_HPILE_BERMB6505_TIME_ALL.GWO											
15	0.456	29904	0.000	0.000	1.00	1.7	0.050	0.100	50.11	7.2	40.0
16	0.456	29904	0.000	0.000	1.00	2.5	0.050	0.100	53.45	7.2	40.0
17	0.456	29904	0.000	0.000	1.00	3.2	0.050	0.100	56.79	7.2	40.0
18	0.456	29904	0.000	0.000	1.00	3.9	0.050	0.100	60.13	7.2	40.0
19	0.456	29904	0.000	0.000	1.00	4.7	0.050	0.100	63.47	7.2	40.0
20	0.456	29904	0.000	0.000	1.00	5.4	0.050	0.100	66.81	7.2	40.0
21	0.456	29904	0.000	0.000	1.00	6.1	0.050	0.100	70.16	7.2	40.0
22	0.456	29904	0.000	0.000	1.00	6.9	0.050	0.100	73.50	7.2	40.0
23	0.456	29904	0.000	0.000	1.00	7.6	0.050	0.100	76.84	7.2	40.0
24	0.456	29904	0.000	0.000	1.00	8.3	0.050	0.100	80.18	7.2	40.0
25	0.456	29904	0.000	0.000	1.00	9.1	0.050	0.100	83.52	7.2	40.0
26	0.456	29904	0.000	0.000	1.00	9.8	0.050	0.100	86.86	7.2	40.0
27	0.456	29904	0.000	0.000	1.00	10.5	0.050	0.100	90.20	7.2	40.0
Toe						302.1	0.150	0.354			

12.315 kips total unreduced pile weight (g= 32.17 ft/s²)
12.321 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficacy
49.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	B1	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	B1	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
383.1	8.3	6.86	6.88	0.00		1	0	26.79		7	3	102.8		44.6

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth (ft) 52.7
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in²) 450.400 Pile Type H Pile
Pile Size (inch) 18.110

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c	
			ft	in ²	ksi	lb/ft ³		ft	ft/s	k/ft/s
0.0			39.96	30000.	492.0	7.2	0	16807.	71.3	
90.2			39.96	30000.	492.0	7.2	0	16807.	71.3	

Wave Travel Time 2L/c (ms) 10.734

Pile and Soil Model				Total	Capacity	Rut	(kips)	411.6			
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
		kips	k/in	ft	ft	kips	s/ft	inch	ft	ft	in ²
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0
12	0.456	29904	0.000	0.000	1.00	0.2	0.050	0.100	40.09	7.2	40.0
13	0.456	29904	0.000	0.000	1.00	0.9	0.050	0.100	43.43	7.2	40.0
14	0.456	29904	0.000	0.000	1.00	1.7	0.050	0.100	46.77	7.2	40.0
15	0.456	29904	0.000	0.000	1.00	2.4	0.050	0.100	50.11	7.2	40.0
16	0.456	29904	0.000	0.000	1.00	3.1	0.050	0.100	53.45	7.2	40.0
17	0.456	29904	0.000	0.000	1.00	3.9	0.050	0.100	56.79	7.2	40.0
18	0.456	29904	0.000	0.000	1.00	4.6	0.050	0.100	60.13	7.2	40.0
19	0.456	29904	0.000	0.000	1.00	5.3	0.050	0.100	63.47	7.2	40.0
20	0.456	29904	0.000	0.000	1.00	6.1	0.050	0.100	66.81	7.2	40.0
21	0.456	29904	0.000	0.000	1.00	6.8	0.050	0.100	70.16	7.2	40.0
22	0.456	29904	0.000	0.000	1.00	7.5	0.050	0.100	73.50	7.2	40.0
23	0.456	29904	0.000	0.000	1.00	8.3	0.050	0.100	76.84	7.2	40.0
24	0.456	29904	0.000	0.000	1.00	9.0	0.050	0.100	80.18	7.2	40.0
25	0.456	29904	0.000	0.000	1.00	9.7	0.050	0.100	83.52	7.2	40.0
26	0.456	29904	0.000	0.000	1.00	10.5	0.050	0.100	86.86	7.2	40.0
27	0.456	29904	0.000	0.000	1.00	11.2	0.050	0.100	90.20	7.2	40.0
Toe						320.5	0.150	0.354			

12.315 kips total unreduced pile weight ($g = 32.17 \text{ ft/s}^2$)

INTAKE2_004_HPILE_BERMB6505_TIME_ALL.GWO
12.321 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	
52.71	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi		kip-ft		b/min	
411.6	9.1	7.01	7.02	0.00	1	0	27.46	7	3	102.7	44.2

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Depth	(ft)	56.7	
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in ²)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft				ksi	lb/ft ³	ft		ft/s	k/ft/s
0.0			39.96	30000.	492.0	7.2	0	16807.	71.3
90.2			39.96	30000.	492.0	7.2	0	16807.	71.3

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model				Total Capacity	Rut (kips)	450.1			
		Stiffn	C-Slk	T-Slk	CoR			Soil-S	Soil-D	Quake	LbTop
		kips	k/in	ft	ft	kips	s/ft	inch	ft	in ²	
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0
11	0.456	29904	0.000	0.000	1.00	0.3	0.050	0.100	36.75	7.2	40.0
12	0.456	29904	0.000	0.000	1.00	1.1	0.050	0.100	40.09	7.2	40.0
13	0.456	29904	0.000	0.000	1.00	1.8	0.050	0.100	43.43	7.2	40.0
14	0.456	29904	0.000	0.000	1.00	2.5	0.050	0.100	46.77	7.2	40.0
15	0.456	29904	0.000	0.000	1.00	3.3	0.050	0.100	50.11	7.2	40.0
16	0.456	29904	0.000	0.000	1.00	4.0	0.050	0.100	53.45	7.2	40.0
17	0.456	29904	0.000	0.000	1.00	4.7	0.050	0.100	56.79	7.2	40.0
18	0.456	29904	0.000	0.000	1.00	5.5	0.050	0.100	60.13	7.2	40.0
19	0.456	29904	0.000	0.000	1.00	6.2	0.050	0.100	63.47	7.2	40.0
20	0.456	29904	0.000	0.000	1.00	6.9	0.050	0.100	66.81	7.2	40.0
21	0.456	29904	0.000	0.000	1.00	7.7	0.050	0.100	70.16	7.2	40.0
22	0.456	29904	0.000	0.000	1.00	8.4	0.050	0.100	73.50	7.2	40.0
23	0.456	29904	0.000	0.000	1.00	9.1	0.050	0.100	76.84	7.2	40.0
24	0.456	29904	0.000	0.000	1.00	9.9	0.050	0.100	80.18	7.2	40.0
25	0.456	29904	0.000	0.000	1.00	10.6	0.050	0.100	83.52	7.2	40.0
26	0.456	29904	0.000	0.000	1.00	11.3	0.050	0.100	86.86	7.2	40.0
27	0.456	29904	0.000	0.000	1.00	12.1	0.050	0.100	90.20	7.2	40.0
Toe					344.7	0.150	0.354				

12.315 kips total unreduced pile weight (g= 32.17 ft/s²)
12.321 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	

56.69	11.50	1.00	0.800
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WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi		kip-ft		b/min	
450.1	10.0	7.23	7.17	0.00	1	0	28.37	5	3	103.2	43.6

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Depth	(ft)	62.7		
Shaft Gain/Loss Factor		0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in ²)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in ²	ksi	lb/ft ³	ft	ft/s	k/ft/s			
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3		
90.2	39.96	30000.	492.0	7.2	0	16807.	71.3		

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model				Soil-S	Soil-D	Quake	LbTop	Perim	Area	766.4
		Stiffn	C-Slk	T-Slk	CoR							
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0	
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0	
9	0.456	29904	0.000	0.000	1.00	0.2	0.050	0.100	30.07	7.2	40.0	
10	0.456	29904	0.000	0.000	1.00	0.9	0.050	0.100	33.41	7.2	40.0	
11	0.456	29904	0.000	0.000	1.00	1.7	0.050	0.100	36.75	7.2	40.0	
12	0.456	29904	0.000	0.000	1.00	2.4	0.050	0.100	40.09	7.2	40.0	
13	0.456	29904	0.000	0.000	1.00	3.1	0.050	0.100	43.43	7.2	40.0	
14	0.456	29904	0.000	0.000	1.00	3.9	0.050	0.100	46.77	7.2	40.0	
15	0.456	29904	0.000	0.000	1.00	4.6	0.050	0.100	50.11	7.2	40.0	
16	0.456	29904	0.000	0.000	1.00	5.3	0.050	0.100	53.45	7.2	40.0	
17	0.456	29904	0.000	0.000	1.00	6.1	0.050	0.100	56.79	7.2	40.0	
18	0.456	29904	0.000	0.000	1.00	6.8	0.050	0.100	60.13	7.2	40.0	
19	0.456	29904	0.000	0.000	1.00	7.5	0.050	0.100	63.47	7.2	40.0	
20	0.456	29904	0.000	0.000	1.00	8.2	0.050	0.100	66.81	7.2	40.0	
21	0.456	29904	0.000	0.000	1.00	9.0	0.050	0.100	70.16	7.2	40.0	
22	0.456	29904	0.000	0.000	1.00	9.7	0.050	0.100	73.50	7.2	40.0	
23	0.456	29904	0.000	0.000	1.00	10.4	0.050	0.100	76.84	7.2	40.0	
24	0.456	29904	0.000	0.000	1.00	11.2	0.050	0.100	80.18	7.2	40.0	
25	0.456	29904	0.000	0.000	1.00	11.9	0.050	0.100	83.52	7.2	40.0	
26	0.456	29904	0.000	0.000	1.00	17.5	0.050	0.100	86.86	7.2	40.0	
27	0.456	29904	0.000	0.000	1.00	20.5	0.050	0.100	90.20	7.2	40.0	
Toe						625.6	0.150	0.354				

12.315 kips total unreduced pile weight (g= 32.17 ft/s²)

12.321 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	
62.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
766.4	20.7		8.28	8.35	-1.14	18	40		34.51	26	8	108.8		40.7

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	68.7		
Shaft Gain/Loss Factor		0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in ²)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in ²	ksi	lb/ft ³	ft	ft/s	k/ft/s			
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3		
90.2	39.96	30000.	492.0	7.2	0	16807.	71.3		

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Wave Travel Time 2L/c (ms) 10.734

Pile and Soil Model				Total	Capacity	Rut	(kips)	805.7			
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0
7	0.456	29904	0.000	0.000	1.00	0.1	0.050	0.100	23.39	7.2	40.0
8	0.456	29904	0.000	0.000	1.00	0.8	0.050	0.100	26.73	7.2	40.0
9	0.456	29904	0.000	0.000	1.00	1.5	0.050	0.100	30.07	7.2	40.0
10	0.456	29904	0.000	0.000	1.00	2.2	0.050	0.100	33.41	7.2	40.0
11	0.456	29904	0.000	0.000	1.00	3.0	0.050	0.100	36.75	7.2	40.0
12	0.456	29904	0.000	0.000	1.00	3.7	0.050	0.100	40.09	7.2	40.0
13	0.456	29904	0.000	0.000	1.00	4.4	0.050	0.100	43.43	7.2	40.0
14	0.456	29904	0.000	0.000	1.00	5.2	0.050	0.100	46.77	7.2	40.0
15	0.456	29904	0.000	0.000	1.00	5.9	0.050	0.100	50.11	7.2	40.0
16	0.456	29904	0.000	0.000	1.00	6.6	0.050	0.100	53.45	7.2	40.0
17	0.456	29904	0.000	0.000	1.00	7.4	0.050	0.100	56.79	7.2	40.0
18	0.456	29904	0.000	0.000	1.00	8.1	0.050	0.100	60.13	7.2	40.0
19	0.456	29904	0.000	0.000	1.00	8.8	0.050	0.100	63.47	7.2	40.0
20	0.456	29904	0.000	0.000	1.00	9.6	0.050	0.100	66.81	7.2	40.0
21	0.456	29904	0.000	0.000	1.00	10.3	0.050	0.100	70.16	7.2	40.0
22	0.456	29904	0.000	0.000	1.00	11.0	0.050	0.100	73.50	7.2	40.0
23	0.456	29904	0.000	0.000	1.00	11.8	0.050	0.100	76.84	7.2	40.0
24	0.456	29904	0.000	0.000	1.00	15.9	0.050	0.100	80.18	7.2	40.0
25	0.456	29904	0.000	0.000	1.00	20.3	0.050	0.100	83.52	7.2	40.0
26	0.456	29904	0.000	0.000	1.00	21.3	0.050	0.100	86.86	7.2	40.0
27	0.456	29904	0.000	0.000	1.00	22.3	0.050	0.100	90.20	7.2	40.0
Toe						625.6	0.150	0.354			

12.315 kips total unreduced pile weight (g= 32.17 ft/s²)

12.321 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficcy
ft	ft	Ratio	
68.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_Hpile 03/07/2020
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Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	B1	Rt
kips	b/ft	down	up	ksi	ksi			ksi		kip-ft		b/min		
805.7	22.2	8.36	8.41	-1.05	14	33	33.78	26	8	109.1		40.5		

WaterFix_2019-CER_Intake2_004_Hpile 03/07/2020
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Depth	(ft)	72.5	
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:
Toe Area (in²) 450.400 Pile Type H Pile
Pile Size (inch) 18.110

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s
0.0	39.96	30000.	492.0	7.2	0	16807.		71.3	
90.2	39.96	30000.	492.0	7.2	0	16807.		71.3	

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model	Total	Capacity	Rut	(kips)	832.4				
	kips	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.456	29904	0.010	0.000	0.85	0.0	0.000	0.100	3.34	7.2	40.0
2	0.456	29904	0.000	0.000	1.00	0.0	0.000	0.100	6.68	7.2	40.0
6	0.456	29904	0.000	0.000	1.00	0.2	0.050	0.100	20.04	7.2	40.0
7	0.456	29904	0.000	0.000	1.00	0.9	0.050	0.100	23.39	7.2	40.0
8	0.456	29904	0.000	0.000	1.00	1.6	0.050	0.100	26.73	7.2	40.0

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9	0.456	29904	0.000	0.000	1.00	2.3	0.050	0.100	30.07	7.2	40.0
10	0.456	29904	0.000	0.000	1.00	3.1	0.050	0.100	33.41	7.2	40.0
11	0.456	29904	0.000	0.000	1.00	3.8	0.050	0.100	36.75	7.2	40.0
12	0.456	29904	0.000	0.000	1.00	4.5	0.050	0.100	40.09	7.2	40.0
13	0.456	29904	0.000	0.000	1.00	5.3	0.050	0.100	43.43	7.2	40.0
14	0.456	29904	0.000	0.000	1.00	6.0	0.050	0.100	46.77	7.2	40.0
15	0.456	29904	0.000	0.000	1.00	6.7	0.050	0.100	50.11	7.2	40.0
16	0.456	29904	0.000	0.000	1.00	7.5	0.050	0.100	53.45	7.2	40.0
17	0.456	29904	0.000	0.000	1.00	8.2	0.050	0.100	56.79	7.2	40.0
18	0.456	29904	0.000	0.000	1.00	8.9	0.050	0.100	60.13	7.2	40.0
19	0.456	29904	0.000	0.000	1.00	9.7	0.050	0.100	63.47	7.2	40.0
20	0.456	29904	0.000	0.000	1.00	10.4	0.050	0.100	66.81	7.2	40.0
21	0.456	29904	0.000	0.000	1.00	11.1	0.050	0.100	70.16	7.2	40.0
22	0.456	29904	0.000	0.000	1.00	11.9	0.050	0.100	73.50	7.2	40.0
23	0.456	29904	0.000	0.000	1.00	17.0	0.050	0.100	76.84	7.2	40.0
24	0.456	29904	0.000	0.000	1.00	20.4	0.050	0.100	80.18	7.2	40.0
25	0.456	29904	0.000	0.000	1.00	21.4	0.050	0.100	83.52	7.2	40.0
26	0.456	29904	0.000	0.000	1.00	22.4	0.050	0.100	86.86	7.2	40.0
27	0.456	29904	0.000	0.000	1.00	23.4	0.050	0.100	90.20	7.2	40.0
Toe						625.6	0.150	0.354			

12.315 kips total unreduced pile weight (g= 32.17 ft/s²)
 12.321 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	
72.50	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
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Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
832.4	23.4	8.41	8.46	-1.20	14	33		33.35	27	9	109.2	40.4		

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
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SUMMARY OVER DEPTHS

Depth	G/L at Shaft and Toe: 0.500 1.000										
	Rut	Frictn	End	Bg	Bl	Ct	Com	Str	Ten	Str	Stroke
ft	kips	kips	kips	bl/ft		ksi	ksi			ft	kip-ft
6.0	37.7	1.2	36.5	Hammer	did not run						
12.0	77.7	4.7	73.0	1.3	13.146	0.000		4.41		123.3	
15.7	103.6	8.1	95.5	1.7	14.112	0.000		4.79		119.4	
19.7	132.4	12.7	119.7	2.4	15.613	0.000		5.07		114.8	
25.7	177.8	21.6	156.2	3.3	18.959	0.000		5.51		110.9	
31.7	225.6	32.9	192.7	4.4	21.620	0.000		5.90		107.9	
37.7	275.8	46.6	229.2	5.7	23.433	0.000		6.20		104.7	
43.7	328.3	62.6	265.6	6.9	25.362	0.000		6.55		103.6	
49.7	383.1	81.0	302.1	8.3	26.786	0.000		6.86		102.8	
52.7	411.6	91.1	320.5	9.1	27.459	0.000		7.01		102.7	
56.7	450.1	105.4	344.7	10.0	28.371	0.000		7.23		103.2	
62.7	766.4	140.9	625.6	20.7	34.513	-1.136		8.28		108.8	
68.7	805.7	180.2	625.6	22.2	33.783	-1.046		8.36		109.1	
72.5	832.4	206.8	625.6	23.4	33.351	-1.198		8.41		109.2	

Total Driving Time 13 minutes; Total No. of Blows 541
 Starting at penetration 6.0 ft

WaterFix_2019-CER_Intake2_004_HPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth	Temp.	Wait	Equivalent	Pressure	Stiffn.	Cushion	
ft	Length	Time	Stroke	Ratio	Efficacy.	Factor	CoR

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	90.20	0.00	11.50	1.00	0.80	1.00	1.00
6.00	90.20	0.00	11.50	1.00	0.80	1.00	1.00
12.00	90.20	0.00	11.50	1.00	0.80	1.00	1.00
15.71	90.20	0.00	11.50	1.00	0.80	1.00	1.00
19.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
25.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
31.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
37.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
43.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
49.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
52.71	90.20	0.00	11.50	1.00	0.80	1.00	1.00
56.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
62.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
68.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
72.50	90.20	0.00	11.50	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth	Shaft ft	End Res. k/ft ²	Shaft Bearing kips	Toe Quake inch	Shaft Quake inch	Toe Damping s/ft	Shaft Damping s/ft	Soil Setup Normlzd	Limit ft	Setup Time hrs
0.00	0.00	0.00	0.100	0.354	0.050	0.150	1.000	1.000	6.560	1.000
37.00	0.68	224.97	0.100	0.354	0.050	0.150	1.000	1.000	6.560	1.000
37.00	0.68	224.97	0.100	0.354	0.050	0.150	1.000	1.000	6.560	1.000
57.00	1.04	346.57	0.100	0.354	0.050	0.150	1.000	1.000	6.560	1.000
57.00	1.61	625.56	0.100	0.354	0.050	0.150	1.000	1.000	6.560	1.000
72.50	2.00	625.56	0.100	0.354	0.050	0.150	1.000	1.000	6.560	1.000
90.20	2.00	625.56	0.100	0.354	0.050	0.150	1.000	1.000	6.560	1.000

INTAKE2_004_SHEETPILE_BERMB6505_TIME_ALL.GWO

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

↑
Input File: C:\USERS\MAU\Desktop\WATERFIX\INTAKE PILE DRIVABILITY\PILE_DRIVING\GRLWEAP\DRIVING TIME\BERMINGHAM B6505\INTAKE 2\SHEET PILE\INTAKE2_004_SHEETPILE_BERMB6505_TIME_ALL.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (12/4/2015)

Input File Contents
WaterFix_2019-CER_Intake2_004_SheetPile

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
-100	0	433	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0.000
Pile g	Hammer g	Toe	Area	Pile	Size													
32.185	32.185	52.850	0.000															
W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp												
6.000	424.000	30000.0	6.000	0.700	0.000	0.0												
A Cu	E Cu	T Cu	CoR	ROut	StCu													
0.000	0.0	0.000	0.000	0.000	0.0													
LPle	APle	EPle	WPle	Peri	CI	CoR												
90.200	52.84	30000.0	492.000	13.451	0	0.850												
FFatigue	F0	0-Bottom																
0	0.000	0.000																
Manufac	Hmr	Name	HmrType	No Seg-s														
BERMINGH	B6505			1	4													
Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy													
17.64	142.90	23.50	11.50	11.50	0.80													
IB. Wt	IB. L	IB.Dia	IB CoR	IB RO														

INTAKE2_004_SHEETPILE_BERMB6505_TIME_ALL.GWO

3.75	43.00	19.00	0.900	0.010					
CompStrk	A	Chamber	V	Chamber					
20.30	452.40	658.00	0.0000	0.0000					
P atm	P1	P2	P3	P4					
14.70	1375.00	0.00	0.00	0.00					
Stroke	Effic.	Pressure	R-Weight	T-Delay					
11.5000	0.8000	1375.0000	0.0000	0.0000					
Qs	Qt	Js	Jt	Qx					
0.100	0.100	0.100	0.150	0.000					
Research	Soil Model:	Atoe, Plug, Gap, Q-fac							
		0.000	0.000	0.000					
Research	Soil Model:	RD-skn: m, d, toe: m, d							
		0.000	0.000	0.000					
Res. Distribution									
Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimD	SU T
0.00	0.00	0.00	0.10	0.12	0.05	0.15	1.20	6.56	1.0
37.00	0.68	26.40	0.10	0.12	0.05	0.15	1.20	6.56	1.0
37.00	0.68	26.40	0.10	0.12	0.05	0.15	1.20	6.56	1.0
57.00	1.04	40.67	0.10	0.12	0.05	0.15	1.20	6.56	1.0
57.00	1.61	73.40	0.10	0.12	0.05	0.15	1.20	6.56	1.0
72.50	2.00	73.40	0.10	0.12	0.05	0.15	1.20	6.56	1.0
90.20	2.00	73.40	0.10	0.12	0.05	0.15	1.20	6.56	1.0
Gain/Loss factors: shaft and toe									
0.50000	0.00000	0.00000	0.00000	0.00000					
1.00000	0.00000	0.00000	0.00000	0.00000					
Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR		
6.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
12.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
15.71	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
19.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
25.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
31.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
37.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
43.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
49.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
52.71	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
56.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
62.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
68.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
72.50	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000		

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

Version 2010

English Units

WaterFix_2019-CER_Intake2_004_SheetPile

Hammer Model:		B6505	Made by:			BERMINGH
No.	Weight	Stiffn	CoR	C-Slk	Dampg	
1	4.410					
2	4.410	352088.1	1.000	0.0100		
3	4.410	352088.1	1.000	0.0100		
4	4.410	352088.1	1.000	0.0100		
Imp Block	3.750	123917.9	0.900	0.0100		
Helmet	6.000	2120000.0	0.700	0.0100	18.1	
Combined Pile Top		39542.1				

HAMMER OPTIONS:

Hammer File ID No.	433	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	17.64	Ram Length	(inch)	142.90
Maximum Stroke	(ft)	11.50			
Rated Stroke	(ft)	11.50	Efficiency		0.800

Maximum Pressure (psi) 1375.00 Actual Pressure (psi) 1375.00

INTAKE2_004_SHEETPILE_BERMB6505_TIME_ALL.GWO
 Compression Exponent 1.350 Expansion Exponent 1.250
 Ram Diameter (inch) 23.50
 Comb. Start Volume (in3) 724.00 Comb. End Volume (in3) 768.00

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION		PILE CUSHION	
Cross Sect. Area (in2)	424.00	Cross Sect. Area (in2)	0.00
Elastic-Modulus (ksi)	30000.0	Elastic-Modulus (ksi)	0.0
Thickness (inch)	6.00	Thickness (inch)	0.00
Coeff of Restitution	0.7	Coeff of Restitution	1.0
RoundOut (ft)	0.0	RoundOut (ft)	0.0
Stiffness (kips/in)	2120000.0	Stiffness (kips/in)	0.0

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth (ft)	6.0		
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area (in2)	52.850	Pile Type	Sheet Pile
Pile Size (inch)	0.000		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0			52.84	30000.	492.0	13.5	0	16807.	94.3
90.2			52.84	30000.	492.0	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 10.734

Pile and Soil Model				Total Capacity (kips)	Rut (inches)	6.5					
No.	Weight kips	Stiffn k/in	C-Slk ft	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2		
1	0.603	39542	0.010	0.000	0.85	0.0	0.000	0.100	3.34	13.5	52.8
2	0.603	39542	0.000	0.000	1.00	0.0	0.000	0.100	6.68	13.5	52.8
26	0.603	39542	0.000	0.000	1.00	0.4	0.050	0.100	86.86	13.5	52.8
27	0.603	39542	0.000	0.000	1.00	1.8	0.050	0.100	90.20	13.5	52.8
Toe						4.3	0.150	0.121			

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)
 16.292 kips total reduced pile weight (g= 32.19 ft/s²)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile	Pile Segments: Automatic		
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	1.886

Driveability Analysis

Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	3	Analysis Time-Input (ms)	0
Output Level: Normal			
Gravity Mass, Pile, Hammer:	32.170	32.185	32.185
Output Segment Generation:	Automatic		

Depth ft	Stroke ft	Pressure Ratio	Efficy
6.00	11.50	1.00	0.800

INITIAL STATIC ANALYSIS: Total Wt, Sum(R) 26.0 6.5
 Hammer+Pile Weight > Rult: Pile Runs

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Rut	B1 Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	B1 Rt
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INTAKE2_004_SHEETPILE_BERMB6505_TIME_ALL.GWO

kips	b/ft	down	up	ksi		ksi	kip-ft	b/min
6.5	0.0	11.50	0.00	0.00	1 0	0.00	1 0	0.0

03/07/2020
GRLWEAP Version 2010

↑
WaterFix_2019-CER_Intake2_004_SheetPile
CH2M HILL

Depth (ft) 12.0
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area	(in2)	52.850	Pile Type	Sheet Pile
Pile Size	(inch)	0.000		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0			52.84	30000.	492.0	13.5	0	16807.	94.3
90.2			52.84	30000.	492.0	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model			Total Capacity	Rut	(kips)	17.4			
		Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
		kips	k/in	ft	ft	kips	s/ft	inch	ft	ft	in2
1	0.603	39542	0.010	0.000	0.85	0.0	0.000	0.100	3.34	13.5	52.8
2	0.603	39542	0.000	0.000	1.00	0.0	0.000	0.100	6.68	13.5	52.8
24	0.603	39542	0.000	0.000	1.00	0.2	0.050	0.100	80.18	13.5	52.8
25	0.603	39542	0.000	0.000	1.00	1.5	0.050	0.100	83.52	13.5	52.8
26	0.603	39542	0.000	0.000	1.00	2.9	0.050	0.100	86.86	13.5	52.8
27	0.603	39542	0.000	0.000	1.00	4.3	0.050	0.100	90.20	13.5	52.8
Toe						8.6	0.150	0.121			

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)
16.292 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
12.00	11.50	1.00	0.800

INITIAL STATIC ANALYSIS: Total Wt, Sum(R) 26.0 17.4
Hammer+Pile Weight > Rult: Pile Runs

↑
WaterFix_2019-CER_Intake2_004_SheetPile
CH2M HILL

03/07/2020
GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
17.4	0.0		11.50	0.00	0.00	1	0		0.00	1	0	0.0	76.8	

↑
WaterFix_2019-CER_Intake2_004_SheetPile
CH2M HILL

03/07/2020
GRLWEAP Version 2010

Depth (ft) 15.7
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area	(in2)	52.850	Pile Type	Sheet Pile
Pile Size	(inch)	0.000		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0			52.84	30000.	492.0	13.5	0	16807.	94.3
90.2			52.84	30000.	492.0	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model			Total Capacity	Rut	(kips)	26.4			
		Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
		kips	k/in	ft	ft	kips	s/ft	inch	ft	ft	in2
1	0.603	39542	0.010	0.000	0.85	0.0	0.000	0.100	3.34	13.5	52.8

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2	0.603	39542	0.000	0.000	1.00	0.0	0.000	0.100	6.68	13.5	52.8
23	0.603	39542	0.000	0.000	1.00	0.3	0.050	0.100	76.84	13.5	52.8
24	0.603	39542	0.000	0.000	1.00	1.7	0.050	0.100	80.18	13.5	52.8
25	0.603	39542	0.000	0.000	1.00	3.0	0.050	0.100	83.52	13.5	52.8
26	0.603	39542	0.000	0.000	1.00	4.4	0.050	0.100	86.86	13.5	52.8
27	0.603	39542	0.000	0.000	1.00	5.8	0.050	0.100	90.20	13.5	52.8
Toe						11.2	0.150	0.121			

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)
 16.292 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.71	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
26.4			Hammer did not run											

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth	(ft)	19.7
Shaft Gain/Loss Factor		0.500
		Toe Gain/Loss Factor
		1.000

PILE PROFILE:

Toe Area	(in ²)	52.850	Pile Type	Sheet Pile
Pile Size	(inch)	0.000		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s
0.0	52.84	30000.		492.0		13.5	0	16807.	94.3
90.2	52.84	30000.		492.0		13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model	Total Capacity	Rut (kips)	37.9	
	kips	Stiffn C-Slk T-Slk CoR	Soil-S Soil-D Quake LbTop Perim	ft	in ²	
		k/in ft ft	kips s/ft inch	ft	ft	
1	0.603	39542 0.010 0.000 0.85	0.0 0.000 0.100	3.34	13.5	52.8
2	0.603	39542 0.000 0.000 1.00	0.0 0.000 0.100	6.68	13.5	52.8
22	0.603	39542 0.000 0.000 1.00	0.5 0.050 0.100	73.50	13.5	52.8
23	0.603	39542 0.000 0.000 1.00	1.9 0.050 0.100	76.84	13.5	52.8
24	0.603	39542 0.000 0.000 1.00	3.3 0.050 0.100	80.18	13.5	52.8
25	0.603	39542 0.000 0.000 1.00	4.7 0.050 0.100	83.52	13.5	52.8
26	0.603	39542 0.000 0.000 1.00	6.0 0.050 0.100	86.86	13.5	52.8
27	0.603	39542 0.000 0.000 1.00	7.4 0.050 0.100	90.20	13.5	52.8
Toe			14.0	0.150	0.121	

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)
 16.292 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
19.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
37.9	0.9	3.86	3.84	-1.89	9 76	9.63	1	5	108.4					60.3

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

INTAKE2_004_SHEETPILE_BERMB6505_TIME_ALL.GWO
 Depth (ft) 25.7
 Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in2)	52.850	Pile Type	Sheet Pile
Pile Size (inch)	0.000		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	52.84	30000.	52.84	492.0	13.5	0	16807.	94.3	
90.2	52.84	30000.	52.84	492.0	13.5	0	16807.	94.3	

Wave Travel Time 2L/c (ms) 10.734

Pile and Soil Model				Total Capacity (kips)	59.0						
No.	Weight kips	Stiffn k/in	C-Slk ft	Soil-S kips	Capacity s/ft	Rut inch	(kips)	59.0			
				Soil-D kips	Quake s/ft	LbTop ft	Perim ft	Area in2			
1	0.603	39542	0.010	0.000	0.85	0.0	0.000	0.100	3.34	13.5	52.8
2	0.603	39542	0.000	0.000	1.00	0.0	0.000	0.100	6.68	13.5	52.8
20	0.603	39542	0.000	0.000	1.00	0.3	0.050	0.100	66.81	13.5	52.8
21	0.603	39542	0.000	0.000	1.00	1.6	0.050	0.100	70.16	13.5	52.8
22	0.603	39542	0.000	0.000	1.00	3.0	0.050	0.100	73.50	13.5	52.8
23	0.603	39542	0.000	0.000	1.00	4.4	0.050	0.100	76.84	13.5	52.8
24	0.603	39542	0.000	0.000	1.00	5.8	0.050	0.100	80.18	13.5	52.8
25	0.603	39542	0.000	0.000	1.00	7.1	0.050	0.100	83.52	13.5	52.8
26	0.603	39542	0.000	0.000	1.00	8.5	0.050	0.100	86.86	13.5	52.8
27	0.603	39542	0.000	0.000	1.00	9.9	0.050	0.100	90.20	13.5	52.8
Toe		39542	0.000	0.000	1.00	18.3	0.050	0.121			

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)

16.292 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficy
25.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Rut kips	Bl b/ft	Ct down	Stroke (ft)	Ten up	Str ksi	i	t	Comp ksi	Str kip-ft	i t ENTHRU kip-ft	Bl b/min	Rt
59.0	1.1	4.25	4.23	-1.15	8 46			10.25	1	5 113.3		57.4

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth (ft)	31.7
Shaft Gain/Loss Factor	0.500
Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area (in2)	52.850	Pile Type	Sheet Pile
Pile Size (inch)	0.000		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	52.84	30000.	52.84	492.0	13.5	0	16807.	94.3	
90.2	52.84	30000.	52.84	492.0	13.5	0	16807.	94.3	

Wave Travel Time 2L/c (ms) 10.734

Pile and Soil Model				Total Capacity (kips)	84.5						
No.	Weight kips	Stiffn k/in	C-Slk ft	Soil-S kips	Capacity s/ft	Rut inch	(kips)	84.5			
				Soil-D kips	Quake s/ft	LbTop ft	Perim ft	Area in2			
1	0.603	39542	0.010	0.000	0.85	0.0	0.000	0.100	3.34	13.5	52.8
2	0.603	39542	0.000	0.000	1.00	0.0	0.000	0.100	6.68	13.5	52.8
18	0.603	39542	0.000	0.000	1.00	0.2	0.050	0.100	60.13	13.5	52.8
19	0.603	39542	0.000	0.000	1.00	1.4	0.050	0.100	63.47	13.5	52.8
20	0.603	39542	0.000	0.000	1.00	2.7	0.050	0.100	66.81	13.5	52.8
21	0.603	39542	0.000	0.000	1.00	4.1	0.050	0.100	70.16	13.5	52.8
22	0.603	39542	0.000	0.000	1.00	5.5	0.050	0.100	73.50	13.5	52.8

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23	0.603	39542	0.000	0.000	1.00	6.9	0.050	0.100	76.84	13.5	52.8
24	0.603	39542	0.000	0.000	1.00	8.2	0.050	0.100	80.18	13.5	52.8
25	0.603	39542	0.000	0.000	1.00	9.6	0.050	0.100	83.52	13.5	52.8
26	0.603	39542	0.000	0.000	1.00	11.0	0.050	0.100	86.86	13.5	52.8
27	0.603	39542	0.000	0.000	1.00	12.4	0.050	0.100	90.20	13.5	52.8
Toe						22.6	0.150	0.121			

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)
 16.292 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficacy
31.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
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Rut kips	B1 b/ft	Ct down	Stroke (ft)	Ten up	Str ksi	i	t	Comp ksi	Str kip-ft	i	t	ENTHRU kip-ft	B1 b/min
84.5	1.2	4.57	4.58	-0.62	7	46	11.42	1	3	120.1		55.2	

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth Shaft Gain/Loss Factor	(ft) 0.500	37.7	Toe Gain/Loss Factor	1.000
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PILE PROFILE:
 Toe Area (in²) 52.850 Pile Type Sheet Pile
 Pile Size (inch) 0.000

L ft	b in ²	Top ksi	Area lb/ft ³	E-Mod ft	Spec Wt ft	Perim ft	C Index ft	Wave Sp ft/s	EA/c k/ft/s
0.0	52.84	30000.	492.0	52.84	30000.	13.5	0	16807.	94.3
90.2	52.84	30000.	492.0	90.2	30000.	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 10.734

No.	Weight kips	Pile and Soil Model				Total Capacity Rut (kips)	114.4 Area in ²				
		Stiffn k/in	C-Slk ft	T-Slk ft	CoR						
1	0.603	39542	0.010	0.000	0.85	0.0	0.000	0.100	3.34	13.5	52.8
2	0.603	39542	0.000	0.000	1.00	0.0	0.000	0.100	6.68	13.5	52.8
16	0.603	39542	0.000	0.000	1.00	0.1	0.050	0.100	53.45	13.5	52.8
17	0.603	39542	0.000	0.000	1.00	1.1	0.050	0.100	56.79	13.5	52.8
18	0.603	39542	0.000	0.000	1.00	2.5	0.050	0.100	60.13	13.5	52.8
19	0.603	39542	0.000	0.000	1.00	3.8	0.050	0.100	63.47	13.5	52.8
20	0.603	39542	0.000	0.000	1.00	5.2	0.050	0.100	66.81	13.5	52.8
21	0.603	39542	0.000	0.000	1.00	6.6	0.050	0.100	70.16	13.5	52.8
22	0.603	39542	0.000	0.000	1.00	8.0	0.050	0.100	73.50	13.5	52.8
23	0.603	39542	0.000	0.000	1.00	9.3	0.050	0.100	76.84	13.5	52.8
24	0.603	39542	0.000	0.000	1.00	10.7	0.050	0.100	80.18	13.5	52.8
25	0.603	39542	0.000	0.000	1.00	12.1	0.050	0.100	83.52	13.5	52.8
26	0.603	39542	0.000	0.000	1.00	13.5	0.050	0.100	86.86	13.5	52.8
27	0.603	39542	0.000	0.000	1.00	14.8	0.050	0.100	90.20	13.5	52.8
Toe						26.9	0.150	0.121			

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)
 16.292 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficacy
37.69	11.50	1.00	0.800

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Rut kips	B1 b/ft	Ct down	Stroke (ft)	Ten up	Str ksi	i	t	Comp ksi	Str kip-ft	i	t	ENTHRU kip-ft	B1 b/min
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INTAKE2_004_SHEETPILE_BERMB6505_TIME_ALL.GWO
 114.4 1.4 4.89 4.87 -1.62 5 12 15.15 1 3 122.8 53.6

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth (ft) 43.7
 Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area	(in ²)	52.850	Pile Type	Sheet Pile
Pile Size	(inch)	0.000		

L	b	Top ft	Area in ²	E-Mod ksi	Spec Wt lb/ft ³	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0		52.84	30000.	492.0	13.5	0	16807.	94.3	
90.2		52.84	30000.	492.0	13.5	0	16807.	94.3	

Wave Travel Time 2L/c (ms) 10.734

No.	Weight kips	Pile and Soil Model			Total Capacity kips	Rut s/ft	(kips)	148.8			
		Stiffn k/in	C-Slk ft	T-Slk ft					CoR	Soil-S kips	Soil-D inch
1	0.603	39542	0.010	0.000	0.85	0.0	0.000	0.100	3.34	13.5	52.8
2	0.603	39542	0.000	0.000	1.00	0.0	0.000	0.100	6.68	13.5	52.8
14	0.603	39542	0.000	0.000	1.00	0.0	0.050	0.100	46.77	13.5	52.8
15	0.603	39542	0.000	0.000	1.00	0.8	0.050	0.100	50.11	13.5	52.8
16	0.603	39542	0.000	0.000	1.00	2.2	0.050	0.100	53.45	13.5	52.8
17	0.603	39542	0.000	0.000	1.00	3.5	0.050	0.100	56.79	13.5	52.8
18	0.603	39542	0.000	0.000	1.00	4.9	0.050	0.100	60.13	13.5	52.8
19	0.603	39542	0.000	0.000	1.00	6.3	0.050	0.100	63.47	13.5	52.8
20	0.603	39542	0.000	0.000	1.00	7.7	0.050	0.100	66.81	13.5	52.8
21	0.603	39542	0.000	0.000	1.00	9.0	0.050	0.100	70.16	13.5	52.8
22	0.603	39542	0.000	0.000	1.00	10.4	0.050	0.100	73.50	13.5	52.8
23	0.603	39542	0.000	0.000	1.00	11.8	0.050	0.100	76.84	13.5	52.8
24	0.603	39542	0.000	0.000	1.00	13.2	0.050	0.100	80.18	13.5	52.8
25	0.603	39542	0.000	0.000	1.00	14.5	0.050	0.100	83.52	13.5	52.8
26	0.603	39542	0.000	0.000	1.00	15.9	0.050	0.100	86.86	13.5	52.8
27	0.603	39542	0.000	0.000	1.00	17.3	0.050	0.100	90.20	13.5	52.8
Toe					31.2	0.150	0.121				

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)
 16.292 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficy
43.69	11.50	1.00	0.800

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 CH2M HILL GRLWEAP Version 2010

Rut kips	B1 b/ft	Ct down	Stroke (ft) up	Ten ksi	i 5	t 12	Comp 17.76	Str ksi	i 7	t 3	ENTHRU 118.0	B1 kip-ft b/min	Rt 51.9
148.8	1.9	5.20	5.16	-2.86									

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth (ft) 49.7
 Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area	(in ²)	52.850	Pile Type	Sheet Pile
Pile Size	(inch)	0.000		

L	b	Top ft	Area in ²	E-Mod ksi	Spec Wt lb/ft ³	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0		52.84	30000.	492.0	13.5	0	16807.	94.3	
90.2		52.84	30000.	492.0	13.5	0	16807.	94.3	

Wave Travel Time 2L/c (ms) 10.734

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No.	Weight	Pile and Soil Model				Total Capacity (kips)	Rut (inches)	LbTop ft	Perim ft	Area in2	
		Stiffn kips	C-Slk ft	T-Slk ft	CoR						
1	0.603	39542	0.010	0.000	0.85	0.0	0.000	0.100	3.34	13.5	52.8
2	0.603	39542	0.000	0.000	1.00	0.0	0.000	0.100	6.68	13.5	52.8
13	0.603	39542	0.000	0.000	1.00	0.5	0.050	0.100	43.43	13.5	52.8
14	0.603	39542	0.000	0.000	1.00	1.9	0.050	0.100	46.77	13.5	52.8
15	0.603	39542	0.000	0.000	1.00	3.3	0.050	0.100	50.11	13.5	52.8
16	0.603	39542	0.000	0.000	1.00	4.6	0.050	0.100	53.45	13.5	52.8
17	0.603	39542	0.000	0.000	1.00	6.0	0.050	0.100	56.79	13.5	52.8
18	0.603	39542	0.000	0.000	1.00	7.4	0.050	0.100	60.13	13.5	52.8
19	0.603	39542	0.000	0.000	1.00	8.8	0.050	0.100	63.47	13.5	52.8
20	0.603	39542	0.000	0.000	1.00	10.1	0.050	0.100	66.81	13.5	52.8
21	0.603	39542	0.000	0.000	1.00	11.5	0.050	0.100	70.16	13.5	52.8
22	0.603	39542	0.000	0.000	1.00	12.9	0.050	0.100	73.50	13.5	52.8
23	0.603	39542	0.000	0.000	1.00	14.3	0.050	0.100	76.84	13.5	52.8
24	0.603	39542	0.000	0.000	1.00	15.6	0.050	0.100	80.18	13.5	52.8
25	0.603	39542	0.000	0.000	1.00	17.0	0.050	0.100	83.52	13.5	52.8
26	0.603	39542	0.000	0.000	1.00	18.4	0.050	0.100	86.86	13.5	52.8
27	0.603	39542	0.000	0.000	1.00	19.8	0.050	0.100	90.20	13.5	52.8
Toe						35.5	0.150	0.121			

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)

16.292 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficacy
49.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_SheetPile
CH2M HILL

03/07/2020

GRLWEAP Version 2010

Rut kips	B1 b/ft	Ct down	Stroke (ft) up	Ten ksi	Str -3.16	i 4	t 12	Comp 19.67	Str 13	i 5	t 111.8	ENTHRU b/min 50.5	B1	Rt
187.6	2.5	5.43	5.49	-3.16										

WaterFix_2019-CER_Intake2_004_SheetPile
CH2M HILL

03/07/2020

GRLWEAP Version 2010

Depth (ft)	52.7
Shaft Gain/Loss Factor	0.500
Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area (in ²)	52.850	Pile Type	Sheet Pile
Pile Size (inch)	0.000		

L ft	b in ²	Top Area ksi	E-Mod lb/ft ³	Spec Wt ft	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	52.84	30000.	492.0	13.5	0	16807.	94.3	
90.2	52.84	30000.	492.0	13.5	0	16807.	94.3	

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model				Total Capacity (kips)	Rut (inches)	LbTop ft	Perim ft	Area in2	
		Stiffn kips	C-Slk ft	T-Slk ft	CoR						
1	0.603	39542	0.010	0.000	0.85	0.0	0.000	0.100	3.34	13.5	52.8
2	0.603	39542	0.000	0.000	1.00	0.0	0.000	0.100	6.68	13.5	52.8
12	0.603	39542	0.000	0.000	1.00	0.4	0.050	0.100	40.09	13.5	52.8
13	0.603	39542	0.000	0.000	1.00	1.8	0.050	0.100	43.43	13.5	52.8
14	0.603	39542	0.000	0.000	1.00	3.1	0.050	0.100	46.77	13.5	52.8
15	0.603	39542	0.000	0.000	1.00	4.5	0.050	0.100	50.11	13.5	52.8
16	0.603	39542	0.000	0.000	1.00	5.9	0.050	0.100	53.45	13.5	52.8
17	0.603	39542	0.000	0.000	1.00	7.3	0.050	0.100	56.79	13.5	52.8
18	0.603	39542	0.000	0.000	1.00	8.6	0.050	0.100	60.13	13.5	52.8
19	0.603	39542	0.000	0.000	1.00	10.0	0.050	0.100	63.47	13.5	52.8
20	0.603	39542	0.000	0.000	1.00	11.4	0.050	0.100	66.81	13.5	52.8
21	0.603	39542	0.000	0.000	1.00	12.8	0.050	0.100	70.16	13.5	52.8
22	0.603	39542	0.000	0.000	1.00	14.1	0.050	0.100	73.50	13.5	52.8

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23	0.603	39542	0.000	0.000	1.00	15.5	0.050	0.100	76.84	13.5	52.8
24	0.603	39542	0.000	0.000	1.00	16.9	0.050	0.100	80.18	13.5	52.8
25	0.603	39542	0.000	0.000	1.00	18.3	0.050	0.100	83.52	13.5	52.8
26	0.603	39542	0.000	0.000	1.00	19.6	0.050	0.100	86.86	13.5	52.8
27	0.603	39542	0.000	0.000	1.00	21.0	0.050	0.100	90.20	13.5	52.8
Toe						37.6	0.150	0.121			

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)
 16.292 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	
52.71	11.50	1.00	0.800

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Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
208.8	2.8	5.64	5.62	-3.48	4	12	20.92	13	5	111.0	49.7			

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth	(ft)	56.7	
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in ²)	52.850	Pile Type	Sheet Pile
Pile Size	(inch)	0.000		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s
0.0	52.84	30000.	492.0			13.5	0	16807.	94.3
90.2	52.84	30000.	492.0			13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model	Total Capacity	Rut (kips)	238.5
	kips	Stiffn C-Slk T-Slk CoR	Soil-S Soil-D Quake LbTop Perim Area	ft	in ²
		k/in ft ft	kips s/ft inch ft ft in ²		
1	0.603	39542 0.010 0.000 0.85	0.0 0.000 0.100	3.34	13.5 52.8
2	0.603	39542 0.000 0.000 1.00	0.0 0.000 0.100	6.68	13.5 52.8
11	0.603	39542 0.000 0.000 1.00	0.6 0.050 0.100	36.75	13.5 52.8
12	0.603	39542 0.000 0.000 1.00	2.0 0.050 0.100	40.09	13.5 52.8
13	0.603	39542 0.000 0.000 1.00	3.4 0.050 0.100	43.43	13.5 52.8
14	0.603	39542 0.000 0.000 1.00	4.8 0.050 0.100	46.77	13.5 52.8
15	0.603	39542 0.000 0.000 1.00	6.1 0.050 0.100	50.11	13.5 52.8
16	0.603	39542 0.000 0.000 1.00	7.5 0.050 0.100	53.45	13.5 52.8
17	0.603	39542 0.000 0.000 1.00	8.9 0.050 0.100	56.79	13.5 52.8
18	0.603	39542 0.000 0.000 1.00	10.3 0.050 0.100	60.13	13.5 52.8
19	0.603	39542 0.000 0.000 1.00	11.6 0.050 0.100	63.47	13.5 52.8
20	0.603	39542 0.000 0.000 1.00	13.0 0.050 0.100	66.81	13.5 52.8
21	0.603	39542 0.000 0.000 1.00	14.4 0.050 0.100	70.16	13.5 52.8
22	0.603	39542 0.000 0.000 1.00	15.8 0.050 0.100	73.50	13.5 52.8
23	0.603	39542 0.000 0.000 1.00	17.2 0.050 0.100	76.84	13.5 52.8
24	0.603	39542 0.000 0.000 1.00	18.5 0.050 0.100	80.18	13.5 52.8
25	0.603	39542 0.000 0.000 1.00	19.9 0.050 0.100	83.52	13.5 52.8
26	0.603	39542 0.000 0.000 1.00	21.3 0.050 0.100	86.86	13.5 52.8
27	0.603	39542 0.000 0.000 1.00	22.7 0.050 0.100	90.20	13.5 52.8
Toe			40.4 0.150 0.121		

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)
 16.292 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	
56.69	11.50	1.00	0.800

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INTAKE2_004_SHEETPILE_BERMB6505_TIME_ALL.GWO
 WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Rut	B1	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	B1	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
238.5	3.3		5.83	5.80	-3.36	4	12		21.95	12	4	108.4		48.9

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth (ft)	62.7		
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:
 Toe Area (in²) 52.850 Pile Type Sheet Pile
 Pile Size (inch) 0.000

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft		in ²	ksi	lb/ft ³		ft		ft/s	k/ft/s
0.0		52.84	30000.	492.0		13.5	0	16807.	94.3
90.2		52.84	30000.	492.0		13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model				Total Capacity		Rut (kips)	338.1		
		Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D			Quake	
	kips	k/in	ft	ft	kips	s/ft	inch	ft	ft	in ²	
1	0.603	39542	0.010	0.000	0.85	0.0	0.000	0.100	3.34	13.5	52.8
2	0.603	39542	0.000	0.000	1.00	0.0	0.000	0.100	6.68	13.5	52.8
9	0.603	39542	0.000	0.000	1.00	0.4	0.050	0.100	30.07	13.5	52.8
10	0.603	39542	0.000	0.000	1.00	1.7	0.050	0.100	33.41	13.5	52.8
11	0.603	39542	0.000	0.000	1.00	3.1	0.050	0.100	36.75	13.5	52.8
12	0.603	39542	0.000	0.000	1.00	4.5	0.050	0.100	40.09	13.5	52.8
13	0.603	39542	0.000	0.000	1.00	5.9	0.050	0.100	43.43	13.5	52.8
14	0.603	39542	0.000	0.000	1.00	7.2	0.050	0.100	46.77	13.5	52.8
15	0.603	39542	0.000	0.000	1.00	8.6	0.050	0.100	50.11	13.5	52.8
16	0.603	39542	0.000	0.000	1.00	10.0	0.050	0.100	53.45	13.5	52.8
17	0.603	39542	0.000	0.000	1.00	11.4	0.050	0.100	56.79	13.5	52.8
18	0.603	39542	0.000	0.000	1.00	12.7	0.050	0.100	60.13	13.5	52.8
19	0.603	39542	0.000	0.000	1.00	14.1	0.050	0.100	63.47	13.5	52.8
20	0.603	39542	0.000	0.000	1.00	15.5	0.050	0.100	66.81	13.5	52.8
21	0.603	39542	0.000	0.000	1.00	16.9	0.050	0.100	70.16	13.5	52.8
22	0.603	39542	0.000	0.000	1.00	18.2	0.050	0.100	73.50	13.5	52.8
23	0.603	39542	0.000	0.000	1.00	19.6	0.050	0.100	76.84	13.5	52.8
24	0.603	39542	0.000	0.000	1.00	21.0	0.050	0.100	80.18	13.5	52.8
25	0.603	39542	0.000	0.000	1.00	22.4	0.050	0.100	83.52	13.5	52.8
26	0.603	39542	0.000	0.000	1.00	32.8	0.050	0.100	86.86	13.5	52.8
27	0.603	39542	0.000	0.000	1.00	38.5	0.050	0.100	90.20	13.5	52.8
Toe						73.4	0.150	0.121			

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)
 16.292 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
62.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Rut	B1	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	B1	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
338.1	5.3		6.45	6.43	-1.80	3	13		24.73	10	4	103.0		46.3

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth (ft)	68.7		
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

INTAKE2_004_SHEETPILE_BERMB6505_TIME_ALL.GWO

PILE PROFILE:

Toe Area	(in2)	52.850	Pile Type	Sheet Pile
Pile Size	(inch)	0.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	52.84	30000.	492.0	13.5	0	16807.	94.3
90.2	52.84	30000.	492.0	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 10.734

No.	Weight	Pile and Soil Model			Soil-S kips	Soil-D s/ft	Quake inch	Rut LbTop ft	Capacity ft	(kips)	411.9
		Stiffn kips	C-Slk k/in	T-Slk ft							
1	0.603	39542	0.010	0.000	0.85	0.0	0.000	0.100	3.34	13.5	52.8
2	0.603	39542	0.000	0.000	1.00	0.0	0.000	0.100	6.68	13.5	52.8
7	0.603	39542	0.000	0.000	1.00	0.2	0.050	0.100	23.39	13.5	52.8
8	0.603	39542	0.000	0.000	1.00	1.5	0.050	0.100	26.73	13.5	52.8
9	0.603	39542	0.000	0.000	1.00	2.8	0.050	0.100	30.07	13.5	52.8
10	0.603	39542	0.000	0.000	1.00	4.2	0.050	0.100	33.41	13.5	52.8
11	0.603	39542	0.000	0.000	1.00	5.6	0.050	0.100	36.75	13.5	52.8
12	0.603	39542	0.000	0.000	1.00	7.0	0.050	0.100	40.09	13.5	52.8
13	0.603	39542	0.000	0.000	1.00	8.3	0.050	0.100	43.43	13.5	52.8
14	0.603	39542	0.000	0.000	1.00	9.7	0.050	0.100	46.77	13.5	52.8
15	0.603	39542	0.000	0.000	1.00	11.1	0.050	0.100	50.11	13.5	52.8
16	0.603	39542	0.000	0.000	1.00	12.5	0.050	0.100	53.45	13.5	52.8
17	0.603	39542	0.000	0.000	1.00	13.8	0.050	0.100	56.79	13.5	52.8
18	0.603	39542	0.000	0.000	1.00	15.2	0.050	0.100	60.13	13.5	52.8
19	0.603	39542	0.000	0.000	1.00	16.6	0.050	0.100	63.47	13.5	52.8
20	0.603	39542	0.000	0.000	1.00	18.0	0.050	0.100	66.81	13.5	52.8
21	0.603	39542	0.000	0.000	1.00	19.3	0.050	0.100	70.16	13.5	52.8
22	0.603	39542	0.000	0.000	1.00	20.7	0.050	0.100	73.50	13.5	52.8
23	0.603	39542	0.000	0.000	1.00	22.1	0.050	0.100	76.84	13.5	52.8
24	0.603	39542	0.000	0.000	1.00	29.9	0.050	0.100	80.18	13.5	52.8
25	0.603	39542	0.000	0.000	1.00	38.1	0.050	0.100	83.52	13.5	52.8
26	0.603	39542	0.000	0.000	1.00	40.0	0.050	0.100	86.86	13.5	52.8
27	0.603	39542	0.000	0.000	1.00	41.9	0.050	0.100	90.20	13.5	52.8
Toe					73.4	0.150	0.121				

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)

16.292 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
68.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi		kip-ft	b/min		
411.9	6.6	6.72	6.78	-1.20	21	50	25.87	8	4	99.2	45.2

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	72.5
Shaft Gain/Loss Factor		0.500
Toe Gain/Loss Factor		1.000

PILE PROFILE:

Toe Area	(in2)	52.850	Pile Type	Sheet Pile
Pile Size	(inch)	0.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	52.84	30000.	492.0	13.5	0	16807.	94.3
90.2	52.84	30000.	492.0	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 10.734

INTAKE2_004_SHEETPILE_BERMB6505_TIME_ALL.GWO											
Pile and Soil Model				Total Capacity	Rut	(kips)	461.9				
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
		kips	k/in	ft	ft	kips	s/ft	inch	ft	ft	in ²
1	0.603	39542	0.010	0.000	0.85	0.0	0.000	0.100	3.34	13.5	52.8
2	0.603	39542	0.000	0.000	1.00	0.0	0.000	0.100	6.68	13.5	52.8
6	0.603	39542	0.000	0.000	1.00	0.3	0.050	0.100	20.04	13.5	52.8
7	0.603	39542	0.000	0.000	1.00	1.7	0.050	0.100	23.39	13.5	52.8
8	0.603	39542	0.000	0.000	1.00	3.0	0.050	0.100	26.73	13.5	52.8
9	0.603	39542	0.000	0.000	1.00	4.4	0.050	0.100	30.07	13.5	52.8
10	0.603	39542	0.000	0.000	1.00	5.8	0.050	0.100	33.41	13.5	52.8
11	0.603	39542	0.000	0.000	1.00	7.2	0.050	0.100	36.75	13.5	52.8
12	0.603	39542	0.000	0.000	1.00	8.5	0.050	0.100	40.09	13.5	52.8
13	0.603	39542	0.000	0.000	1.00	9.9	0.050	0.100	43.43	13.5	52.8
14	0.603	39542	0.000	0.000	1.00	11.3	0.050	0.100	46.77	13.5	52.8
15	0.603	39542	0.000	0.000	1.00	12.7	0.050	0.100	50.11	13.5	52.8
16	0.603	39542	0.000	0.000	1.00	14.0	0.050	0.100	53.45	13.5	52.8
17	0.603	39542	0.000	0.000	1.00	15.4	0.050	0.100	56.79	13.5	52.8
18	0.603	39542	0.000	0.000	1.00	16.8	0.050	0.100	60.13	13.5	52.8
19	0.603	39542	0.000	0.000	1.00	18.2	0.050	0.100	63.47	13.5	52.8
20	0.603	39542	0.000	0.000	1.00	19.5	0.050	0.100	66.81	13.5	52.8
21	0.603	39542	0.000	0.000	1.00	20.9	0.050	0.100	70.16	13.5	52.8
22	0.603	39542	0.000	0.000	1.00	22.3	0.050	0.100	73.50	13.5	52.8
23	0.603	39542	0.000	0.000	1.00	31.9	0.050	0.100	76.84	13.5	52.8
24	0.603	39542	0.000	0.000	1.00	38.4	0.050	0.100	80.18	13.5	52.8
25	0.603	39542	0.000	0.000	1.00	40.2	0.050	0.100	83.52	13.5	52.8
26	0.603	39542	0.000	0.000	1.00	42.1	0.050	0.100	86.86	13.5	52.8
27	0.603	39542	0.000	0.000	1.00	44.0	0.050	0.100	90.20	13.5	52.8
Toe						73.4	0.150	0.121			

16.284 kips total unreduced pile weight (g= 32.17 ft/s²)

16.292 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	
72.50	11.50	1.00	0.800

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft	down	up	ksi	ksi				ksi			kip-ft	b/min	
461.9	7.5	6.93	6.97	-1.72	16	50	26.72	7	3	97.8	44.5			

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.500 1.000														
Depth	Rut	Frictn	End	Bg	Bl	Ct	Com	Str	Ten	Str	Stroke	ENTHRU		
ft	kips		kips	kips	bl/ft		ksi	ksi		ksi	ft	kip-ft		
6.0	6.5		2.2		4.3		0.0	0.000	0.000		11.50	0.0		
12.0	17.4		8.9		8.6		0.0	0.000	0.000		11.50	0.0		
15.7	26.4		15.2		11.2	Hammer	did not run							
19.7	37.9		23.9		14.0		0.9	9.626	-1.895		3.86	108.4		
25.7	59.0		40.7		18.3		1.1	10.248	-1.147		4.25	113.3		
31.7	84.5		61.9		22.6		1.2	11.421	-0.622		4.57	120.1		
37.7	114.4		87.5		26.9		1.4	15.149	-1.616		4.89	122.8		
43.7	148.8		117.6		31.2		1.9	17.763	-2.863		5.20	118.0		
49.7	187.6		152.2		35.5		2.5	19.668	-3.162		5.43	111.8		
52.7	208.8		171.2		37.6		2.8	20.923	-3.483		5.64	111.0		
56.7	238.5		198.1		40.4		3.3	21.950	-3.358		5.83	108.4		
62.7	338.1		264.7		73.4		5.3	24.725	-1.804		6.45	103.0		
68.7	411.9		338.5		73.4		6.6	25.865	-1.200		6.72	99.2		
72.5	461.9		388.5		73.4		7.5	26.722	-1.720		6.93	97.8		

Total Driving Time 3 minutes;
Starting at penetration 6.0 ft Total No. of Blows 155

WaterFix_2019-CER_Intake2_004_SheetPile 03/07/2020
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Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp. Length ft	Wait Time hr	Equivalent Stroke ft	Pressure Ratio	Stiffn. Efficcy.	Factor	Cushion CoR
6.00	90.20	0.00	11.50	1.00	0.80	1.00	1.00
12.00	90.20	0.00	11.50	1.00	0.80	1.00	1.00
15.71	90.20	0.00	11.50	1.00	0.80	1.00	1.00
19.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
25.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
31.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
37.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
43.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
49.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
52.71	90.20	0.00	11.50	1.00	0.80	1.00	1.00
56.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
62.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
68.69	90.20	0.00	11.50	1.00	0.80	1.00	1.00
72.50	90.20	0.00	11.50	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth ft	Shaft Res. k/ft ²	End Bearing kips	Shaft Quake inch	Toe Quake inch	Shaft Damping s/ft	Toe Damping s/ft	Soil Setup Normlzd	Limit Distance ft	Setup Time hrs
0.00	0.00	0.00	0.100	0.121	0.050	0.150	1.000	6.560	1.000
37.00	0.68	26.40	0.100	0.121	0.050	0.150	1.000	6.560	1.000
37.00	0.68	26.40	0.100	0.121	0.050	0.150	1.000	6.560	1.000
57.00	1.04	40.67	0.100	0.121	0.050	0.150	1.000	6.560	1.000
57.00	1.61	73.40	0.100	0.121	0.050	0.150	1.000	6.560	1.000
72.50	2.00	73.40	0.100	0.121	0.050	0.150	1.000	6.560	1.000
90.20	2.00	73.40	0.100	0.121	0.050	0.150	1.000	6.560	1.000

GRLWEAP ANALYSIS - INTAKE 3
BERMINGHAMMER B6505 (STROKE HEIGHT 6.8 FEET)

INTAKE3_014_HPILE_BERMB6505_2_TIME_ALL.GWO

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

↑
Input File: C:\USERS\MAU\Desktop\WATERFIX\INTAKE PILE DRIVABILITY\PILE_DRIVING\FOR AF REVIEW REV3\BERMINGHAMMER B6565 SETTING 2\INTAKE 3\H PILE\INTAKE3_014_HPILE_BERMB6505_2_TIME_ALL.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (12/4/2015)

Input File Contents
WaterFix_2019-CER_Intake3_014_HPile
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEx
-100 0 433 -1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0.000
Pile g Hammer g Toe Area Pile Size Pile Type
32.185 32.185 450.400 18.110 H Pile
W Cp A Cp E Cp T Cp CoR ROut StCp
6.000 424.000 30000.0 6.000 0.700 0.010 0.0
A Cu E Cu T Cu CoR ROut StCu
0.000 0.0 0.000 0.000 0.000 0.0
LPle APle EPle WPle Peri CI CoR ROut
65.470 39.96 30000.0 492.000 7.160 0 0.850 0.010
FFatigue F0 0-Bottom
0 0.000 0.000
Manufac Hmr Name HmrType No Seg-s
BERMINGH B6505 1 4
Ram Wt Ram L Ram Dia MaxStrk RtdStrk Effic
17.64 142.90 23.50 11.50 11.50 0.80
IB. Wt IB. L IB.Dia IB CoR IB RO

INTAKE3_014_HPILE_BERMB6505_2_TIME_ALL.GWO

3.75	43.00	19.00	0.900	0.010					
CompStrk	A	Chamber	V	Chamber					
20.30	452.40	658.00	0.0000	0.0000					
P atm	P1	P2	P3	P4					
14.70	1375.00	0.00	0.00	0.00					
Stroke	Effic.	Pressure	R-Weight	T-Delay					
6.8000	0.8000	1375.0000	0.0000	0.0000					
Qs	Qt	Js	Jt	Qx					
0.100	0.100	0.100	0.150	0.000					
Research	Soil Model:	Atoe, Plug, Gap, Q-fac							
		0.000	0.000	0.000					
Research	Soil Model:	RD-skn: m, d, toe: m, d							
		0.000	0.000	0.000					
Res. Distribution									
Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimD	SU T
0.00	0.00	0.00	0.10	0.35	0.05	0.15	1.20	6.56	1.0
18.10	0.33	110.05	0.10	0.35	0.05	0.15	1.20	6.56	1.0
18.10	0.66	487.27	0.10	0.18	0.05	0.15	1.20	6.56	1.0
27.37	1.12	818.23	0.10	0.18	0.05	0.15	1.20	6.56	1.0
65.47	1.12	818.23	0.10	0.18	0.05	0.15	1.20	6.56	1.0
Gain/Loss factors: shaft and toe									
0.50000	0.00000	0.00000	0.00000	0.00000	0.00000				
1.00000	0.00000	0.00000	0.00000	0.00000	0.00000				
Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR		
6.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	
12.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	
15.71	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	
19.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	
25.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	
27.37	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	
0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

Version 2010

English Units

WaterFix_2019-CER_Intake3_014_Hpile

Hammer	Model:	B6505	Made by:	BERMINGH	
No.	Weight	Stiffn	CoR	C-Slk	Dampg
	kips	k/inch		ft	k/ft/s
1	4.410				
2	4.410	352088.1	1.000	0.0100	
3	4.410	352088.1	1.000	0.0100	
4	4.410	352088.1	1.000	0.0100	
Imp Block	3.750	123917.9	0.900	0.0100	
Helmet	6.000	2120000.0	0.700	0.0098	18.1
Combined Pile Top		30517.8			

HAMMER OPTIONS:

Hammer File ID No.	433	Hammer Type	OE Diesel
Stroke Option	VarP-FxdS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	17.64	Ram Length	(inch)	142.90
Maximum Stroke	(ft)	11.50	Actual Stroke	(ft)	6.80
Rated Stroke	(ft)	11.50	Efficiency		0.800
Maximum Pressure	(psi)	1375.00	Actual Pressure	(psi)	1375.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	23.50			
Comb. Start Volume	(in3)	724.00	Comb. End Volume	(in3)	768.00

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

INTAKE3_014_HPILE_BERMB6505_2_TIME_ALL.GWO

Cross Sect. Area	(in ²)	424.00	Cross Sect. Area	(in ²)	0.00
Elastic-Modulus	(ksi)	30000.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	6.00	Thickness	(inch)	0.00
Coeff of Restitution		0.7	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	2120000.0	Stiffness	(kips/in)	0.0

WaterFix_2019-CER_Intake3_014_HPile
CH2M HILL

04/14/2020
GRLWEAP Version 2010

Depth	(ft)	6.0			
Shaft Gain/Loss Factor		0.500	Toe Gain/Loss Factor		1.000

PILE PROFILE:

Toe Area	(in ²)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s
0.0			39.96	30000.	492.0	7.2	0	16807.	71.3
65.5			39.96	30000.	492.0	7.2	0	16807.	71.3

Wave Travel Time 2L/c (ms) 7.791

No.	Weight	Pile and Soil Model				Total Capacity	Rut	(kips)	37.7		
		Stiffn kips	C-Slk ft/in	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in ²
1	0.447	30518	0.010	0.000	0.85	0.0	0.000	0.100	3.27	7.2	40.0
2	0.447	30518	0.000	0.000	1.00	0.0	0.000	0.100	6.55	7.2	40.0
19	0.447	30518	0.000	0.000	1.00	0.2	0.050	0.100	62.20	7.2	40.0
20	0.447	30518	0.000	0.000	1.00	0.9	0.050	0.100	65.47	7.2	40.0
Toe						36.5	0.150	0.354			

8.939 kips total unreduced pile weight (g= 32.17 ft/s²)

8.943 kips total reduced pile weight (g= 32.19 ft/s²)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	1.427
Driveability Analysis			
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	3	Analysis Time-Input (ms)	0
Output Level: Normal			
Gravity Mass, Pile, Hammer:	32.170	32.185	32.185
Output Segment Generation:	Automatic		

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
6.00	6.80	1.00	0.800

WaterFix_2019-CER_Intake3_014_HPile
CH2M HILL

04/14/2020
GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp Str	i	t ENTHRU	Bl Rt
kips	b/ft	down	up	ksi	ksi		kip-ft	b/min
37.7	0.9	6.80	6.76	-2.64	10 11	23.48	1 4	233.6 45.5

WaterFix_2019-CER_Intake3_014_HPile
CH2M HILL

04/14/2020
GRLWEAP Version 2010

Depth	(ft)	12.0			
Shaft Gain/Loss Factor		0.500	Toe Gain/Loss Factor		1.000

PILE PROFILE:

Toe Area	(in ²)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c

INTAKE3_014_HPILE_BERMB6505_2_TIME_ALL.GWO							
ft	in ²	ksi	lb/ft ³	ft	ft/s	k/ft/s	
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3
65.5	39.96	30000.	492.0	7.2	0	16807.	71.3

Wave Travel Time 2L/c (ms) 7.791

Pile and Soil Model				Total Capacity (kips)	Rut (kips)	77.7					
No.	Weight kips	Stiffn C-Slk k/in	T-Slk ft	Soil-S CoR	Soil-D kips s/ft	Quake inch	LbTop ft	Perim ft	Area in ²		
1	0.447	30518	0.010	0.000	0.85	0.0	0.000	0.100	3.27	7.2	40.0
2	0.447	30518	0.000	0.000	1.00	0.0	0.000	0.100	6.55	7.2	40.0
17	0.447	30518	0.000	0.000	1.00	0.2	0.050	0.100	55.65	7.2	40.0
18	0.447	30518	0.000	0.000	1.00	0.8	0.050	0.100	58.92	7.2	40.0
19	0.447	30518	0.000	0.000	1.00	1.5	0.050	0.100	62.20	7.2	40.0
20	0.447	30518	0.000	0.000	1.00	2.2	0.050	0.100	65.47	7.2	40.0
Toe					73.0	0.150	0.354				

8.939 kips total unreduced pile weight (g= 32.17 ft/s²)

8.943 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Effacy
12.00	6.80	1.00	0.800

WaterFix_2019-CER_Intake3_014_HPile 04/14/2020
CH2M HILL GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	Str ksi	i 1	t 0	Comp 22.74	Str ksi	i 1	t 5	ENTHRU kip-ft	Bl Rt b/min
77.7	1.1	6.80	6.77	0.00							247.7	45.5

WaterFix_2019-CER_Intake3_014_HPile 04/14/2020
CH2M HILL GRLWEAP Version 2010

Depth (ft)	15.7
Shaft Gain/Loss Factor	0.500
Toe Gain/Loss Factor	1.000

PILE PROFILE:
Toe Area (in²) 450.400 Pile Type H Pile
Pile Size (inch) 18.110

L ft	b in ²	Top Area ksi	E-Mod lb/ft ³	Spec Wt ft	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3	
65.5	39.96	30000.	492.0	7.2	0	16807.	71.3	

Wave Travel Time 2L/c (ms) 7.791

Pile and Soil Model				Total Capacity (kips)	Rut (kips)	103.6					
No.	Weight kips	Stiffn C-Slk k/in	T-Slk ft	Soil-S CoR	Soil-D kips s/ft	Quake inch	LbTop ft	Perim ft	Area in ²		
1	0.447	30518	0.010	0.000	0.85	0.0	0.000	0.100	3.27	7.2	40.0
2	0.447	30518	0.000	0.000	1.00	0.0	0.000	0.100	6.55	7.2	40.0
16	0.447	30518	0.000	0.000	1.00	0.2	0.050	0.100	52.38	7.2	40.0
17	0.447	30518	0.000	0.000	1.00	0.9	0.050	0.100	55.65	7.2	40.0
18	0.447	30518	0.000	0.000	1.00	1.6	0.050	0.100	58.92	7.2	40.0
19	0.447	30518	0.000	0.000	1.00	2.3	0.050	0.100	62.20	7.2	40.0
20	0.447	30518	0.000	0.000	1.00	3.0	0.050	0.100	65.47	7.2	40.0
Toe					95.5	0.150	0.354				

8.939 kips total unreduced pile weight (g= 32.17 ft/s²)

8.943 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Effacy
15.71	6.80	1.00	0.800

WaterFix_2019-CER_Intake3_014_HPile 04/14/2020
CH2M HILL GRLWEAP Version 2010

INTAKE3 014 HPILE BERMB6505 2 TIME ALL.GWO

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
103.6	1.3		6.80	6.74	0.00	1	0	22.87		1	5	231.7	45.5	

WaterFix_2019-CER_Intake3_014_HPile 04/14/2020
CH2M HILL GRLWEAP Version 2010

Depth (ft) 19.7
 Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in²) 450.400 Pile Type H Pile
Pile Size (inch) 18.110

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c		
			ft	in ²	ksi	lb/ft ³		ft	k/ft/s		
0.0			39.96	30000.		492.0		7.2	0	16807.	71.3
65.5			39.96	30000.		492.0		7.2	0	16807.	71.3

Wave Travel Time 2L/c (ms) 7.791

Pile and Soil Model					Total	Capacity	Rut	(kips)	558.8		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.447	30518	0.010	0.000	0.85	0.0	0.000	0.100	3.27	7.2	40.0
2	0.447	30518	0.000	0.000	1.00	0.0	0.000	0.100	6.55	7.2	40.0
14	0.447	30518	0.000	0.000	1.00	0.0	0.050	0.100	45.83	7.2	40.0
15	0.447	30518	0.000	0.000	1.00	0.4	0.050	0.100	49.10	7.2	40.0
16	0.447	30518	0.000	0.000	1.00	1.1	0.050	0.100	52.38	7.2	40.0
17	0.447	30518	0.000	0.000	1.00	1.8	0.050	0.100	55.65	7.2	40.0
18	0.447	30518	0.000	0.000	1.00	2.5	0.050	0.100	58.92	7.2	40.0
19	0.447	30518	0.000	0.000	1.00	3.2	0.050	0.100	62.20	7.2	40.0
20	0.447	30518	0.000	0.000	1.00	5.9	0.050	0.100	65.47	7.2	40.0
Toe						544.0	0.150	0.177			

8.939 kips total unreduced pile weight (g= 32.17 ft/s²)
8.943 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficacy
19.69	6.80	1.00	0.800

WaterFix_2019-CER_Intake3_014_HPile 04/14/2020
CH2M HILL GRLWEAP Version 2010

Rut	B1	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	B1	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
558.8	17.5	6.80	6.76	0.00		1	0	34.45	20	6	75.3		44.9	

WaterFix_2019-CER_Intake3_014_HPile 04/14/2020
CH2M HILL GRLWEAP Version 2010

Depth (ft) 25.7
 Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area	(in ²)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

L	b	Top	Area	E-Mod	Spec	Wt	Perim	C	Index	Wave	Sp	EA/c
			ft	in ²	ksi	lb/ft ³	ft			ft/s		k/ft/s
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3					
65.5	39.96	30000	492.0	7.2	0	16807	71.3					

Wave Travel Time $2L/c$ (ms) 7.791

INTAKE3_014_HPILE_BERMB6505_2_TIME_ALL.GWO

1	0.447	30518	0.010	0.000	0.85	0.0	0.000	0.100	3.27	7.2	40.0
2	0.447	30518	0.000	0.000	1.00	0.0	0.000	0.100	6.55	7.2	40.0
13	0.447	30518	0.000	0.000	1.00	0.3	0.050	0.100	42.56	7.2	40.0
14	0.447	30518	0.000	0.000	1.00	0.9	0.050	0.100	45.83	7.2	40.0
15	0.447	30518	0.000	0.000	1.00	1.7	0.050	0.100	49.10	7.2	40.0
16	0.447	30518	0.000	0.000	1.00	2.4	0.050	0.100	52.38	7.2	40.0
17	0.447	30518	0.000	0.000	1.00	3.1	0.050	0.100	55.65	7.2	40.0
18	0.447	30518	0.000	0.000	1.00	5.1	0.050	0.100	58.92	7.2	40.0
19	0.447	30518	0.000	0.000	1.00	9.3	0.050	0.100	62.20	7.2	40.0
20	0.447	30518	0.000	0.000	1.00	11.2	0.050	0.100	65.47	7.2	40.0
Toe						758.2	0.150	0.177			

8.939 kips total unreduced pile weight (g= 32.17 ft/s²)
 8.943 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficy
25.69	6.80	1.00	0.800

WaterFix_2019-CER_Intake3_014_HPile 04/14/2020
 CH2M HILL GRLWEAP Version 2010

Rut kips	Bl b/ft	Ct down	Stroke (ft)	Ten up	Str ksi	i	t	Comp ksi	Str kip-ft	i	t	ENTHRU kip-ft	Bl Rt b/min
792.1	33.2	6.80	6.82	-1.26	16	26		38.98	20	6	67.9	44.7	

WaterFix_2019-CER_Intake3_014_HPile 04/14/2020
 CH2M HILL GRLWEAP Version 2010

Depth Shaft Gain/Loss Factor	(ft)	27.4	Toe Gain/Loss Factor	0.500	1.000
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PILE PROFILE:
 Toe Area (in²) 450.400 Pile Type H Pile
 Pile Size (inch) 18.110

L ft	b in ²	Top ksi	Area lb/ft ³	E-Mod ksi	Spec Wt ft	Perim ft	C Index ft/s	Wave Sp k/ft/s	EA/c
0.0	39.96	30000.	492.0	7.2	0	16807.			71.3
65.5	39.96	30000.	492.0	7.2	0	16807.			71.3

Wave Travel Time 2L/c (ms) 7.791

No.	Weight kips	Pile and Soil Model Stiffn C-Slk T-Slk CoR	Total Capacity Soil-S kips	Rut Soil-D s/ft	(kips)	858.5 Quake inch	LbTop ft	Perim ft	Area in ²
1	0.447	30518 0.010 0.000 0.85	0.0	0.000	0.100	3.27	7.2	40.0	
2	0.447	30518 0.000 0.000 1.00	0.0	0.000	0.100	6.55	7.2	40.0	
12	0.447	30518 0.000 0.000 1.00	0.0	0.050	0.100	39.28	7.2	40.0	
13	0.447	30518 0.000 0.000 1.00	0.6	0.050	0.100	42.56	7.2	40.0	
14	0.447	30518 0.000 0.000 1.00	1.3	0.050	0.100	45.83	7.2	40.0	
15	0.447	30518 0.000 0.000 1.00	2.0	0.050	0.100	49.10	7.2	40.0	
16	0.447	30518 0.000 0.000 1.00	2.7	0.050	0.100	52.38	7.2	40.0	
17	0.447	30518 0.000 0.000 1.00	3.4	0.050	0.100	55.65	7.2	40.0	
18	0.447	30518 0.000 0.000 1.00	7.8	0.050	0.100	58.92	7.2	40.0	
19	0.447	30518 0.000 0.000 1.00	10.3	0.050	0.100	62.20	7.2	40.0	
20	0.447	30518 0.000 0.000 1.00	12.1	0.050	0.100	65.47	7.2	40.0	
Toe			818.2	0.150	0.177				

8.939 kips total unreduced pile weight (g= 32.17 ft/s²)
 8.943 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficy
27.37	6.80	1.00	0.800

WaterFix_2019-CER_Intake3_014_HPile 04/14/2020
 CH2M HILL GRLWEAP Version 2010

INTAKE3_014_HPILE_BERMB6505_2_TIME_ALL.GWO

Rut	B1	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	B1	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
858.5	40.6		6.80	6.85	-1.84	15	25		39.64	20	6	66.5		44.7

WaterFix_2019-CER_Intake3_014_HPile
CH2M HILL

04/14/2020

GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.500 1.000												
Depth	Rut	Friectn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU				
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft				
6.0	37.7	1.2	36.5	0.9	23.482	-2.638	6.80	233.6				
12.0	77.7	4.7	73.0	1.1	22.741	0.000	6.80	247.7				
15.7	103.6	8.1	95.5	1.3	22.870	0.000	6.80	231.7				
19.7	558.8	14.8	544.0	17.5	34.450	0.000	6.80	75.3				
25.7	792.1	33.8	758.2	33.2	38.979	-1.258	6.80	67.9				
27.4	858.5	40.3	818.2	40.6	39.641	-1.839	6.80	66.5				

Total Driving Time 6 minutes; Total No. of Blows 261
Starting at penetration 6.0 ft

WaterFix_2019-CER_Intake3_014_HPile
CH2M HILL

04/14/2020

GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth	Temp.	Wait Time	Equivalent Stroke	Pressure Ratio	Stiffn. Efficacy.	Cushion Factor	Cushion CoR
ft	Length ft	Time hr	Stroke ft				
6.00	65.47	0.00	6.80	1.00	0.80	1.00	1.00
12.00	65.47	0.00	6.80	1.00	0.80	1.00	1.00
15.71	65.47	0.00	6.80	1.00	0.80	1.00	1.00
19.69	65.47	0.00	6.80	1.00	0.80	1.00	1.00
25.69	65.47	0.00	6.80	1.00	0.80	1.00	1.00
27.37	65.47	0.00	6.80	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth	Shaft Res.	End Bearing kips	Shaft Quake inch	Toe Quake inch	Shaft Damping s/ft	Toe Damping s/ft	Soil Setup Normlzd	Limit Distance ft	Setup Time hrs
0.00	0.00	0.00	0.100	0.354	0.050	0.150	1.000	6.560	1.000
18.10	0.33	110.05	0.100	0.354	0.050	0.150	1.000	6.560	1.000
18.10	0.66	487.27	0.100	0.177	0.050	0.150	1.000	6.560	1.000
27.37	1.12	818.23	0.100	0.177	0.050	0.150	1.000	6.560	1.000
65.47	1.12	818.23	0.100	0.177	0.050	0.150	1.000	6.560	1.000

INTAKE3_014_SHEETPILE_BERMB6505_2_TIME_ALL.GWO

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

↑
Input File: C:\USERS\MAU\Desktop\WATERFIX\INTAKE PILE DRIVABILITY\PILE_DRIVING\FOR AF REVIEW REV3\BERMINGHAMMER B6565 SETTING 2\INTAKE 3\SHEET PILE\INTAKE3_014_SHEETPILE_BERMB6505_2_TIME_ALL.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (12/4/2015)

Input File Contents
WaterFix_2019-CER_Intake3_014_SPile
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEx
-100 0 433 -1 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0.000
Pile g Hammer g Toe Area Pile Size Pile Type
32.185 32.185 52.850 0.000 Sheet Pile
W Cp A Cp E Cp T Cp CoR ROut StCp
6.000 424.000 30000.0 6.000 0.700 0.010 0.0
A Cu E Cu T Cu CoR ROut StCu
0.000 0.0 0.000 0.000 0.000 0.0
LPle APle EPle WPle Peri CI CoR ROut
65.470 52.84 30000.0 492.000 13.451 0 0.850 0.010
FFatigue F0 0-Bottom
0 0.000 0.000
Manufac Hmr Name HmrType No Seg-s
BERMINGH B6505 1 4
Ram Wt Ram L Ram Dia MaxStrk RtdStrk Effic
17.64 142.90 23.50 11.50 11.50 0.80
IB. Wt IB. L IB.Dia IB CoR IB RO

INTAKE3_014_SHEETPILE_BERMB6505_2_TIME_ALL.GWO

3.75	43.00	19.00	0.900	0.010									
CompStrk	A	Chamber	V	Chamber	C	Delay	C	Duratn	Exp	Coeff	VolCStart	Vol	CEnd
20.30	452.40	658.00	0.0000	0.0000	1.250	724.00	768.00						
P atm	P1	P2	P3	P4	P5								
14.70	1375.00	0.00	0.00	0.00	0.00								
Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW						
6.8000	0.8000	1375.0000	0.0000	0.0000	0.0000	0.0000	0.0000						
Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept						
0.100	0.100	0.100	0.150	0.000	0.000	0.000	0.000						
Research	Soil Model:	Atoe,	Plug,	Gap,	Q-fac								
		0.000	0.000	0.000	0.000								
Research	Soil Model:	RD-skn:	m,	d,	toe:	m,	d						
		0.000	0.000	0.000	0.000								
Res. Distribution													
Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimD	SU T				
0.00	0.00	0.00	0.10	0.12	0.05	0.15	1.20	6.56	1.0				
18.10	0.33	12.91	0.10	0.12	0.05	0.15	1.20	6.56	1.0				
18.10	0.66	57.18	0.10	0.10	0.05	0.15	1.20	6.56	1.0				
27.37	1.12	96.01	0.10	0.10	0.05	0.15	1.20	6.56	1.0				
65.47	1.12	96.01	0.10	0.10	0.05	0.15	1.20	6.56	1.0				
Gain/Loss factors: shaft and toe													
0.50000	0.00000	0.00000	0.00000	0.00000									
1.00000	0.00000	0.00000	0.00000	0.00000									
Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR						
6.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000						
12.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000						
15.71	0.00	0.00	0.000	0.000	0.000	0.000	0.000						
19.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000						
25.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000						
27.37	0.00	0.00	0.000	0.000	0.000	0.000	0.000						
0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000						

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

Version 2010

English Units

WaterFix_2019-CER_Intake3_014_SPile

Hammer	Model:	B6505	Made by:	BERMINGH	
No.	Weight	Stiffn	CoR	C-Slk	Dampg
	kips	k/inch		ft	k/ft/s
1	4.410				
2	4.410	352088.1	1.000	0.0100	
3	4.410	352088.1	1.000	0.0100	
4	4.410	352088.1	1.000	0.0100	
Imp Block	3.750	123917.9	0.900	0.0100	
Helmet	6.000	2120000.0	0.700	0.0098	18.1
Combined Pile Top		40354.3			

HAMMER OPTIONS:

Hammer File ID No.	433	Hammer Type	OE Diesel
Stroke Option	VarP-FxdS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	17.64	Ram Length	(inch)	142.90
Maximum Stroke	(ft)	11.50	Actual Stroke	(ft)	6.80
Rated Stroke	(ft)	11.50	Efficiency		0.800
Maximum Pressure	(psi)	1375.00	Actual Pressure	(psi)	1375.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	23.50			
Comb. Start Volume	(in3)	724.00	Comb. End Volume	(in3)	768.00

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

INTAKE3_014_SHEETPILE_BERMB6505_2_TIME_ALL.GWO
 Cross Sect. Area (in²) 424.00 Cross Sect. Area (in²) 0.00
 Elastic-Modulus (ksi) 30000.0 Elastic-Modulus (ksi) 0.0
 Thickness (inch) 6.00 Thickness (inch) 0.00
 Coeff of Restitution 0.7 Coeff of Restitution 1.0
 RoundOut (ft) 0.0 RoundOut (ft) 0.0
 Stiffness (kips/in) 2120000.0 Stiffness (kips/in) 0.0

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
 CH2M HILL GRLWEAP Version 2010

Depth (ft) 6.0
 Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in ²)	52.850	Pile Type	Sheet Pile
Pile Size (inch)	0.000		

L	b	Top ft	Area in ²	E-Mod ksi	Spec Wt lb/ft ³	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	52.84	52.84	30000.	30000.	492.0	13.5	0	16807.	94.3
65.5	52.84	52.84	30000.	30000.	492.0	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 7.791

No.	Weight kips	Pile and Soil Model				Total Capacity (kips)	Rut ft	6.5			
		Stiffn k/in	C-Slk ft	T-Slk ft	CoR						
1	0.591	40354	0.010	0.000	0.85	0.0	0.000	0.100	3.27	13.5	52.8
2	0.591	40354	0.000	0.000	1.00	0.0	0.000	0.100	6.55	13.5	52.8
19	0.591	40354	0.000	0.000	1.00	0.5	0.050	0.100	62.20	13.5	52.8
20	0.591	40354	0.000	0.000	1.00	1.8	0.050	0.100	65.47	13.5	52.8
Toe						4.3	0.150	0.121			

11.820 kips total unreduced pile weight (g= 32.17 ft/s²)

11.825 kips total reduced pile weight (g= 32.19 ft/s²)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile	Pile Segments: Automatic			
No. of Slacks/Splices	0	Pile Damping (%)	1	
		Pile Damping Fact.(k/ft/s)	1.886	
Driveability Analysis				
Soil Damping Option	Smith			
Max No Analysis Iterations	0	Time Increment/Critical	160	
Output Time Interval	3	Analysis Time-Input (ms)	0	
Output Level: Normal				
Gravity Mass, Pile, Hammer:	32.170	32.185	32.185	
Output Segment Generation:	Automatic			

Depth ft	Stroke ft	Pressure Ratio	Efficy
6.00	6.80	1.00	0.800

INITIAL STATIC ANALYSIS: Total Wt, Sum(R) 21.6 6.5
 Hammer+Pile Weight > Rult: Pile Runs

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
 CH2M HILL GRLWEAP Version 2010

Rut kips	B1 b/ft	Ct down	Stroke (ft) up	Ten ksi	Str 1	t 0	Comp 0.00	Str kpsi	i 1	t 0	ENTHRU kip-ft	B1 0.0	Rt b/min 106.5
6.5	0.0	6.80	0.00	0.00	1	0	0.00	1	0	0.0			

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
 CH2M HILL GRLWEAP Version 2010

Depth (ft) 12.0
 Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:

INTAKE3_014_SHEETPILE_BERMB6505_2_TIME_ALL.GWO

Toe Area	(in2)	52.850	Pile Type	Sheet Pile		
Pile Size	(inch)	0.000				

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	52.84	30000.	492.0	13.5	0	16807.	94.3
65.5	52.84	30000.	492.0	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 7.791

No.	Weight kips	Pile and Soil Model			Total Capacity kips	Rut (kips)	17.4				
		Stiffn C-Slk	T-Slk	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2	
1	0.591	40354	0.010	0.000	0.85	0.0	0.000	0.100	3.27	13.5	52.8
2	0.591	40354	0.000	0.000	1.00	0.0	0.000	0.100	6.55	13.5	52.8
17	0.591	40354	0.000	0.000	1.00	0.3	0.050	0.100	55.65	13.5	52.8
18	0.591	40354	0.000	0.000	1.00	1.5	0.050	0.100	58.92	13.5	52.8
19	0.591	40354	0.000	0.000	1.00	2.9	0.050	0.100	62.20	13.5	52.8
20	0.591	40354	0.000	0.000	1.00	4.2	0.050	0.100	65.47	13.5	52.8
Toe					8.6	0.150	0.121				

11.820 kips total unreduced pile weight (g= 32.17 ft/s²)
 11.825 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficy
12.00	6.80	1.00	0.800

INITIAL STATIC ANALYSIS: Total Wt, Sum(R) 21.6 17.4
 Hammer+Pile Weight > Rult: Pile Runs

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
 CH2M HILL GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Ten Str up	Str ksi	i	t	Comp ksi	Str kip-ft	i	t	ENTHRU kip-ft	Bl Rt b/min
17.4	0.0	6.80	0.00	0.00	1	0	0.00	1	0	0.0	106.5	

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
 CH2M HILL GRLWEAP Version 2010

Depth Shaft Gain/Loss Factor	(ft)	15.7	Toe Gain/Loss Factor	0.500	1.000
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PILE PROFILE:

Toe Area	(in2)	52.850	Pile Type	Sheet Pile		
Pile Size	(inch)	0.000				

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	52.84	30000.	492.0	13.5	0	16807.	94.3
65.5	52.84	30000.	492.0	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 7.791

No.	Weight kips	Pile and Soil Model			Total Capacity kips	Rut (kips)	26.4				
		Stiffn C-Slk	T-Slk	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2	
1	0.591	40354	0.010	0.000	0.85	0.0	0.000	0.100	3.27	13.5	52.8
2	0.591	40354	0.000	0.000	1.00	0.0	0.000	0.100	6.55	13.5	52.8
16	0.591	40354	0.000	0.000	1.00	0.4	0.050	0.100	52.38	13.5	52.8
17	0.591	40354	0.000	0.000	1.00	1.7	0.050	0.100	55.65	13.5	52.8
18	0.591	40354	0.000	0.000	1.00	3.0	0.050	0.100	58.92	13.5	52.8
19	0.591	40354	0.000	0.000	1.00	4.4	0.050	0.100	62.20	13.5	52.8
20	0.591	40354	0.000	0.000	1.00	5.7	0.050	0.100	65.47	13.5	52.8
Toe					11.2	0.150	0.121				

11.820 kips total unreduced pile weight (g= 32.17 ft/s²)
 11.825 kips total reduced pile weight (g= 32.19 ft/s²)

INTAKE3_014_SHEETPILE_BERMB6505_2_TIME_ALL.GWO

Depth ft	Stroke ft	Pressure Ratio	Efficacy
15.71	6.80	1.00	0.800

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
 CH2M HILL GRLWEAP Version 2010

Rut kips	B1 b/ft	Ct down	Stroke (ft) up	Ten ksi	Str ksi	i	t	Comp ksi	Str kip-ft	i	t	ENTHRU kip-ft	B1 b/min
26.4	0.8	6.80	6.85	-5.32	8	23	19.21	1	4	191.8	45.3		

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
 CH2M HILL GRLWEAP Version 2010

Depth Shaft Gain/Loss Factor	(ft)	19.7	Toe Gain/Loss Factor	0.500	1.000
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PILE PROFILE:
 Toe Area (in²) 52.850 Pile Type Sheet Pile
 Pile Size (inch) 0.000

L ft	b in ²	Top ksi	Area lb/ft ³	E-Mod ft	Spec Wt ft	Perim ft	C Index ft	Wave Sp ft/s	EA/c k/ft/s
0.0	52.84	30000.	492.0	13.5	0	16807.	94.3		
65.5	52.84	30000.	492.0	13.5	0	16807.	94.3		

Wave Travel Time 2L/c (ms) 7.791

Pile and Soil Model				Total Capacity	Rut (kips)	91.6					
No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in ²
1	0.591	40354	0.010	0.000	0.85	0.0	0.000	0.100	3.27	13.5	52.8
2	0.591	40354	0.000	0.000	1.00	0.0	0.000	0.100	6.55	13.5	52.8
14	0.591	40354	0.000	0.000	1.00	0.0	0.050	0.100	45.83	13.5	52.8
15	0.591	40354	0.000	0.000	1.00	0.7	0.050	0.100	49.10	13.5	52.8
16	0.591	40354	0.000	0.000	1.00	2.0	0.050	0.100	52.38	13.5	52.8
17	0.591	40354	0.000	0.000	1.00	3.3	0.050	0.100	55.65	13.5	52.8
18	0.591	40354	0.000	0.000	1.00	4.6	0.050	0.100	58.92	13.5	52.8
19	0.591	40354	0.000	0.000	1.00	6.0	0.050	0.100	62.20	13.5	52.8
20	0.591	40354	0.000	0.000	1.00	11.1	0.050	0.100	65.47	13.5	52.8
Toe						63.8	0.150	0.100			

11.820 kips total unreduced pile weight (g= 32.17 ft/s²)
 11.825 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficacy
19.69	6.80	1.00	0.800

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
 CH2M HILL GRLWEAP Version 2010

Rut kips	B1 b/ft	Ct down	Stroke (ft) up	Ten ksi	Str ksi	i	t	Comp ksi	Str kip-ft	i	t	ENTHRU kip-ft	B1 b/min
91.6	1.1	6.80	6.82	-0.90	3	10	20.73	1	2	220.2	45.5		

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
 CH2M HILL GRLWEAP Version 2010

Depth Shaft Gain/Loss Factor	(ft)	25.7	Toe Gain/Loss Factor	0.500	1.000
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PILE PROFILE:
 Toe Area (in²) 52.850 Pile Type Sheet Pile
 Pile Size (inch) 0.000

L ft	b in ²	Top ksi	Area lb/ft ³	E-Mod ft	Spec Wt ft	Perim ft	C Index ft	Wave Sp ft/s	EA/c k/ft/s
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INTAKE3_014_SHEETPILE_BERMB6505_2_TIME_ALL.GWO

0.0	52.84	30000.	492.0	13.5	0	16807.	94.3
65.5	52.84	30000.	492.0	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 7.791

No.	Pile and Soil Model				Total	Capacity	Rut	(kips)	152.5		
	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in ²
1	0.591	40354	0.010	0.000	0.85	0.0	0.000	0.100	3.27	13.5	52.8
2	0.591	40354	0.000	0.000	1.00	0.0	0.000	0.100	6.55	13.5	52.8
13	0.591	40354	0.000	0.000	1.00	0.5	0.050	0.100	42.56	13.5	52.8
14	0.591	40354	0.000	0.000	1.00	1.8	0.050	0.100	45.83	13.5	52.8
15	0.591	40354	0.000	0.000	1.00	3.1	0.050	0.100	49.10	13.5	52.8
16	0.591	40354	0.000	0.000	1.00	4.4	0.050	0.100	52.38	13.5	52.8
17	0.591	40354	0.000	0.000	1.00	5.7	0.050	0.100	55.65	13.5	52.8
18	0.591	40354	0.000	0.000	1.00	9.5	0.050	0.100	58.92	13.5	52.8
19	0.591	40354	0.000	0.000	1.00	17.5	0.050	0.100	62.20	13.5	52.8
20	0.591	40354	0.000	0.000	1.00	21.0	0.050	0.100	65.47	13.5	52.8
Toe						89.0	0.150	0.100			

11.820 kips total unreduced pile weight (g= 32.17 ft/s²)

11.825 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
25.69	6.80	1.00	0.800

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
152.5	1.8	6.80	6.77	-0.75	3	10		23.30	7	3		183.7	45.4	

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	27.4	
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:
Toe Area (in²) 52.850 Pile Type Sheet Pile
Pile Size (inch) 0.000

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s
0.0	52.84	30000.	492.0	13.5		0		16807.	94.3
65.5	52.84	30000.	492.0	13.5		0		16807.	94.3

Wave Travel Time 2L/c (ms) 7.791

No.	Pile and Soil Model				Total	Capacity	Rut	(kips)	171.7		
	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in ²
1	0.591	40354	0.010	0.000	0.85	0.0	0.000	0.100	3.27	13.5	52.8
2	0.591	40354	0.000	0.000	1.00	0.0	0.000	0.100	6.55	13.5	52.8
12	0.591	40354	0.000	0.000	1.00	0.1	0.050	0.100	39.28	13.5	52.8
13	0.591	40354	0.000	0.000	1.00	1.1	0.050	0.100	42.56	13.5	52.8
14	0.591	40354	0.000	0.000	1.00	2.5	0.050	0.100	45.83	13.5	52.8
15	0.591	40354	0.000	0.000	1.00	3.8	0.050	0.100	49.10	13.5	52.8
16	0.591	40354	0.000	0.000	1.00	5.1	0.050	0.100	52.38	13.5	52.8
17	0.591	40354	0.000	0.000	1.00	6.4	0.050	0.100	55.65	13.5	52.8
18	0.591	40354	0.000	0.000	1.00	14.6	0.050	0.100	58.92	13.5	52.8
19	0.591	40354	0.000	0.000	1.00	19.3	0.050	0.100	62.20	13.5	52.8
20	0.591	40354	0.000	0.000	1.00	22.8	0.050	0.100	65.47	13.5	52.8
Toe						96.0	0.150	0.100			

11.820 kips total unreduced pile weight (g= 32.17 ft/s²)

11.825 kips total reduced pile weight (g= 32.19 ft/s²)

INTAKE3_014_SHEETPILE_BERMB6505_2_TIME_ALL.GWO

Depth ft	Stroke ft	Pressure Ratio	Efficcy
27.37	6.80	1.00	0.800

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
CH2M HILL GRLWEAP Version 2010

Rut kips	Bl b/ft	Ct	Stroke (ft) down	Ten up	Str ksi	i	t	Comp ksi	Str kip-ft	i	t	ENTHRU kip-ft	Bl b/min	Rt
171.7	2.1	6.80	6.77	-0.60	2	10	23.72	10	4	171.9		45.4		

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
CH2M HILL GRLWEAP Version 2010

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.500 1.000									
Depth ft	Rut kips	Frictn kips	End Bg kips	Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft	
6.0	6.5	2.2	4.3	0.0	0.000	0.000	6.80	0.0	
12.0	17.4	8.9	8.6	0.0	0.000	0.000	6.80	0.0	
15.7	26.4	15.2	11.2	0.8	19.212	-5.316	6.80	191.8	
19.7	91.6	27.7	63.8	1.1	20.734	-0.899	6.80	220.2	
25.7	152.5	63.5	89.0	1.8	23.296	-0.753	6.80	183.7	
27.4	171.7	75.7	96.0	2.1	23.720	-0.600	6.80	171.9	

Total Driving Time 0 minutes; Total No. of Blows 18
Starting at penetration 6.0 ft

WaterFix_2019-CER_Intake3_014_SPile 04/14/2020
CH2M HILL GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp. Length ft	Wait Time hr	Equivalent Stroke ft	Pressure Ratio	Stiffn. Efficy.	Cushion Factor	Cushion CoR
6.00	65.47	0.00	6.80	1.00	0.80	1.00	1.00
12.00	65.47	0.00	6.80	1.00	0.80	1.00	1.00
15.71	65.47	0.00	6.80	1.00	0.80	1.00	1.00
19.69	65.47	0.00	6.80	1.00	0.80	1.00	1.00
25.69	65.47	0.00	6.80	1.00	0.80	1.00	1.00
27.37	65.47	0.00	6.80	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth ft	Shaft Res. Bearing k/ft ²	End Quake kips	Shaft Quake inch	Toe Damping inch	Shaft Damping s/ft	Toe Damping s/ft	Soil Setup Normlzd	Limit ft	Setup Time hrs
0.00	0.00	0.00	0.100	0.121	0.050	0.150	1.000	6.560	1.000
18.10	0.33	12.91	0.100	0.121	0.050	0.150	1.000	6.560	1.000
18.10	0.66	57.18	0.100	0.100	0.050	0.150	1.000	6.560	1.000
27.37	1.12	96.01	0.100	0.100	0.050	0.150	1.000	6.560	1.000
65.47	1.12	96.01	0.100	0.100	0.050	0.150	1.000	6.560	1.000

GRLWEAP ANALYSIS - INTAKE 5
BERMINGHAMMER B6505 (STROKE HEIGHT 11.5 FEET)

INTAKE5_014_HPILE_BERMB6505_TIME_ALL.GWO

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

↑
Input File: C:\USERS\MAU\Desktop\WATERFIX\INTAKE PILE DRIVABILITY\PILE_DRIVING\GRLWEAP\DRIVING TIME\BERMINGHAM B6505\INTAKE 5\H PILE\INTAKE5_014_HPILE_BERMB6505_TIME_ALL.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (12/4/2015)

Input File Contents
WaterFix_2019-CER_Intake5_014_HPile
OUT OSG HAM STR FUL PEL N SPL N-U P-D %SK ISM 0 PHI RSA ITR H-D MXT DEx
-100 0 433 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.000
Pile g Hammer g Toe Area Pile Size Pile Type
32.185 32.185 450.400 18.110 H Pile
W Cp A Cp E Cp T Cp CoR ROut StCp
6.000 424.000 30000.0 6.000 0.700 0.010 0.0
A Cu E Cu T Cu CoR ROut StCu
0.000 0.0 0.000 0.000 0.000 0.0
LPle APle EPle WPle Peri CI CoR ROut
60.310 39.96 30000.0 492.000 7.160 0 0.850 0.010
FFatigue F0 0-Bottom
0 0.000 0.000
Manufac Hmr Name HmrType No Seg-s
BERMINGH B6505 1 4
Ram Wt Ram L Ram Dia MaxStrk RtdStrk Effic
17.64 142.90 23.50 11.50 11.50 0.80
IB. Wt IB. L IB.Dia IB CoR IB RO

INTAKE5_014_HPILE_BERMB6505_TIME_ALL.GWO

3.75	43.00	19.00	0.900	0.010					
CompStrk	A	Chamber	V	Chamber					
20.30	452.40	658.00	0.0000	0.0000					
P atm	P1	P2	P3	P4					
14.70	1375.00	0.00	0.00	0.00					
Stroke	Effic.	Pressure	R-Weight	T-Delay					
11.5000	0.8000	1375.0000	0.0000	0.0000					
Qs	Qt	Js	Jt	Qx					
0.100	0.100	0.100	0.150	0.000					
Research	Soil Model:	Atoe, Plug, Gap, Q-fac							
	0.000	0.000	0.000	0.000					
Research	Soil Model:	RD-skn: m, d, toe: m, d							
	0.000	0.000	0.000	0.000					
Res. Distribution									
Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimD	SU T
0.00	0.00	0.00	0.10	0.35	0.05	0.15	1.20	6.56	1.0
36.30	0.67	220.71	0.10	0.35	0.05	0.15	1.20	6.56	1.0
36.30	0.67	220.71	0.10	0.35	0.05	0.15	1.20	6.56	1.0
38.81	0.71	235.97	0.10	0.35	0.05	0.15	1.20	6.56	1.0
60.31	0.71	235.97	0.10	0.35	0.05	0.15	1.20	6.56	1.0
Gain/Loss factors: shaft and toe									
0.50000	0.00000	0.00000	0.00000	0.00000	0.00000				
1.00000	0.00000	0.00000	0.00000	0.00000	0.00000				
Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR		
6.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
12.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
15.71	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
19.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
25.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
31.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
37.69	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
38.81	0.00	0.00	0.000	0.000	0.000	0.000	0.000		
0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000		

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

Version 2010

English Units

WaterFix_2019-CER_Intake5_014_Hpile

Hammer	Model:	B6505	Made by:	BERMINGH	
No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	4.410				
2	4.410	352088.1	1.000	0.0100	
3	4.410	352088.1	1.000	0.0100	
4	4.410	352088.1	1.000	0.0100	
Imp Block	3.750	123917.9	0.900	0.0100	
Helmet	6.000	2120000.0	0.700	0.0098	18.1
Combined Pile Top		29815.9			

HAMMER OPTIONS:

Hammer File ID No.	433	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	17.64	Ram Length	(inch)	142.90
Maximum Stroke	(ft)	11.50			
Rated Stroke	(ft)	11.50	Efficiency		0.800
Maximum Pressure	(psi)	1375.00	Actual Pressure	(psi)	1375.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	23.50			
Comb. Start Volume	(in3)	724.00	Comb. End Volume	(in3)	768.00

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

INTAKE5_014_HPILE_BERMB6505_TIME_ALL.GWO

HAMMER CUSHION		PILE CUSHION			
Cross Sect. Area	(in ²)	424.00	Cross Sect. Area	(in ²)	0.00
Elastic-Modulus	(ksi)	30000.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	6.00	Thickness	(inch)	0.00
Coeff of Restitution		0.7	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	2120000.0	Stiffness	(kips/in)	0.0

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	6.0			
Shaft Gain/Loss Factor		0.500	Toe Gain/Loss Factor		1.000

PILE PROFILE:

Toe Area	(in ²)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in ²	ksi	lb/ft ³	ft	ft	ft	ft/s	k/ft/s	
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3		
60.3	39.96	30000.	492.0	7.2	0	16807.	71.3		

Wave Travel Time 2L/c (ms) 7.177

No.	Weight	Pile and Soil Model	Total Capacity	Rut (kips)	37.7
	Stiffn	C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop Perim Area
	kips	k/in ft ft	kips	s/ft inch	ft ft in ²
1	0.457	29816 0.010 0.000 0.85	0.0	0.000 0.100	3.35 7.2 40.0
2	0.457	29816 0.000 0.000 1.00	0.0	0.000 0.100	6.70 7.2 40.0
17	0.457	29816 0.000 0.000 1.00	0.2	0.050 0.100	56.96 7.2 40.0
18	0.457	29816 0.000 0.000 1.00	1.0	0.050 0.100	60.31 7.2 40.0
Toe			36.5	0.150 0.354	

8.234 kips total unreduced pile weight (g= 32.17 ft/s²)
8.238 kips total reduced pile weight (g= 32.19 ft/s²)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile	Pile Segments: Automatic		
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	1.427
Driveability Analysis			
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	3	Analysis Time-Input (ms)	0
Output Level: Normal			
Gravity Mass, Pile, Hammer:	32.170	32.185	32.185
Output Segment Generation:	Automatic		

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
6.00	11.50	1.00	0.800

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i t Comp Str	i t ENTHRU Bl Rt	
kips	b/ft	down	up	ksi	kip-ft b/min	
37.7	Hammer did not run					

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	12.0			
Shaft Gain/Loss Factor		0.500	Toe Gain/Loss Factor		1.000

PILE PROFILE:

Toe Area	(in ²)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

INTAKE5_014_HPILE_BERMB6505_TIME_ALL.GWO

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3
60.3	39.96	30000.	492.0	7.2	0	16807.	71.3

Wave Travel Time 2L/c (ms) 7.177

Pile and Soil Model				Total	Capacity	Rut	(kips)	77.7			
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in ²
1	0.457	29816	0.010	0.000	0.85	0.0	0.000	0.100	3.35	7.2	40.0
2	0.457	29816	0.000	0.000	1.00	0.0	0.000	0.100	6.70	7.2	40.0
15	0.457	29816	0.000	0.000	1.00	0.1	0.050	0.100	50.26	7.2	40.0
16	0.457	29816	0.000	0.000	1.00	0.8	0.050	0.100	53.61	7.2	40.0
17	0.457	29816	0.000	0.000	1.00	1.5	0.050	0.100	56.96	7.2	40.0
18	0.457	29816	0.000	0.000	1.00	2.3	0.050	0.100	60.31	7.2	40.0
Toe						73.0	0.150	0.354			

8.234 kips total unreduced pile weight (g= 32.17 ft/s²)

8.238 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
12.00	11.50	1.00	0.800

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt	
kips	b/ft	down	up	ksi		ksi		kip-ft	b/min		
77.7	1.3	4.12	4.14	0.00	1	0	12.44	1	5	124.9	58.1

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	15.7
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor

PILE PROFILE:		
Toe Area	(in ²)	450.400 Pile Type
Pile Size	(inch)	18.110

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3
60.3	39.96	30000.	492.0	7.2	0	16807.	71.3

Wave Travel Time 2L/c (ms) 7.177

Pile and Soil Model				Total	Capacity	Rut	(kips)	103.6			
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in ²
1	0.457	29816	0.010	0.000	0.85	0.0	0.000	0.100	3.35	7.2	40.0
2	0.457	29816	0.000	0.000	1.00	0.0	0.000	0.100	6.70	7.2	40.0
14	0.457	29816	0.000	0.000	1.00	0.2	0.050	0.100	46.91	7.2	40.0
15	0.457	29816	0.000	0.000	1.00	0.9	0.050	0.100	50.26	7.2	40.0
16	0.457	29816	0.000	0.000	1.00	1.6	0.050	0.100	53.61	7.2	40.0
17	0.457	29816	0.000	0.000	1.00	2.3	0.050	0.100	56.96	7.2	40.0
18	0.457	29816	0.000	0.000	1.00	3.1	0.050	0.100	60.31	7.2	40.0
Toe						95.5	0.150	0.354			

8.234 kips total unreduced pile weight (g= 32.17 ft/s²)

8.238 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.71	11.50	1.00	0.800

▲

INTAKE5_014_HPILE_BERMB6505_TIME_ALL.GWO

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
103.6	1.8	4.60	4.56	0.00		1	0	12.83		1	4	118.3		55.0

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth (ft) 19.7
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in²) 450.400 Pile Type H Pile
Pile Size (inch) 18.110

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
			ft	in ²	ksi	lb/ft ³		ft	k/ft/s
0.0			39.96	3000.	492.0	7.2	0	16807.	71.3
60.3			39.96	3000.	492.0	7.2	0	16807.	71.3

Wave Travel Time 2L/c (ms) 7.177

Pile and Soil Model					Total	Capacity	Rut	(kips)	132.4		
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
1	0.457	29816	0.010	0.000	0.85	0.0	0.000	0.100	3.35	7.2	40.0
2	0.457	29816	0.000	0.000	1.00	0.0	0.000	0.100	6.70	7.2	40.0
13	0.457	29816	0.000	0.000	1.00	0.3	0.050	0.100	43.56	7.2	40.0
14	0.457	29816	0.000	0.000	1.00	1.0	0.050	0.100	46.91	7.2	40.0
15	0.457	29816	0.000	0.000	1.00	1.7	0.050	0.100	50.26	7.2	40.0
16	0.457	29816	0.000	0.000	1.00	2.5	0.050	0.100	53.61	7.2	40.0
17	0.457	29816	0.000	0.000	1.00	3.2	0.050	0.100	56.96	7.2	40.0
18	0.457	29816	0.000	0.000	1.00	4.0	0.050	0.100	60.31	7.2	40.0
Toe						119.7	0.150	0.354			

8.234 kips total unreduced pile weight (g= 32.17 ft/s²)
8.238 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficacy
19.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
132.4	2.4		4.97	4.94	0.00	1	0	15.14		1	5	115.3		52.9

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth (ft) 25.7
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in²) 450.400 Pile Type H Pile
Pile Size (inch) 18.110

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
			in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3		
60.2	39.96	30000.	492.0	7.2	0	16807.	71.3		

Wave Travel Time 21/c (ms) 7.177

INTAKE5_014_HPILE_BERMB6505_TIME_ALL.GWO											
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	0.457	29816	0.010	0.000	0.85	0.0	0.000	0.100	3.35	7.2	40.0
2	0.457	29816	0.000	0.000	1.00	0.0	0.000	0.100	6.70	7.2	40.0
11	0.457	29816	0.000	0.000	1.00	0.2	0.050	0.100	36.86	7.2	40.0
12	0.457	29816	0.000	0.000	1.00	0.9	0.050	0.100	40.21	7.2	40.0
13	0.457	29816	0.000	0.000	1.00	1.6	0.050	0.100	43.56	7.2	40.0
14	0.457	29816	0.000	0.000	1.00	2.3	0.050	0.100	46.91	7.2	40.0
15	0.457	29816	0.000	0.000	1.00	3.1	0.050	0.100	50.26	7.2	40.0
16	0.457	29816	0.000	0.000	1.00	3.8	0.050	0.100	53.61	7.2	40.0
17	0.457	29816	0.000	0.000	1.00	4.5	0.050	0.100	56.96	7.2	40.0
18	0.457	29816	0.000	0.000	1.00	5.3	0.050	0.100	60.31	7.2	40.0
Toe					156.2	0.150	0.354				

8.234 kips total unreduced pile weight (g= 32.17 ft/s²)
 8.238 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
25.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi			ksi				kip-ft	b/min	
177.8	3.4	5.44	5.42	0.00	1	0	18.33	9	4	111.2	50.3			

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Depth	(ft)	31.7	
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:
 Toe Area (in²) 450.400 Pile Type H Pile
 Pile Size (inch) 18.110

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in ²	ksi	lb/ft ³	ft		ft		ft/s	k/ft/s
0.0	39.96	30000.	492.0	7.2	0	16807.	71.3		
60.3	39.96	30000.	492.0	7.2	0	16807.	71.3		

Wave Travel Time 2L/c (ms) 7.177

No.	Weight	Pile and Soil Model			Total Capacity	Rut (kips)	225.6				
	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D Quake	LbTop	Perim	Area		
	kips	k/in	ft	ft	kips	s/ft	inch	ft	in ²		
1	0.457	29816	0.010	0.000	0.85	0.0	0.000	0.100	3.35	7.2	40.0
2	0.457	29816	0.000	0.000	1.00	0.0	0.000	0.100	6.70	7.2	40.0
9	0.457	29816	0.000	0.000	1.00	0.1	0.050	0.100	30.16	7.2	40.0
10	0.457	29816	0.000	0.000	1.00	0.7	0.050	0.100	33.51	7.2	40.0
11	0.457	29816	0.000	0.000	1.00	1.4	0.050	0.100	36.86	7.2	40.0
12	0.457	29816	0.000	0.000	1.00	2.2	0.050	0.100	40.21	7.2	40.0
13	0.457	29816	0.000	0.000	1.00	2.9	0.050	0.100	43.56	7.2	40.0
14	0.457	29816	0.000	0.000	1.00	3.7	0.050	0.100	46.91	7.2	40.0
15	0.457	29816	0.000	0.000	1.00	4.4	0.050	0.100	50.26	7.2	40.0
16	0.457	29816	0.000	0.000	1.00	5.1	0.050	0.100	53.61	7.2	40.0
17	0.457	29816	0.000	0.000	1.00	5.9	0.050	0.100	56.96	7.2	40.0
18	0.457	29816	0.000	0.000	1.00	6.6	0.050	0.100	60.31	7.2	40.0
Toe					192.7	0.150	0.354				

8.234 kips total unreduced pile weight (g= 32.17 ft/s²)
 8.238 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
31.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

CH2M HILL

INTAKE5_014_HPILE_BERMB6505_TIME_ALL.GWO
GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
225.6	4.5	5.87	5.84	0.00		1	0	21.52	10	4	108.1		48.3	

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	37.7	
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2		ksi	lb/ft3		ft		ft/s	k/ft/s
0.0	39.96	30000.	492.0		7.2	0	16807.		71.3
60.3	39.96	30000.	492.0		7.2	0	16807.		71.3

Wave Travel Time 2L/c (ms) 7.177

No.	Weight	Pile and Soil Model	Total Capacity	Rut (kips)	275.7		
	kips	Stiffn C-Slk T-Slk CoR	Soil-S	Soil-D Quake	LbTop	Perim	Area
		k/in ft ft	kips	s/ft inch	ft	ft	in2
1	0.457	29816 0.010 0.000 0.85	0.0	0.000 0.100	3.35	7.2	40.0
2	0.457	29816 0.000 0.000 1.00	0.0	0.000 0.100	6.70	7.2	40.0
7	0.457	29816 0.000 0.000 1.00	0.0	0.050 0.100	23.45	7.2	40.0
8	0.457	29816 0.000 0.000 1.00	0.6	0.050 0.100	26.80	7.2	40.0
9	0.457	29816 0.000 0.000 1.00	1.3	0.050 0.100	30.16	7.2	40.0
10	0.457	29816 0.000 0.000 1.00	2.0	0.050 0.100	33.51	7.2	40.0
11	0.457	29816 0.000 0.000 1.00	2.8	0.050 0.100	36.86	7.2	40.0
12	0.457	29816 0.000 0.000 1.00	3.5	0.050 0.100	40.21	7.2	40.0
13	0.457	29816 0.000 0.000 1.00	4.2	0.050 0.100	43.56	7.2	40.0
14	0.457	29816 0.000 0.000 1.00	5.0	0.050 0.100	46.91	7.2	40.0
15	0.457	29816 0.000 0.000 1.00	5.7	0.050 0.100	50.26	7.2	40.0
16	0.457	29816 0.000 0.000 1.00	6.4	0.050 0.100	53.61	7.2	40.0
17	0.457	29816 0.000 0.000 1.00	7.2	0.050 0.100	56.96	7.2	40.0
18	0.457	29816 0.000 0.000 1.00	7.9	0.050 0.100	60.31	7.2	40.0
Toe			229.2	0.150 0.354			

8.234 kips total unreduced pile weight (g= 32.17 ft/s²)8.238 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
37.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
275.7	5.8	6.21	6.26	0.00		1	0	23.72	8	4	104.8		46.8	

WaterFix_2019-CER_Intake5_014_HPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	38.8	
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	450.400	Pile Type	H Pile
Pile Size	(inch)	18.110		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2		ksi	lb/ft3		ft		ft/s	k/ft/s
0.0	39.96	30000.	492.0		7.2	0	16807.		71.3
60.3	39.96	30000.	492.0		7.2	0	16807.		71.3

INTAKE5_014_HPILE_BERMB6505_TIME_ALL.GWO

Wave Travel Time 2L/c (ms) 7.177

No.	Weight kips	Pile and Soil Model			Soil-S kips	Soil-D s/ft	Quake inch	Total Capacity (kips)	Rut ft	LbTop ft	Perim ft	Area in ²
		Stiffn C-Slk k/in	T-Slk ft	CoR								
1	0.457	29816	0.010	0.000	0.85	0.0	0.000	0.100	3.35	7.2	40.0	
2	0.457	29816	0.000	0.000	1.00	0.0	0.000	0.100	6.70	7.2	40.0	
7	0.457	29816	0.000	0.000	1.00	0.1	0.050	0.100	23.45	7.2	40.0	
8	0.457	29816	0.000	0.000	1.00	0.8	0.050	0.100	26.80	7.2	40.0	
9	0.457	29816	0.000	0.000	1.00	1.5	0.050	0.100	30.16	7.2	40.0	
10	0.457	29816	0.000	0.000	1.00	2.3	0.050	0.100	33.51	7.2	40.0	
11	0.457	29816	0.000	0.000	1.00	3.0	0.050	0.100	36.86	7.2	40.0	
12	0.457	29816	0.000	0.000	1.00	3.7	0.050	0.100	40.21	7.2	40.0	
13	0.457	29816	0.000	0.000	1.00	4.5	0.050	0.100	43.56	7.2	40.0	
14	0.457	29816	0.000	0.000	1.00	5.2	0.050	0.100	46.91	7.2	40.0	
15	0.457	29816	0.000	0.000	1.00	6.0	0.050	0.100	50.26	7.2	40.0	
16	0.457	29816	0.000	0.000	1.00	6.7	0.050	0.100	53.61	7.2	40.0	
17	0.457	29816	0.000	0.000	1.00	7.4	0.050	0.100	56.96	7.2	40.0	
18	0.457	29816	0.000	0.000	1.00	8.2	0.050	0.100	60.31	7.2	40.0	
Toe						236.0	0.150	0.354				

8.234 kips total unreduced pile weight (g= 32.17 ft/s²)
 8.238 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficy
38.81	11.50	1.00	0.800

WaterFix_2019-CER_Intake5_014_Hpile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Rut kips	Bl b/ft	Ct down	Stroke (ft) up	Ten ksi	i	t	Comp ksi	Str kip-ft	i	t	ENTHRU kip-ft	Bl Rt b/min
285.4	6.0	6.28	6.33	0.00	1	0	24.08	8	4	104.3	46.6	

WaterFix_2019-CER_Intake5_014_Hpile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

SUMMARY OVER DEPTHS

Depth ft	G/L at Shaft and Toe: 0.500 1.000									
	Rut kips	Frictn kips	End Bg kips	Bl Ct bl/ft	Com Str ksi	Ten Str ksi	Stroke ft	ENTHRU kip-ft		
6.0	37.7	1.2	36.5	Hammer did not run						
12.0	77.7	4.7	73.0	1.3	12.443	0.000	4.12	124.9		
15.7	103.6	8.1	95.5	1.8	12.835	0.000	4.60	118.3		
19.7	132.4	12.7	119.7	2.4	15.137	0.000	4.97	115.3		
25.7	177.8	21.6	156.2	3.4	18.331	0.000	5.44	111.2		
31.7	225.6	32.9	192.7	4.5	21.523	0.000	5.87	108.1		
37.7	275.7	46.6	229.2	5.8	23.716	0.000	6.21	104.8		
38.8	285.4	49.4	236.0	6.0	24.079	0.000	6.28	104.3		

Total Driving Time 2 minutes; Total No. of Blows 95
 Starting at penetration 6.0 ft

WaterFix_2019-CER_Intake5_014_Hpile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp. Length ft	Wait Time hr	Equivalent Stroke ft	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
6.00	60.31	0.00	11.50	1.00	0.80	1.00	1.00
12.00	60.31	0.00	11.50	1.00	0.80	1.00	1.00
15.71	60.31	0.00	11.50	1.00	0.80	1.00	1.00
19.69	60.31	0.00	11.50	1.00	0.80	1.00	1.00
25.69	60.31	0.00	11.50	1.00	0.80	1.00	1.00

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31.69	60.31	0.00	11.50	1.00	0.80	1.00	1.00
37.69	60.31	0.00	11.50	1.00	0.80	1.00	1.00
38.81	60.31	0.00	11.50	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth	Shaft ft	End Res. k/ft ²	Shaft Bearing kips	Toe Quake inch	Shaft Quake inch	Toe Damping s/ft	Shaft Damping s/ft	Soil Normlzd	Setup Distance ft	Setup Time hrs
0.00	0.00	0.00	0.100	0.354	0.354	0.050	0.150	1.000	6.560	1.000
36.30	0.67	220.71	0.100	0.354	0.354	0.050	0.150	1.000	6.560	1.000
36.30	0.67	220.71	0.100	0.354	0.354	0.050	0.150	1.000	6.560	1.000
38.81	0.71	235.97	0.100	0.354	0.354	0.050	0.150	1.000	6.560	1.000
60.31	0.71	235.97	0.100	0.354	0.354	0.050	0.150	1.000	6.560	1.000

INTAKE5_014_SHEETPILE_BERMB6505_TIME_ALL.GWO

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.
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ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

↑
Input File: C:\USERS\MAU\Desktop\WATERFIX\INTAKE PILE DRIVABILITY\PILE_DRIVING\GRLWEAP\DRIVING TIME\BERMINGHAM B6505\INTAKE 5\SHEET PILE\INTAKE5_014_SHEETPILE_BERMB6505_TIME_ALL.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (12/4/2015)

Input File Contents
WaterFix_2019-CER_Intake5_014_SheetPile

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
-100	0	433	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0.000
Pile g	Hammer g	Toe	Area	Pile	Size													
32.185	32.185		52.850		0.000													
W Cp	A Cp	E Cp	T Cp		CoR		ROut			StCp								
6.000	424.000	30000.0	6.000		0.700		0.000			0.0								
A Cu	E Cu	T Cu	CoR		ROut		StCu											
0.000	0.0	0.000	0.000		0.000		0.0											
LPle	APle	EPle	WPle		Peri		CI		CoR		ROut							
60.310	52.84	30000.0	492.000		13.451		0		0.850		0.010							
FFatigue	F0	0-Bottom																
0	0.000	0.000																
Manufac	Hmr	Name	HmrType	No Seg-s														
BERMINGH	B6505			1	4													
Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy													
17.64	142.90	23.50	11.50	11.50	0.80													
IB. Wt	IB. L	IB.Dia	IB CoR	IB RO														

INTAKE5_014_SHEETPILE_BERMB6505_TIME_ALL.GWO

3.75	43.00	19.00	0.900	0.010
CompStrk	A	Chamber	V	Chamber
20.30	452.40	658.00	0.0000	0.0000
P atm	P1	P2	P3	P4
14.70	1375.00	0.00	0.00	0.00
Stroke	Effic.	Pressure	R-Weight	T-Delay
11.5000	0.8000	1375.0000	0.0000	0.0000
Qs	Qt	Js	Jt	Qx
0.100	0.100	0.100	0.150	0.000
Research	Soil Model:	Atoe, Plug, Gap, Q-fac		
	0.000	0.000	0.000	0.000
Research	Soil Model:	RD-skn: m, d, toe: m, d		
	0.000	0.000	0.000	0.000
Res. Distribution				
Dpth	Rskn	Rtoe	Qs	Qt
0.00	0.00	0.00	0.10	0.12
36.30	0.67	25.90	0.10	0.12
36.30	0.67	25.90	0.10	0.12
38.81	0.71	27.69	0.10	0.12
60.31	0.71	27.69	0.10	0.12
Gain/Loss factors: shaft and toe				
0.50000	0.00000	0.00000	0.00000	0.00000
1.00000	0.00000	0.00000	0.00000	0.00000
Dpth	L	Wait	Strk	Pmx%
6.00	0.00	0.00	0.000	0.000
12.00	0.00	0.00	0.000	0.000
15.71	0.00	0.00	0.000	0.000
19.69	0.00	0.00	0.000	0.000
25.69	0.00	0.00	0.000	0.000
31.69	0.00	0.00	0.000	0.000
37.69	0.00	0.00	0.000	0.000
38.81	0.00	0.00	0.000	0.000
0.00	0.00	0.00	0.000	0.000

▲ GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

Version 2010

English Units

WaterFix_2019-CER_Intake5_014_SheetPile

Hammer	Model:	B6505	Made by:	BERMINGH	
No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	4.410				
2	4.410	352088.1	1.000	0.0100	
3	4.410	352088.1	1.000	0.0100	
4	4.410	352088.1	1.000	0.0100	
Imp Block	3.750	123917.9	0.900	0.0100	
Helmet	6.000	2120000.0	0.700	0.0100	18.1
Combined Pile Top		39426.3			

HAMMER OPTIONS:

Hammer File ID No.	433	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	17.64	Ram Length	(inch)	142.90
Maximum Stroke	(ft)	11.50			
Rated Stroke	(ft)	11.50	Efficiency		0.800
Maximum Pressure	(psi)	1375.00	Actual Pressure	(psi)	1375.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	23.50			
Comb. Start Volume	(in3)	724.00	Comb. End Volume	(in3)	768.00

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

INTAKE5_014_SHEETPILE_BERMB6505_TIME_ALL.GWO

HAMMER CUSHION		PILE CUSHION			
Cross Sect. Area	(in ²)	424.00	Cross Sect. Area	(in ²)	0.00
Elastic-Modulus	(ksi)	30000.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	6.00	Thickness	(inch)	0.00
Coeff of Restitution		0.7	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	2120000.0	Stiffness	(kips/in)	0.0

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	6.0			
Shaft Gain/Loss Factor		0.500	Toe Gain/Loss Factor		1.000

PILE PROFILE:

Toe Area	(in ²)	52.850	Pile Type	Sheet Pile
Pile Size	(inch)	0.000		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in	ft	in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s
0.0	52.84	30000.	52.84	492.0	13.5	0	16807.	94.3	
60.3	52.84	30000.	52.84	492.0	13.5	0	16807.	94.3	

Wave Travel Time 2L/c (ms) 7.177

Pile and Soil Model				Total Capacity	Rut	(kips)	6.5				
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in ²
1	0.605	39426	0.010	0.000	0.85	0.0	0.000	0.100	3.35	13.5	52.8
2	0.605	39426	0.000	0.000	1.00	0.0	0.000	0.100	6.70	13.5	52.8
17	0.605	39426	0.000	0.000	1.00	0.4	0.050	0.100	56.96	13.5	52.8
18	0.605	39426	0.000	0.000	1.00	1.8	0.050	0.100	60.31	13.5	52.8
Toe						4.3	0.150	0.121			

10.888 kips total unreduced pile weight (g= 32.17 ft/s²)
10.893 kips total reduced pile weight (g= 32.19 ft/s²)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile	Pile Segments: Automatic		
No. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	1.886

Driveability Analysis

Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	3	Analysis Time-Input (ms)	0
Output Level: Normal			
Gravity Mass, Pile, Hammer:	32.170	32.185	32.185

Output Segment Generation: Automatic

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
6.00	11.50	1.00	0.800

INITIAL STATIC ANALYSIS: Total Wt, Sum(R) 20.6 6.5
Hammer+Pile Weight > Rult: Pile Runs

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
6.5	0.0	11.50	0.00	0.00	1	0	0.00	1	0	0.0	0.0	76.8		

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	12.0			
Shaft Gain/Loss Factor		0.500	Toe Gain/Loss Factor		1.000

INTAKE5_014_SHEETPILE_BERMB6505_TIME_ALL.GWO

PILE PROFILE:

Toe Area	(in2)	52.850	Pile Type	Sheet Pile
Pile Size	(inch)	0.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	52.84	30000.	492.0	13.5	0	16807.	94.3
60.3	52.84	30000.	492.0	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 7.177

Pile and Soil Model				Total Capacity (kips)	Rut (kips)	17.4					
No.	Weight kips	Stiffn C-Slk k/in	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2	
1	0.605	39426	0.010	0.000	0.85	0.0	0.000	0.100	3.35	13.5	52.8
2	0.605	39426	0.000	0.000	1.00	0.0	0.000	0.100	6.70	13.5	52.8
15	0.605	39426	0.000	0.000	1.00	0.2	0.050	0.100	50.26	13.5	52.8
16	0.605	39426	0.000	0.000	1.00	1.5	0.050	0.100	53.61	13.5	52.8
17	0.605	39426	0.000	0.000	1.00	2.9	0.050	0.100	56.96	13.5	52.8
18	0.605	39426	0.000	0.000	1.00	4.3	0.050	0.100	60.31	13.5	52.8
Toe					8.6	0.150	0.121				

10.888 kips total unreduced pile weight (g= 32.17 ft/s²)

10.893 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficacy
12.00	11.50	1.00	0.800

INITIAL STATIC ANALYSIS: Total Wt, Sum(R) 20.6 17.4

Hammer+Pile Weight > Rult: Pile Runs

▲

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft)	Ten Str	i	t Comp	Str	i	t ENTHRU	Bl Rt		
kips	b/ft	down	up	ksi		ksi		kip-ft	b/min		
17.4	0.0	11.50	0.00	0.00	1	0	0.00	1	0	0.0	76.8

▲

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth (ft)	15.7
Shaft Gain/Loss Factor	0.500
Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in2)	52.850	Pile Type	Sheet Pile
Pile Size	(inch)	0.000		

L b Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft		ft/s	k/ft/s
0.0	52.84	30000.	492.0	13.5	0	16807.	94.3
60.3	52.84	30000.	492.0	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 7.177

Pile and Soil Model				Total Capacity (kips)	Rut (kips)	26.4					
No.	Weight kips	Stiffn C-Slk k/in	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2	
1	0.605	39426	0.010	0.000	0.85	0.0	0.000	0.100	3.35	13.5	52.8
2	0.605	39426	0.000	0.000	1.00	0.0	0.000	0.100	6.70	13.5	52.8
14	0.605	39426	0.000	0.000	1.00	0.3	0.050	0.100	46.91	13.5	52.8
15	0.605	39426	0.000	0.000	1.00	1.6	0.050	0.100	50.26	13.5	52.8
16	0.605	39426	0.000	0.000	1.00	3.0	0.050	0.100	53.61	13.5	52.8
17	0.605	39426	0.000	0.000	1.00	4.4	0.050	0.100	56.96	13.5	52.8
18	0.605	39426	0.000	0.000	1.00	5.8	0.050	0.100	60.31	13.5	52.8
Toe					11.2	0.150	0.121				

INTAKE5_014_SHEETPILE_BERMB6505_TIME_ALL.GWO
10.888 kips total unreduced pile weight (g= 32.17 ft/s²)
10.893 kips total reduced pile weight (g= 32.19 ft/s²)

Depth Stroke Pressure Efficcy
ft ft Ratio
15.71 11.50 1.00 0.800

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut Bl Ct Stroke (ft) Ten Str i t Comp Str i t ENTHRU Bl Rt
kips b/ft down up ksi ksi kip-ft b/min
26.4 Hammer did not run

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth (ft) 19.7
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in²) 52.850 Pile Type Sheet Pile
Pile Size (inch) 0.000

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s
0.0	52.84	30000.	492.0	13.5	0	16807.	94.3		
60.3	52.84	30000.	492.0	13.5	0	16807.	94.3		

Wave Travel Time 2L/c (ms) 7.177

No.	Weight	Pile and Soil Model	Total Capacity	Rut (kips)	37.9
	kips	Stiffn C-Slk T-Slk CoR	Soil-S Soil-D Quake	LbTop Perim	Area
		k/in ft ft	kips s/ft inch	ft ft	in ²
1	0.605	39426 0.010 0.000 0.85	0.0 0.000 0.100	3.35 13.5	52.8
2	0.605	39426 0.000 0.000 1.00	0.0 0.000 0.100	6.70 13.5	52.8
13	0.605	39426 0.000 0.000 1.00	0.5 0.050 0.100	43.56 13.5	52.8
14	0.605	39426 0.000 0.000 1.00	1.9 0.050 0.100	46.91 13.5	52.8
15	0.605	39426 0.000 0.000 1.00	3.3 0.050 0.100	50.26 13.5	52.8
16	0.605	39426 0.000 0.000 1.00	4.7 0.050 0.100	53.61 13.5	52.8
17	0.605	39426 0.000 0.000 1.00	6.1 0.050 0.100	56.96 13.5	52.8
18	0.605	39426 0.000 0.000 1.00	7.4 0.050 0.100	60.31 13.5	52.8
Toe			14.0 0.150 0.121		

10.888 kips total unreduced pile weight (g= 32.17 ft/s²)
10.893 kips total reduced pile weight (g= 32.19 ft/s²)

Depth Stroke Pressure Efficcy
ft ft Ratio
19.69 11.50 1.00 0.800

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut Bl Ct Stroke (ft) Ten Str i t Comp Str i t ENTHRU Bl Rt
kips b/ft down up ksi ksi kip-ft b/min
37.9 Hammer did not run

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth (ft) 25.7
Shaft Gain/Loss Factor 0.500 Toe Gain/Loss Factor 1.000

PILE PROFILE:

Toe Area (in²) 52.850 Pile Type Sheet Pile
Pile Size (inch) 0.000

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s

	ft	in ²	ksi	lb/ft ³	ft	ft/s	k/ft/s	
0.0	52.84	30000.		492.0	13.5	0	16807.	94.3
60.3	52.84	30000.		492.0	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 7.177

No.	Weight	Pile and Soil Model				Soil-S	Soil-D	Quake	Total Capacity (kips)	Rut	59.0
		Stiffn kips	C-Slk k/in	T-Slk ft	CoR ft						
1	0.605	39426	0.010	0.000	0.85	0.0	0.000	0.100	3.35	13.5	52.8
2	0.605	39426	0.000	0.000	1.00	0.0	0.000	0.100	6.70	13.5	52.8
11	0.605	39426	0.000	0.000	1.00	0.3	0.050	0.100	36.86	13.5	52.8
12	0.605	39426	0.000	0.000	1.00	1.6	0.050	0.100	40.21	13.5	52.8
13	0.605	39426	0.000	0.000	1.00	3.0	0.050	0.100	43.56	13.5	52.8
14	0.605	39426	0.000	0.000	1.00	4.4	0.050	0.100	46.91	13.5	52.8
15	0.605	39426	0.000	0.000	1.00	5.8	0.050	0.100	50.26	13.5	52.8
16	0.605	39426	0.000	0.000	1.00	7.1	0.050	0.100	53.61	13.5	52.8
17	0.605	39426	0.000	0.000	1.00	8.5	0.050	0.100	56.96	13.5	52.8
18	0.605	39426	0.000	0.000	1.00	9.9	0.050	0.100	60.31	13.5	52.8
Toe						18.3	0.150	0.121			

10.888 kips total unreduced pile weight (g= 32.17 ft/s²)

10.893 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
25.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	Bl	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
59.0	1.0		3.81	3.84	0.00	1	0		9.63	1	5	117.0	60.3	

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth (ft)	31.7		
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area (in ²)	52.850	Pile Type	Sheet Pile
Pile Size (inch)	0.000		

L b Top ft	Area in ²	E-Mod ksi	Spec Wt lb/ft ³	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	52.84	30000.	492.0	13.5	0	16807.	94.3
60.3	52.84	30000.	492.0	13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 7.177

No.	Weight	Pile and Soil Model				Soil-S	Soil-D	Quake	Total Capacity (kips)	Rut	84.5
		Stiffn kips	C-Slk k/in	T-Slk ft	CoR ft						
1	0.605	39426	0.010	0.000	0.85	0.0	0.000	0.100	3.35	13.5	52.8
2	0.605	39426	0.000	0.000	1.00	0.0	0.000	0.100	6.70	13.5	52.8
9	0.605	39426	0.000	0.000	1.00	0.1	0.050	0.100	30.16	13.5	52.8
10	0.605	39426	0.000	0.000	1.00	1.3	0.050	0.100	33.51	13.5	52.8
11	0.605	39426	0.000	0.000	1.00	2.7	0.050	0.100	36.86	13.5	52.8
12	0.605	39426	0.000	0.000	1.00	4.1	0.050	0.100	40.21	13.5	52.8
13	0.605	39426	0.000	0.000	1.00	5.5	0.050	0.100	43.56	13.5	52.8
14	0.605	39426	0.000	0.000	1.00	6.9	0.050	0.100	46.91	13.5	52.8
15	0.605	39426	0.000	0.000	1.00	8.2	0.050	0.100	50.26	13.5	52.8
16	0.605	39426	0.000	0.000	1.00	9.6	0.050	0.100	53.61	13.5	52.8
17	0.605	39426	0.000	0.000	1.00	11.0	0.050	0.100	56.96	13.5	52.8
18	0.605	39426	0.000	0.000	1.00	12.4	0.050	0.100	60.31	13.5	52.8
Toe						22.6	0.150	0.121			

10.888 kips total unreduced pile weight (g= 32.17 ft/s²)

INTAKE5_014_SHEETPILE_BERMB6505_TIME_ALL.GWO
10.893 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	
31.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	B1	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	B1	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
84.5	1.2		4.18	4.21	0.00	1	0		9.97	1	4	122.9	57.6	

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	37.7	
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area	(in ²)	52.850	Pile Type	Sheet Pile
Pile Size	(inch)	0.000		

L	b	Top	Area	E-Mod	Spec Wt	Perim	C Index	Wave Sp	EA/c
ft			in ²	ksi	lb/ft ³	ft		ft/s	k/ft/s
0.0	52.84		30000.	492.0		13.5	0	16807.	94.3
60.3	52.84		30000.	492.0		13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 7.177

Pile and Soil Model					Total Capacity	Rut (kips)	114.4				
No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Perim	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in ²
1	0.605	39426	0.010	0.000	0.85	0.0	0.000	0.100	3.35	13.5	52.8
2	0.605	39426	0.000	0.000	1.00	0.0	0.000	0.100	6.70	13.5	52.8
7	0.605	39426	0.000	0.000	1.00	0.0	0.050	0.100	23.45	13.5	52.8
8	0.605	39426	0.000	0.000	1.00	1.0	0.050	0.100	26.80	13.5	52.8
9	0.605	39426	0.000	0.000	1.00	2.4	0.050	0.100	30.16	13.5	52.8
10	0.605	39426	0.000	0.000	1.00	3.8	0.050	0.100	33.51	13.5	52.8
11	0.605	39426	0.000	0.000	1.00	5.2	0.050	0.100	36.86	13.5	52.8
12	0.605	39426	0.000	0.000	1.00	6.6	0.050	0.100	40.21	13.5	52.8
13	0.605	39426	0.000	0.000	1.00	8.0	0.050	0.100	43.56	13.5	52.8
14	0.605	39426	0.000	0.000	1.00	9.3	0.050	0.100	46.91	13.5	52.8
15	0.605	39426	0.000	0.000	1.00	10.7	0.050	0.100	50.26	13.5	52.8
16	0.605	39426	0.000	0.000	1.00	12.1	0.050	0.100	53.61	13.5	52.8
17	0.605	39426	0.000	0.000	1.00	13.5	0.050	0.100	56.96	13.5	52.8
18	0.605	39426	0.000	0.000	1.00	14.9	0.050	0.100	60.31	13.5	52.8
Toe						26.9	0.150	0.121			

10.888 kips total unreduced pile weight (g= 32.17 ft/s²)

10.893 kips total reduced pile weight (g= 32.19 ft/s²)

Depth	Stroke	Pressure	Efficacy
ft	ft	Ratio	
37.69	11.50	1.00	0.800

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Rut	B1	Ct	Stroke (ft)	Ten	Str	i	t	Comp	Str	i	t	ENTHRU	B1	Rt
kips	b/ft		down	up	ksi				ksi			kip-ft	b/min	
114.4	1.4		4.52	4.56	0.00	1	0		12.06	1	3	123.3	55.4	

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
CH2M HILL GRLWEAP Version 2010

Depth	(ft)	38.8	
Shaft Gain/Loss Factor	0.500	Toe Gain/Loss Factor	1.000

INTAKE5_014_SHEETPILE_BERMB6505_TIME_ALL.GWO

PILE PROFILE:

Toe Area	(in2)	52.850	Pile Type	Sheet Pile
Pile Size	(inch)	0.000		

L	b	Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0		52.84	30000.	492.0		13.5	0	16807.	94.3
60.3		52.84	30000.	492.0		13.5	0	16807.	94.3

Wave Travel Time 2L/c (ms) 7.177

No.	Weight kips	Pile and Soil Model			Soil-S kips	Soil-D s/ft	Quake inch	Rut LbTop ft	Capacity (kips)	120.5 Area in2	
		Stiffn C-Slk	T-Slk	CoR							
1	0.605	39426	0.010	0.000	0.85	0.0	0.000	0.100	3.35	13.5	52.8
2	0.605	39426	0.000	0.000	1.00	0.0	0.000	0.100	6.70	13.5	52.8
7	0.605	39426	0.000	0.000	1.00	0.2	0.050	0.100	23.45	13.5	52.8
8	0.605	39426	0.000	0.000	1.00	1.5	0.050	0.100	26.80	13.5	52.8
9	0.605	39426	0.000	0.000	1.00	2.9	0.050	0.100	30.16	13.5	52.8
10	0.605	39426	0.000	0.000	1.00	4.3	0.050	0.100	33.51	13.5	52.8
11	0.605	39426	0.000	0.000	1.00	5.6	0.050	0.100	36.86	13.5	52.8
12	0.605	39426	0.000	0.000	1.00	7.0	0.050	0.100	40.21	13.5	52.8
13	0.605	39426	0.000	0.000	1.00	8.4	0.050	0.100	43.56	13.5	52.8
14	0.605	39426	0.000	0.000	1.00	9.8	0.050	0.100	46.91	13.5	52.8
15	0.605	39426	0.000	0.000	1.00	11.2	0.050	0.100	50.26	13.5	52.8
16	0.605	39426	0.000	0.000	1.00	12.6	0.050	0.100	53.61	13.5	52.8
17	0.605	39426	0.000	0.000	1.00	13.9	0.050	0.100	56.96	13.5	52.8
18	0.605	39426	0.000	0.000	1.00	15.3	0.050	0.100	60.31	13.5	52.8
Toe					27.7	0.150	0.121				

10.888 kips total unreduced pile weight (g= 32.17 ft/s²)10.893 kips total reduced pile weight (g= 32.19 ft/s²)

Depth ft	Stroke ft	Pressure Ratio	Efficy
38.81	11.50	1.00	0.800

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Rut kips	Bl b/ft	Ct down	Stroke (ft) up	Ten ksi	Str i	t	Comp ksi	Str i	t	ENTHRU kip-ft	Bl b/min	Rt
120.5	1.5	4.59	4.63	0.00	1	0	12.94	1	3	122.4	55.0	

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

SUMMARY OVER DEPTHS

Depth ft	G/L at Shaft and Toe: 0.500 1.000									
	Rut kips	Friectn kips	End Bg kips	Bl Ct bl/ft	Com ksi	Str ksi	Ten ksi	Str ft	Stroke kip-ft	ENTHRU
6.0	6.5	2.2	4.3	0.0	0.000	0.000	0.000	11.50	0.0	
12.0	17.4	8.9	8.6	0.0	0.000	0.000	0.000	11.50	0.0	
15.7	26.4	15.2	11.2	Hammer did not run						
19.7	37.9	23.9	14.0	Hammer did not run						
25.7	59.0	40.7	18.3	1.0	9.626	0.000	3.81	117.0		
31.7	84.5	61.9	22.6	1.2	9.968	0.000	4.18	122.9		
37.7	114.4	87.5	26.9	1.4	12.059	0.000	4.52	123.3		
38.8	120.5	92.8	27.7	1.5	12.939	0.000	4.59	122.4		

Total Driving Time 0 minutes; Total No. of Blows 19
 Starting at penetration 6.0 ft

WaterFix_2019-CER_Intake5_014_SheetPile 03/07/2020
 CH2M HILL GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

INTAKE5_014_SHEETPILE_BERMB6505_TIME_ALL.GWO

Depth ft	Temp. Length ft	Wait Time hr	Equivalent Pressure			Stiffn. Factor	Cushion CoR
			Stroke ft	Ratio	Efficacy.		
6.00	60.31	0.00	11.50	1.00	0.80	1.00	1.00
12.00	60.31	0.00	11.50	1.00	0.80	1.00	1.00
15.71	60.31	0.00	11.50	1.00	0.80	1.00	1.00
19.69	60.31	0.00	11.50	1.00	0.80	1.00	1.00
25.69	60.31	0.00	11.50	1.00	0.80	1.00	1.00
31.69	60.31	0.00	11.50	1.00	0.80	1.00	1.00
37.69	60.31	0.00	11.50	1.00	0.80	1.00	1.00
38.81	60.31	0.00	11.50	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth ft	Shaft Res. k/ft ²	End Bearing kips	Shaft Quake inch	Toe Quake inch	Shaft Damping s/ft	Toe Damping s/ft	Soil Setup Normlzd	Limit Distance ft	Setup Time hrs
	0.00	0.00	0.00	0.100	0.121	0.050	0.150	1.000	6.560
36.30	0.67	25.90	0.100	0.121	0.050	0.150	1.000	6.560	1.000
36.30	0.67	25.90	0.100	0.121	0.050	0.150	1.000	6.560	1.000
38.81	0.71	27.69	0.100	0.121	0.050	0.150	1.000	6.560	1.000
60.31	0.71	27.69	0.100	0.121	0.050	0.150	1.000	6.560	1.000

Attachment 2
Results of Analysis by DeepEx

FINAL DRAFT

DeepEX 2020: Report Output

Copyright@2009 - 2020 Deep Excavation LLC: www.deepexcavation.com A
program for the evaluation of deep excavations Deep Excavation LLC, New
York, New York, www.deepexcavation.com

Project: Delta Conveyance - Intake 3



Company: Jacobs

Prepared by engineer: A. Finney

File number: Base Design Rev 1

Time: 11/30/2021 10:11:06 AM

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File: C:\Users\BellanN\OneDrive - Jacobs\Work\Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP

ANALYSIS AND CHECKING SUMMARY

The following tables summarize critical results for all design sections. These results may include wall moments, shears, displacements, stress checks, wall embedment safety factors, basal & slope stability safety factors, etc.

Summary vs Design Section

Base Case	Wall Moment	Wall Shear	Wall Displace	Max Support	Critical Support	Embedment	Comments
	(k-ft/ft)	(k/ft)	(in)	Reaction (k/ft)	Check	Wall FS	
Base Case	236.92	37.4	0	71.16	0.957	N/A	Calculation successful

Extended Summary

Table: Extended summary for all design sections.

Design Section	Calculation Result			Wall Displacement	Settlement
Name				(in)	(in)
Base Case	Calculation successful			3.02	5.41

Table: Extended summary for wall moments and shears for all design sections.

Design Section	Wall Moment	Wall Moment	Wall Shear	Wall Shear
Name	(k-ft/ft)	(k-ft)	(k/ft)	(k)
Base Case	236.92	2771.96	37.4	437.59

Table: Extended summary for wall stress checks for all design sections.

Design Section	STR Combined	STR Moment	STR Shear	Wall Concrete Service
Name	Wall Ratio	Wall Ratio	Wall Ratio	Stress Ratio FIC
Base Case	0.932	0.932	0.809	N/A

Table notes:

STR Combined: Combined stress check, along eccentricity line considering axial load and moment (demand/capacity).

STR Moment : Moment stress check, assuming constant axial load on wall (demand/capacity).

STR Shear : Shear stress check (shear force demand/wall shear capacity).

Table: Extended summary for support results for all design sections

Design Section	Max Support	Max Support	Critical	STR Support	Support Geotech
Name	Reaction (k/ft)	Reaction (k)	Support Check	Ratio	Capacity Ratio (pull)
Base Case	71.16	500	0.957	0.862	0.957

Table notes:

STR Support ratio: Critical structural stress check for support (force demand/structural capacity).

Support geotech capacity ratio: Critical geotechnical capacity stress check (demand/geotechnical capacity).

Critical support check: Critical demand/design capacity ratio (structural or geotechnical).

Table: Summary for basal stability and wall embedment safety factors from conventional analyses.

Design Section	FS	Toe FS	Toe FS	Toe FS
Name	Basal	Passive	Rotation	Length
Base Case	1.428	N/A	N/A	N/A

Table notes:

FSbasal : Critical basal stability safety factor (relevant only when soft clays are present beneath the excavation).

TOE FS Passive : Safety factor for wall embedment based on FS= Available horizontal thrust resistance/Driving hor. thrust.

TOE FS Rotation: Safety factor for wall embedment based on FS= Available resisting moment/Driving moment.

TOE FS Length : Safety factor for wall embedment based on FS= Available wall embedment/Required embedment for FS=1.0

Table: Summary for wall embedment safety factors from elastoplastic analyses.

Design Section	FS Mobilized	FS
Name	Passive	True/Active
Base Case	1.665	1.11

Table notes:

FS Mobilized Passive : Safety factor= Available horizontal passive resistance/Mobilized passive thrust.

FS True/Active : Soil thrust on retained wall side/Minimum theoretically horizontal active force thrust.

Table: Summary for hydraulic safety factors, water flow, and slope stability

Design Section	Hydraulic	Qflow	FSslope
Name	Heave FS	(ft3/hr)	
Base Case	N/A	N/A	N/A

Max. Moment vs Stage

	Base Model
M stg0 (k-ft/ft)	DS: 0
M stg1 (k-ft/ft)	-1.76
M stg2 (k-ft/ft)	-1.76
M stg3 (k-ft/ft)	24.97
M stg4 (k-ft/ft)	24.52
M stg5 (k-ft/ft)	54.9
M stg6 (k-ft/ft)	50.16
M stg7 (k-ft/ft)	52.45
M stg8 (k-ft/ft)	52.85
M stg9 (k-ft/ft)	7.85
M stg10 (k-ft/ft)	11.4
M stg11 (k-ft/ft)	21.88
M stg12 (k-ft/ft)	43.49
M stg13 (k-ft/ft)	43.49
M stg14 (k-ft/ft)	-135.72
M stg15 (k-ft/ft)	-111.77
M stg16 (k-ft/ft)	-132.25
M stg17 (k-ft/ft)	-129.44
M stg18 (k-ft/ft)	-194.12
M stg19 (k-ft/ft)	-146.32
M stg20 (k-ft/ft)	-199.6

Max. Shear vs Stage

	Base Model
V stg0 (k/ft)	DS: 0
V stg1 (k/ft)	0.59
V stg2 (k/ft)	0.59
V stg3 (k/ft)	3.3
V stg4 (k/ft)	3.32
V stg5 (k/ft)	6.85
V stg6 (k/ft)	6.89
V stg7 (k/ft)	6.92
V stg8 (k/ft)	6.96
V stg9 (k/ft)	1.26
V stg10 (k/ft)	1.72
V stg11 (k/ft)	2.55
V stg12 (k/ft)	3.98
V stg13 (k/ft)	3.98
V stg14 (k/ft)	26.91
V stg15 (k/ft)	24.86
V stg16 (k/ft)	28.14
V stg17 (k/ft)	27.58
V stg18 (k/ft)	36.87
V stg19 (k/ft)	-27.16
V stg20 (k/ft)	-34.8

Max. Support F vs Stage

	Base Model
Rmax Stage 0 (k/ft)	DS: 0
Rmax Stage 1 (k/ft)	
Rmax Stage 2 (k/ft)	0
Rmax Stage 3 (k/ft)	1.998
Rmax Stage 4 (k/ft)	3.419
Rmax Stage 5 (k/ft)	3.814
Rmax Stage 6 (k/ft)	3.513
Rmax Stage 7 (k/ft)	4.674
Rmax Stage 8 (k/ft)	4.513
Rmax Stage 9 (k/ft)	3.968
Rmax Stage 10 (k/ft)	4.175
Rmax Stage 11 (k/ft)	4.706
Rmax Stage 12 (k/ft)	7.249
Rmax Stage 13 (k/ft)	7.249
Rmax Stage 14 (k/ft)	50.649
Rmax Stage 15 (k/ft)	46.349
Rmax Stage 16 (k/ft)	53.127
Rmax Stage 17 (k/ft)	51.725
Rmax Stage 18 (k/ft)	71.158
Rmax Stage 19 (k/ft)	54.098
Rmax Stage 20 (k/ft)	68.732

STRUCTURAL MATERIALS DATA

Steel

Name	Strength Fy (ksi)	Fu (ksi)	Elastic E (ksi)	Density g (kcf)
A36	36	58	29000	0.49
A50	50	72.5	29000	0.49

Concrete

Name	Strength Fc' (ksi)	Elastic E (ksi)	Density g (kcf)	Tension Strength Ft (% of Fc')
Fc 3ksi	3	3122	0.15	10
Fc 4ksi	4	3605	0.15	10
Fc 5ksi	5	4031	0.15	10
Fc 6ksi	6	4415	0.15	10

Steel rebar

Name	Strength Fy (ksi)	Elastic E (ksi)
Grade 60	60	29000
Grade 75	75	29000
Grade 80	80	29000
Grade 150	150	29000
Strands 270 ksi	270	29000
S410	59.4	30434.8
S500	72.5	30434.8
B450C	65.2	30434.8

Wood

Name	Ultimate Bending Strength Fbu (ksi)	Ultimate Tensile Strength Ftu (ksi)	Ultimate Shear Strength Fvu (ksi)	Density g (kcf)	Elastic E (ksi)

Construction Timb	1.6	1.4	0.8	0.05	1000
Regular grade	1	1	0.6	0.05	800

STEEL

Name=material name

$f_y=f_{yk}$ = characteristic resistance for steel (for all the codes)

$F_u=f_{uk}$ = ultimate resistance for steel (for all the codes)

Elastic E= Elastic modulus

Density g= specific weight

CONCRETE

Name=material name

$f'_c=f_{ck}$ = cylindrical resistance for concrete (for all the codes)

Elastic E= Elastic modulus

Density g= specific weight

Tension strength= $f_t=f_{ctk}$ = characteristic tension resistance for concrete

STEEL REBARS

Name=material name

$f_y=f_{yk}$ = characteristic resistance for steel (for all the codes)

$F_u=f_{uk}$ = ultimate resistance for steel (for all the codes)

Elastic E= Elastic modulus

Density g= specific weight

WOOD

Name=material name

$F_b=f_{bk}$ = Ultimate bending strength

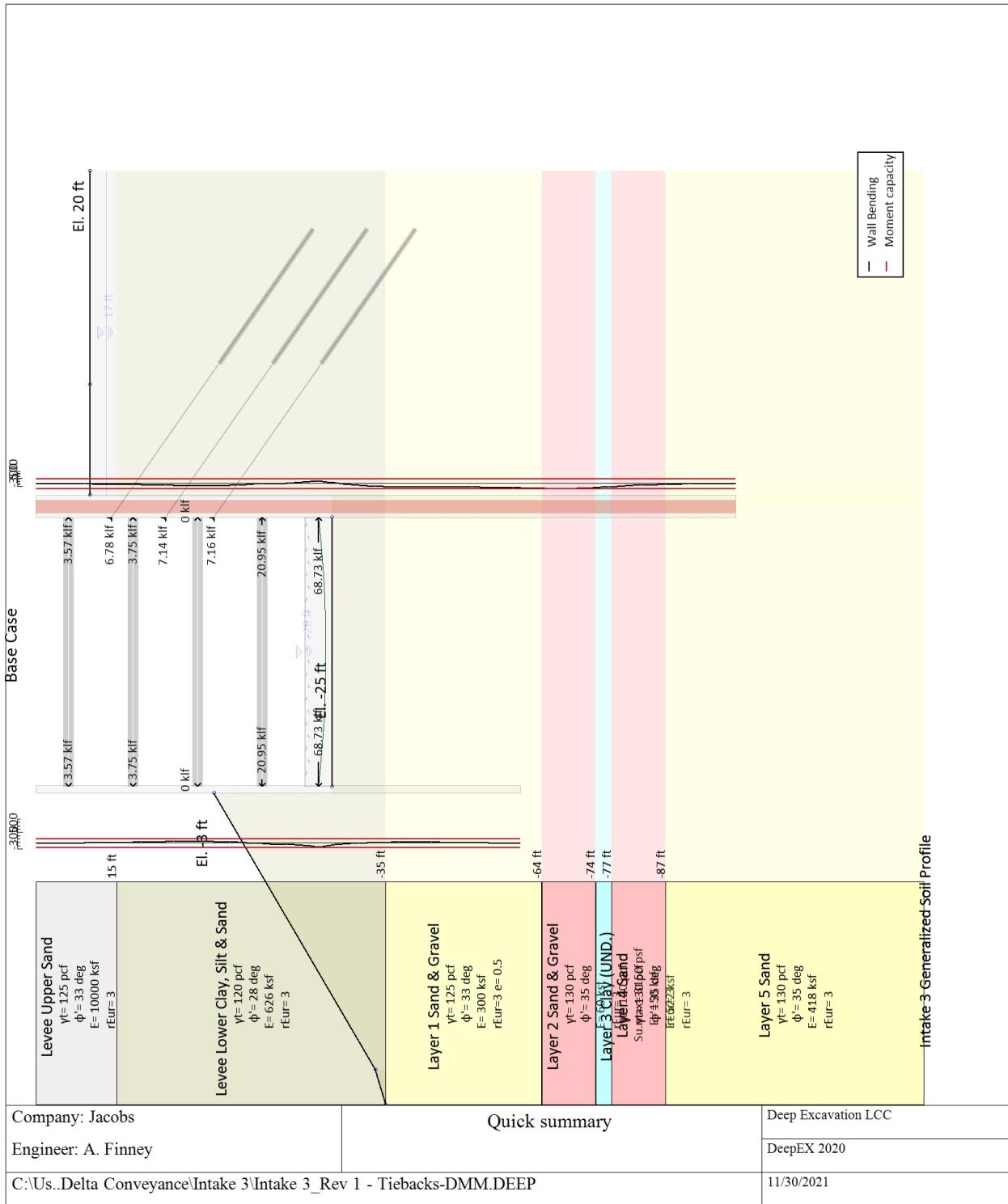
$F_t=f_{tk}$ = Ultimate tensile strength

$F_v=f_{vk}$ = Ultimate shear strength

Density g= specific weight

Elastic E= Elastic modulus

Project: Delta Conveyance - Intake 3
Results for Design Section 0: Base Case



Summary of Wall Moments and Toe Requirements

Top Wall (ft)	Wall Section	L-Wall (ft)	H-Exc. (ft)	Max+M/Cap (k-ft/ft)	Max-M/Cap (k-ft/ft)	FS Toe Pas. mob.	FS Toe Rotation	FS Toe Embedment	FS 1 Toe EL. (ft)	Slope Stab. FS
30	AZ48	90	22	110.59/222.5	199.6/222.5	2.29	N/A	N/A	-25	N/A
-	-	-	-	-	-	-	-	-	-	-
30	DMM Wall	130	45	128.96/254.27	236.92/254.27	2.29	N/A	N/A	-29.36	-

Summary of Basal Stability and Predicted Wall Movements According to Clough 1989 Method Wall: A

1. FSmin	2. DxMax (in)	2. Stiffness	2. FSbasal	3. Dx/H (%)	3. Stiffness	3. FSbasal
@ stage 20	@ stage 14	@ DxMax	@ DxMax	@ stage 14	@ Dx/H max	@ Dx/H max
1.428	1.906	2	1.737	0.722	1.996	1.737

Summary of Basal Stability and Predicted Wall Movements According to Clough 1989 Method Wall: D

1. FSmin	2. DxMax (in)	2. Stiffness	2. FSbasal	3. Dx/H (%)	3. Stiffness	3. FSbasal
@ stage 7	@ stage 14	@ DxMax	@ DxMax	@ stage 14	@ Dx/H max	@ Dx/H max
1.82	0.506	44.9	2.187	0.094	44.913	2.187

Basic information for supports

Support Number	Type	Elev. Z (ft)	X (ft)	Supports Wall #	Angle (deg.)	Space H (ft)	Free L (ft)	Fixed L (ft)
0	Slab	-22.5	21.65	Walls 0-1	-180	5	60.35	0
1	Strut	24	21.65	Walls 0-1	-180	20	60.35	0
2	Tieback	16	82	DMM Wall	150	11.7	40	35
3	Tieback	6	82	DMM Wall	150	11.7	40	35
4	Strut	12	21.65	Walls 0-1	-180	20	60.35	0
5	Strut	-12	21.65	Walls 0-1	-180	20	60.35	0
6	Tieback	-3	82	DMM Wall	150	11.7	40	35
7	Strut	0	21.65	Walls 0-1	-180	20	60.35	0

Notes: Space H= Horizontal support spacing

Fixed L= Fixed support length (tiebacks)

Free L = Free support length

Critical support reactions and stress checks

Support Number	R.Max (k)	R.Min (k)	R.Max (k/ft)	R.Min (k/ft)	STR
0	355.79	0	71.16	0	0.44
1	76.29	0	3.81	0	0.15
2	84.88	0	7.26	0	0.75
3	86.17	0	7.37	0	0.76
4	257.68	0	12.88	0	0.48
5	500	0	25	0	0.86
6	83.76	0	7.16	0	0.96
7	237.24	0	11.86	0	0.45

Notes: R.max = Maximum support reaction.

R.min = Minimum support reaction.

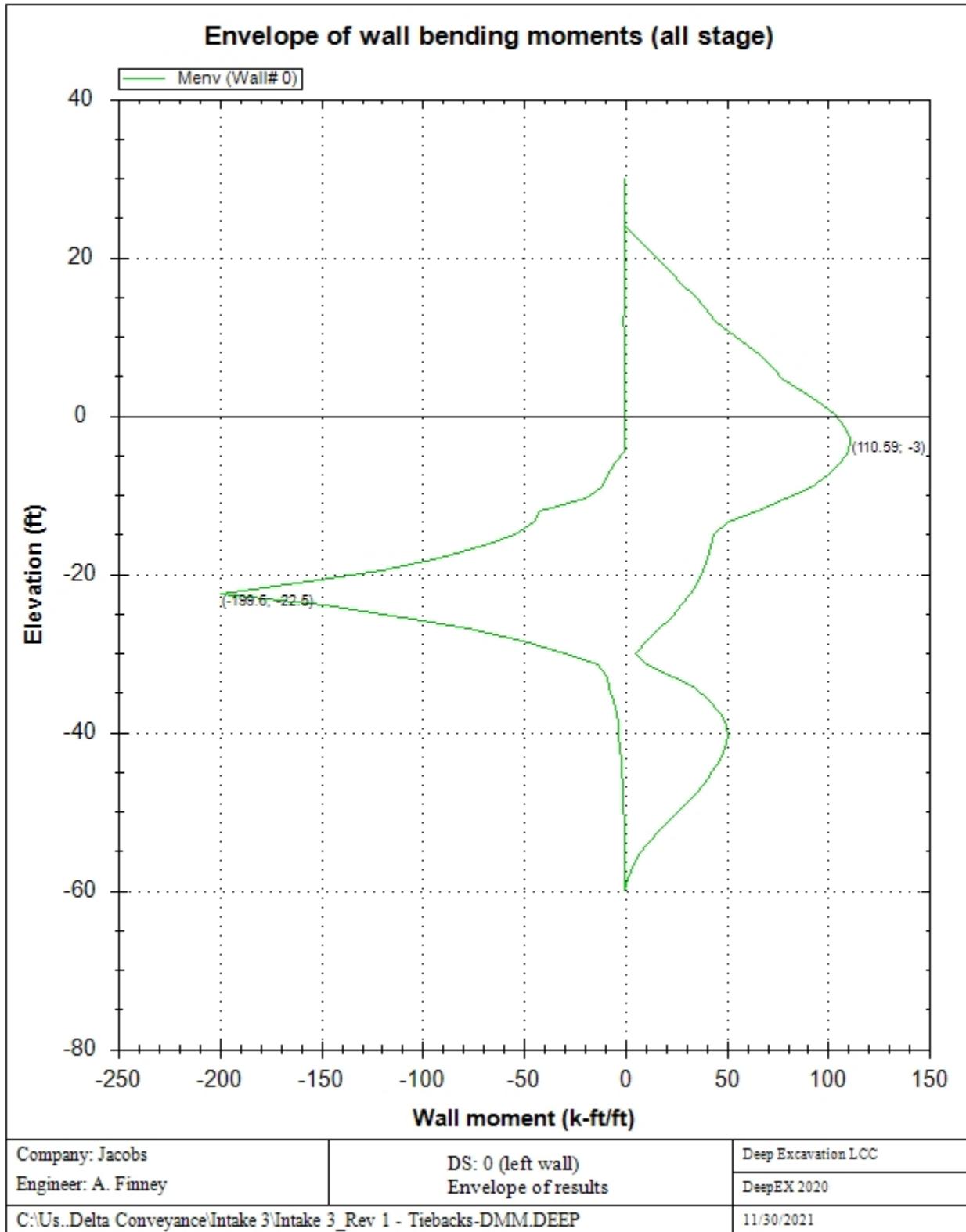
STR = Critical support capacity stress check = Load/Design capacity

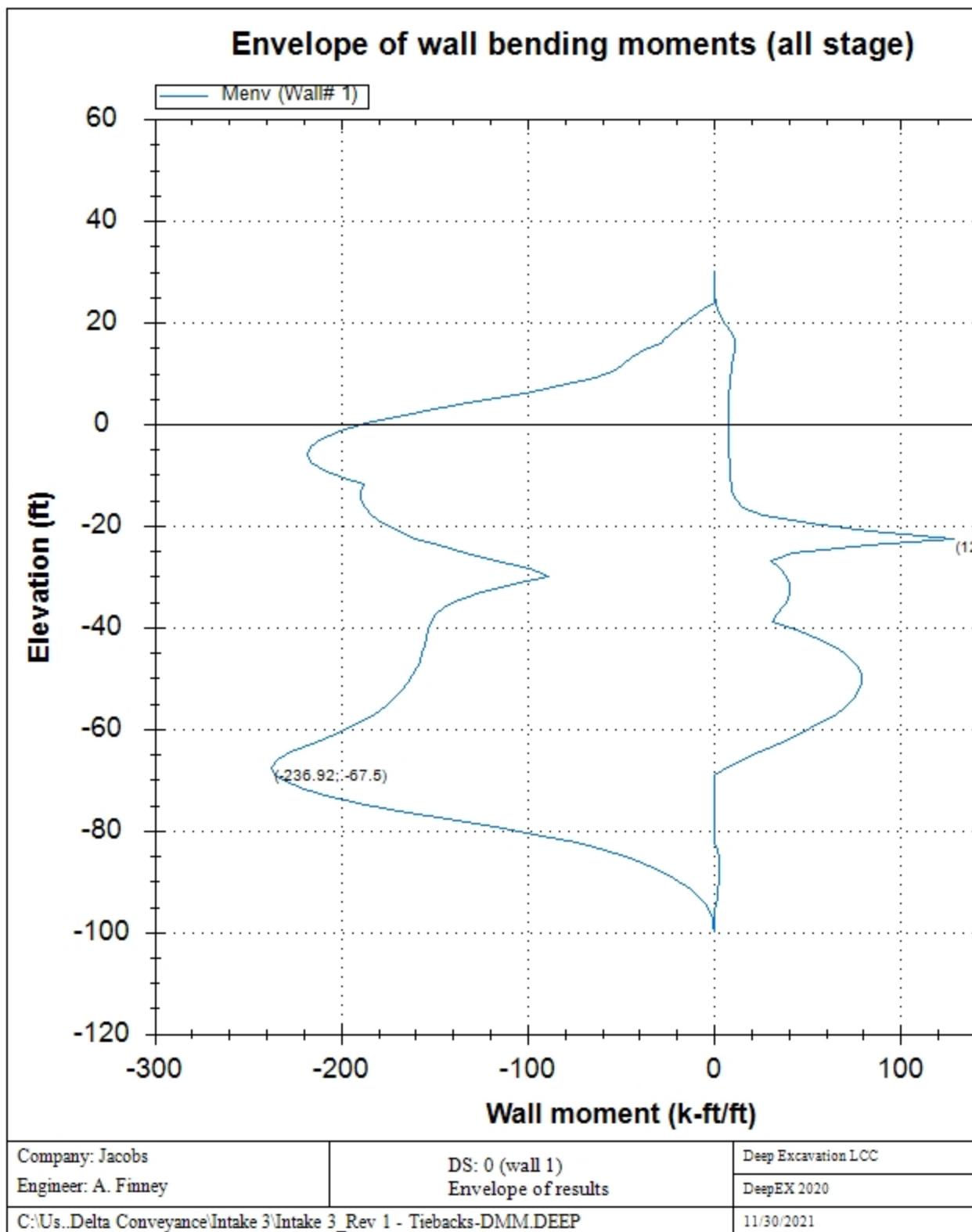
General assumptions for last stage: Stage 19

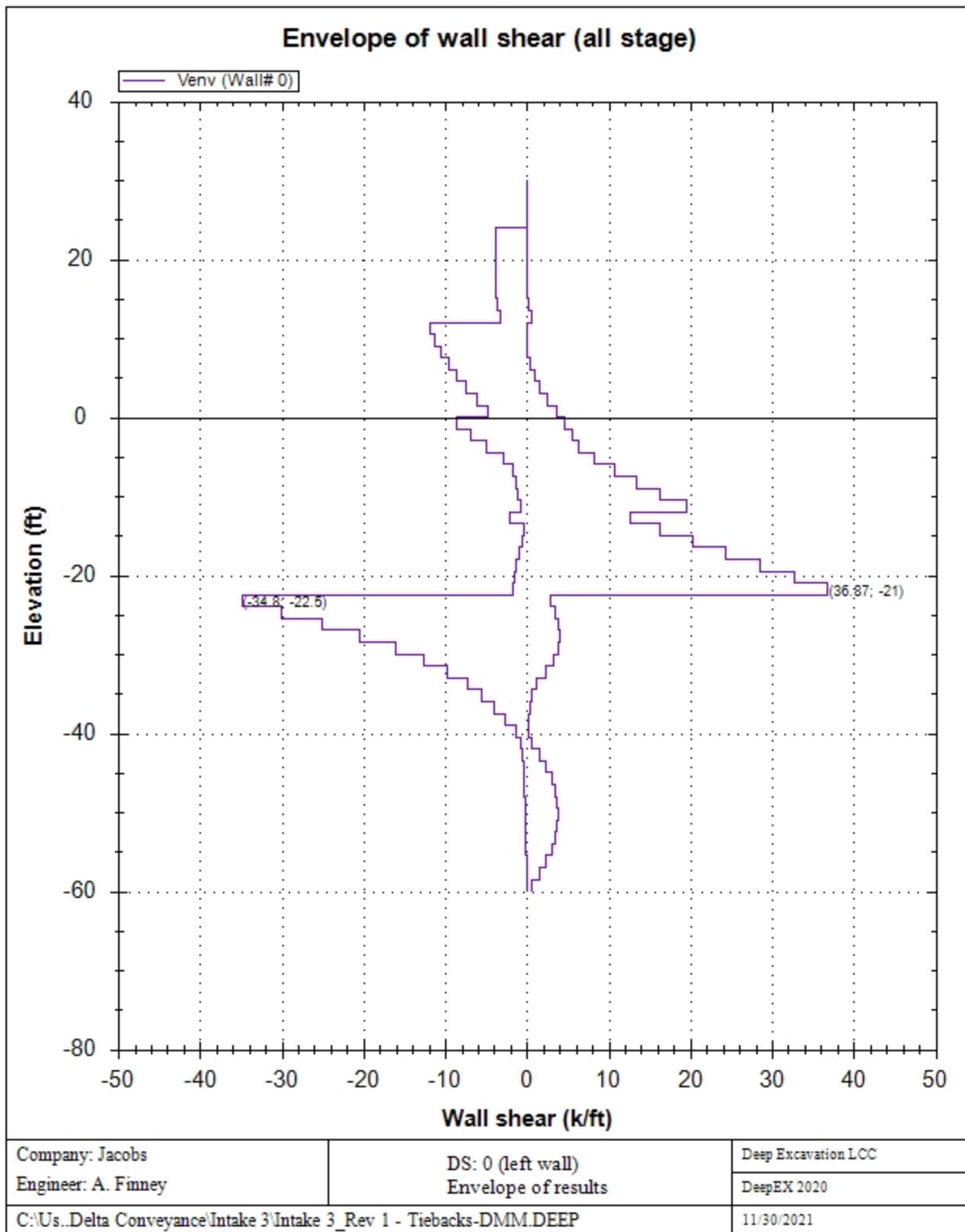
Concrete Code:	
Steel Code:	
Non linear	
Drain State Clays	
Water $\gamma = 62.4 \text{ pcf}$	
Adv. NL surcharge method	
Drive K_a	
Resist K_p	Rankine (Coul. $d=0$)

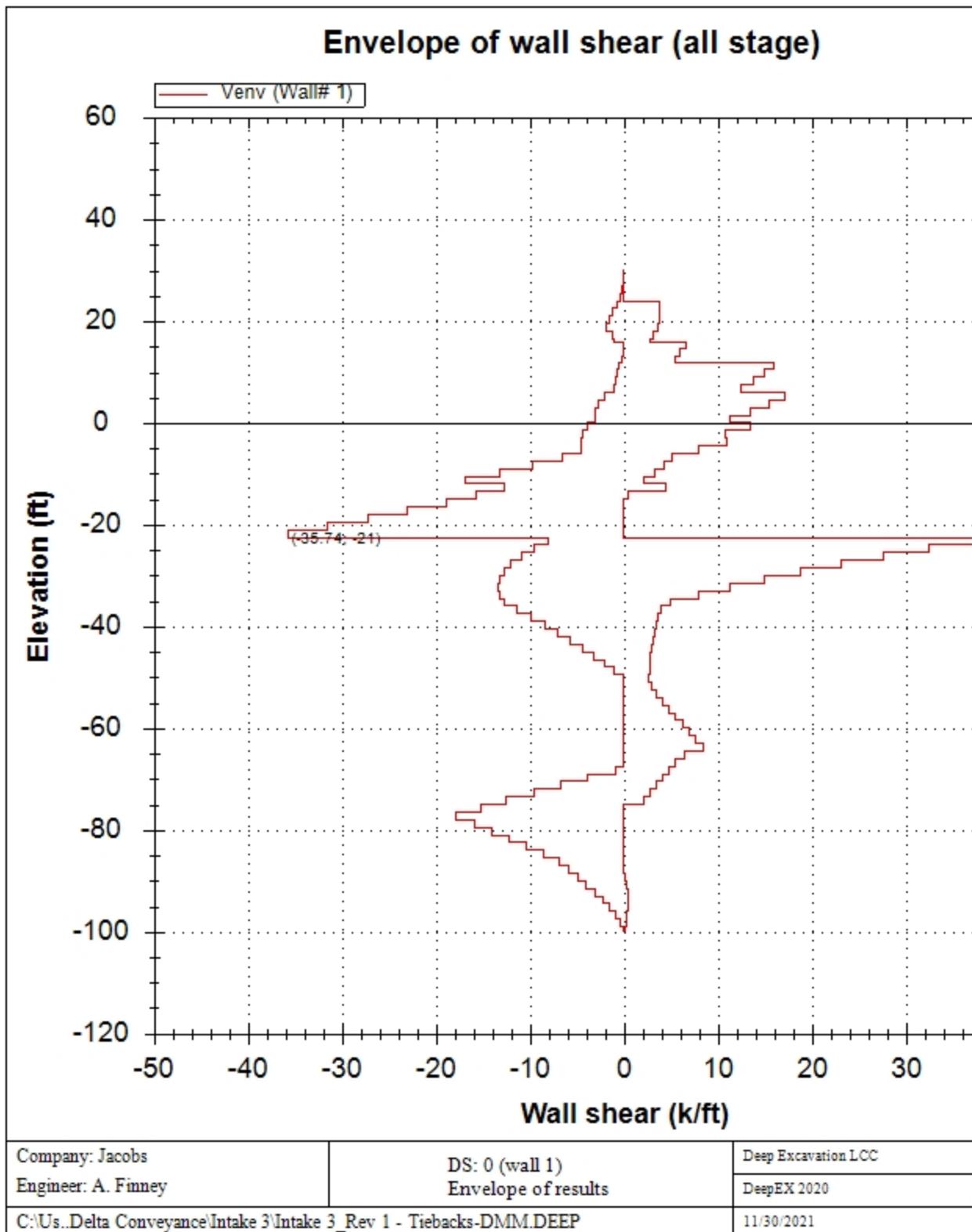
Envelope of results

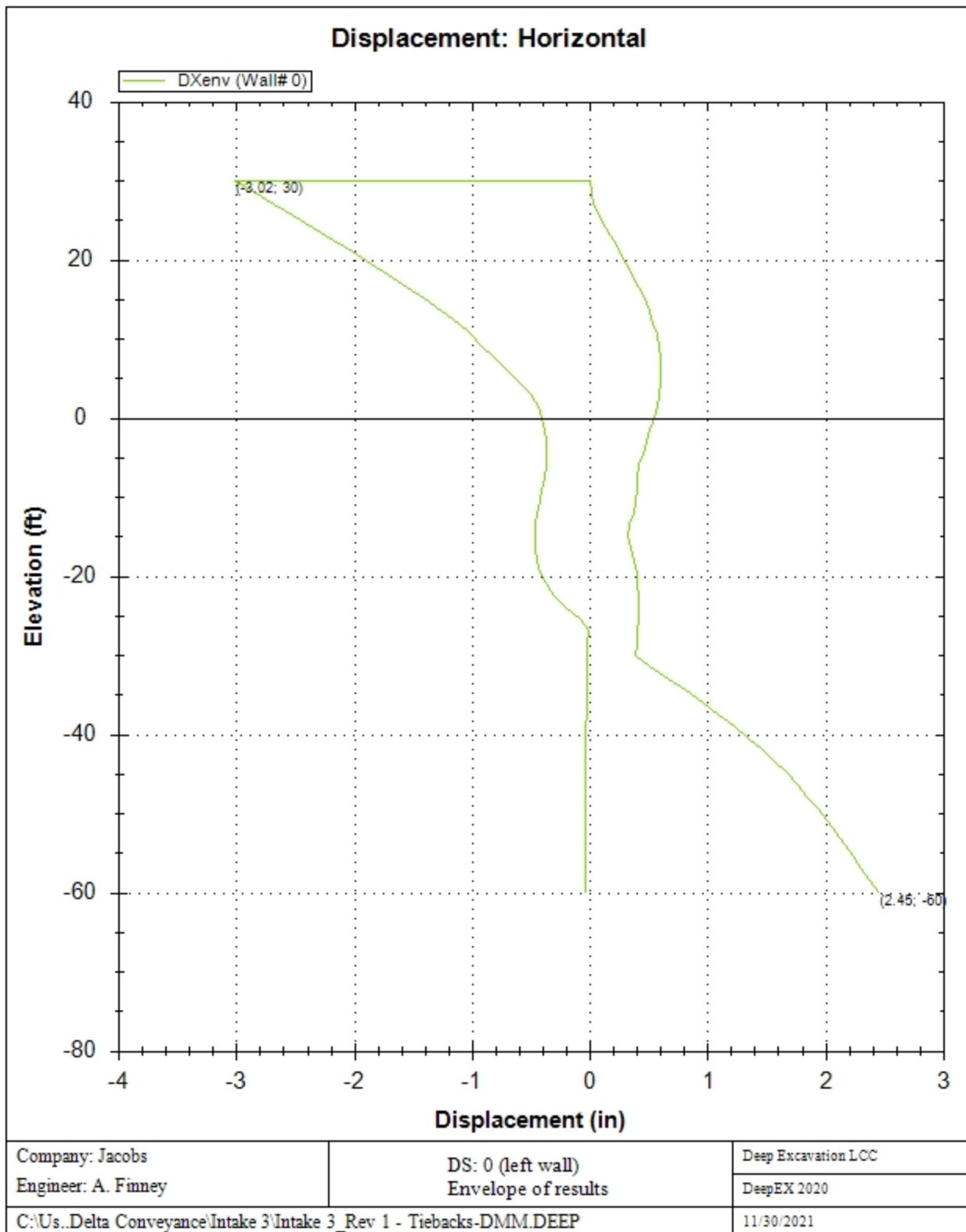
A sequence of result diagrams for each excavation stage is reported

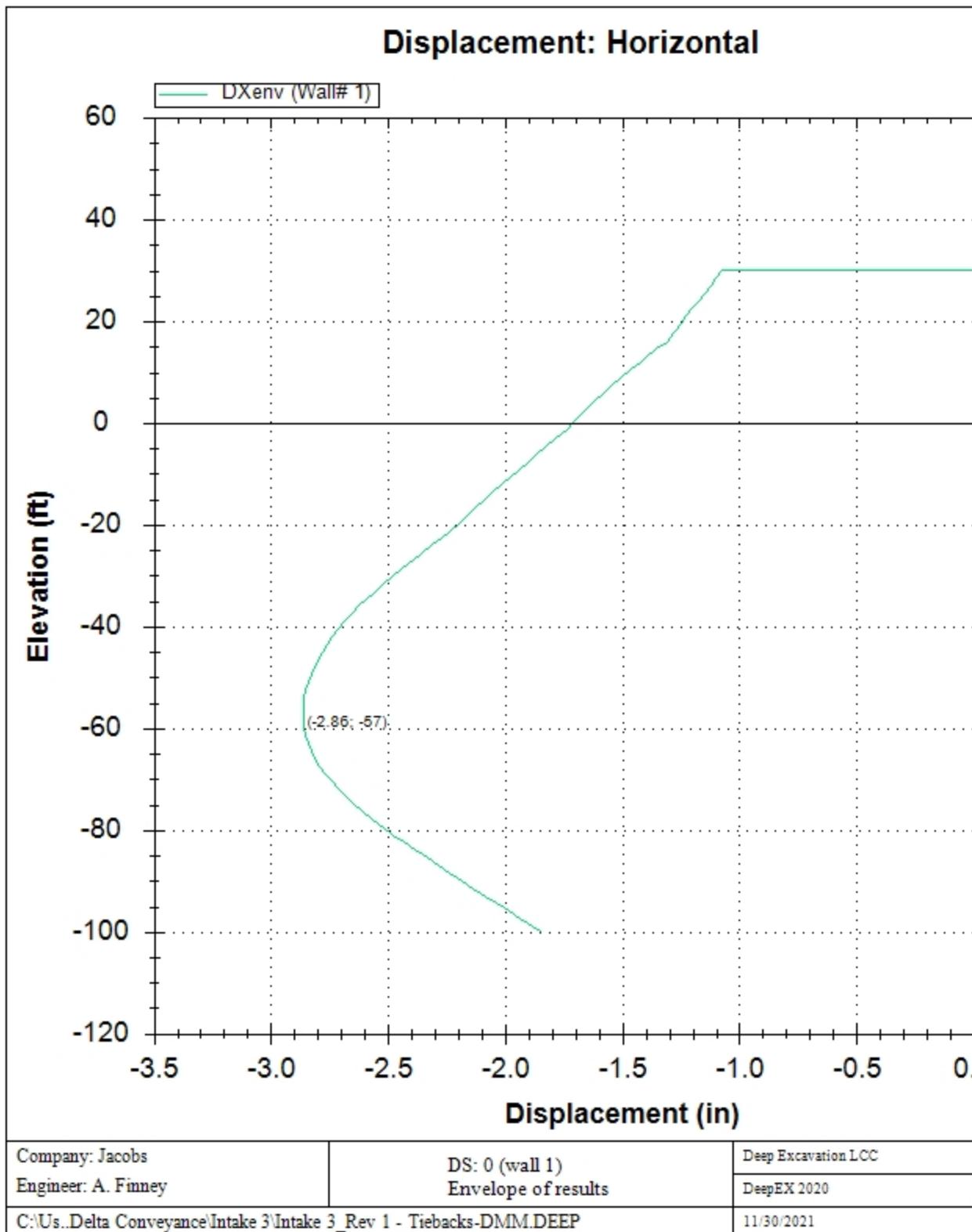












DESIGN APPROACHES AND COMBINATION FACTORS

The Design Approaches (from Codes or Customized by the user) and related safety factors are the following:

F_{tan} fr=mult factor for friction angle

F C'= safety factor on effective cohesion (Eurocode 7 methods)

F Su'= safety factor for undrained shear strength (Eurocode 7 methods)

F EQ= Load factor for seismic loads

F perm load= Load factor for permanent loads (dead load, etc)

F temp load= Load factor on live loads and other temporary loads

F perm supp= Reduction factor for resistance for pull out checking of permanent tiebacks

F temp supp= Reduction factor for resistance for pull out checking of temporary tiebacks

F earth Dstab= Load factor for driving earth pressures, unfavorable (on retained side)

F earth stab= Safety factor for passive pressures, favorable (on excavation side)

F GWT Dstab (ground water)= Load factor for driving water pressures, unfavorable

F GWT stab (ground water)= Load factor for resisting water pressure, favorable

F HYD Dstab= Load factor for hydraulic heave, unfavorable (hydraulic checking)

F HYD stab= Resistance factor for hydraulic heave, favorable (hydraulic checking)

F UPL Dstab= Load factor for uplift check, unfavorable

F UPL stab= Resistance factor for uplift check, favorable

Stage	Design Code	Design Case	F(tan fr)	F (c')	F (Su)	F (EQ)	F(perm load)	F(temp load)	F(perm sup)	F(temp sup)	F Earth (Dstab)	F Earth (stab)	F GWT (Dstab)	F GWT (stab)	F HYD (Dstab)	F HYD (stab)	F UPL (Dstab)	F UPL (stab)
		Name																
0	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

SOIL DATA

Name	g tot (pcf)	g dry (pcf)	Frict (deg)	C' (psf)	Su (psf)	FRp (deg)	FRcv (deg)	Eload (ksf)	rEur (-)	kAp NL	kPp NL	kAcv NL	kPcv NL	Vary	Spring	Color	Model
Levee Upper	125	120	33	0	N/A	N/A	N/A	10000	3	0.3	3.39	N/A	N/A	True	Linear		
Levee Lower	120	115	28	0	N/A	N/A	N/A	626.3	3	0.36	2.77	N/A	N/A	True	Linear		
Layer 1 Sand	125	120	33	0	N/A	N/A	N/A	300	3	0.3	3.39	N/A	N/A	True	EXP		
Layer 2 Sand	130	120	35	0	N/A	N/A	N/A	60	3	0.27	3.69	N/A	N/A	True	Linear		
Layer 3 Clay	120	100	24	200	3150	16.53	24	150	3	0.56	1.8	0.42	2.37	True	Linear		
Layer 4 Sand	130	120	35	0	N/A	N/A	N/A	521.92	3	0.27	3.69	N/A	N/A	True	Linear		
Layer 5 Sand	130	120	35	0	N/A	N/A	N/A	417.54	3	0.27	3.69	N/A	N/A	True	Linear		

Name	Poisson v	Min Ka (clays)	Min sh (clays)	ko.NC	nOCR	aH.EXP (0 to 1)	aV.EXP (0 to 1)	qSkin (psi)	qNails (psi)	kS.nails (k/ft ³)	PL (ksi)
Levee Upper	0.35	-	-	0.455	0.5	-	-	101.5	67.7	200	-
Levee Lower	0.35	-	-	0.531	0.5	-	-	29	19.3	70	-
Layer 1 Sand	0.35	-	-	0.455	0.5	1	0	7.2	4.8	20	-
Layer 2 Sand	0.3	-	-	0.426	0.5	-	-	5.1	3.4	20	-
Layer 3 Clay	0.25	0.2	0.104	0.593	0.5	-	-	13	8.7	20	-
Layer 4 Sand	0.3	-	-	0.426	0.5	-	-	21.8	14.5	30	-
Layer 5 Sand	0.3	-	-	0.426	0.5	-	-	18.1	12.1	30	-

gtot = total soil specific weight

gdry = dry weight of the soil

Frict = friction angle

C' = effective cohesion

Su = Undrained shear strength (only for CLAY soils in undrained conditions, used as a cutoff strength in NL analysis)

Evc = Virgin compression elastic modulus

Eur = unloading/reloading elastic modulus

Kap = Peak active thrust coefficient (initial value, may be modified on each stage according to analysis settings).

Kpp = Peak passive thrust coefficient (initial value, may be modified on each stage according to analysis settings).

Kacv = Constant volume active thrust coeff (only for clays, initial value)

Kpcv = Constant volume passive thrust coeff (only for clays, initial value).

Spring models= spring model (LIN= constant E over the soil layer height , EXP=exponential , SIMC=simplified Winkler)

LIN= Linear-Elastic-Perfectly Plastic,

EXP: Exponential, SUB: Modulus of Subgrade Reaction

SIMC= Simplified Clay mode

SOIL BORINGS

Top Elev= superior Soil level

Soil type= type of the soil (sand , clay , etc)

OCR= overconsolidation ratio

Ko= at rest coefficient

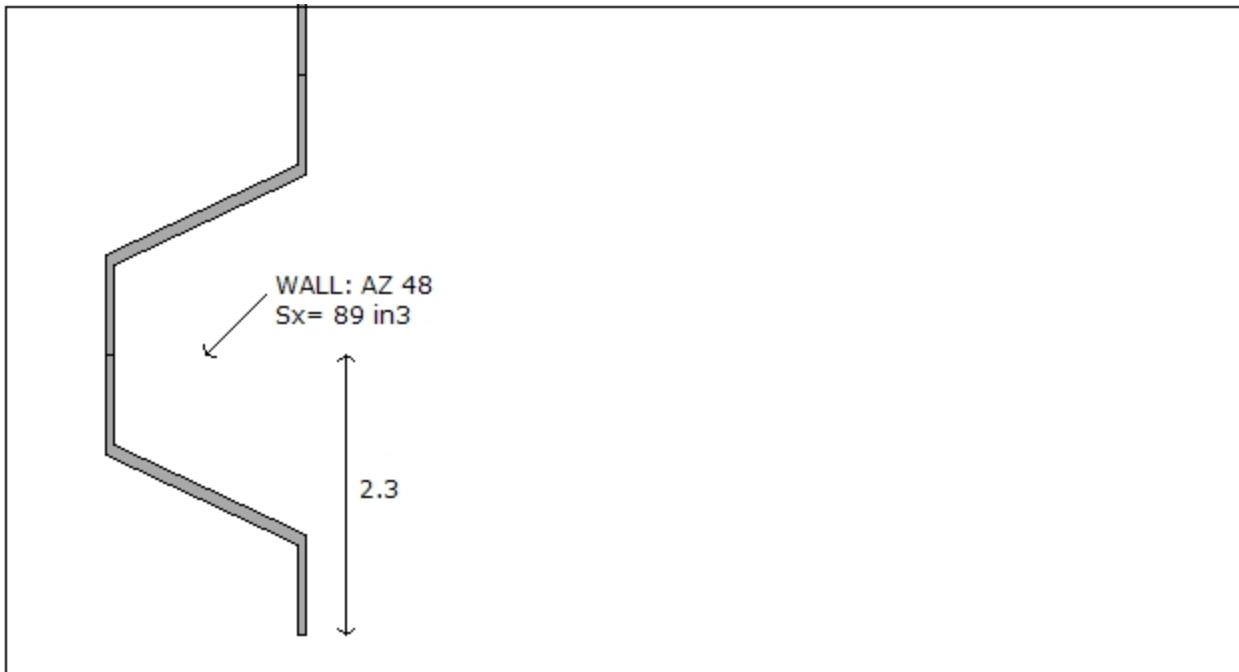
Name: Intake 3 Generalized Soil Profile,

pos: (0, 0)

Top elev.	Soil type	OCR	Ko
30	Levee Upper S	1	0.46
15	Levee Lower C	1	0.53
-35	Layer 1 Sand	1	0.46
-64	Layer 2 Sand	1	0.43
-74	Layer 3 Clay	1	0.59
-77	Layer 4 Sand	1	0.43

WALL DATA

Wall section 0: AZ48



Company: Jacobs	Wall sketch	Deep Excavation LCC
Engineer: A. Finney		DeepEX 2020
C:\Us\Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021

Wall type: Steel sheet piling

Top wall El: 30 ft Bottom wall El: -60 ft

Hor. wall spacing: 1 ft Wall thickness = 1.65 ft

Passive width below exc: 1 ft Active width below exc: 1 ft $S_{water} = 1 \text{ ft}$

Steel members $f_y = 50 \text{ ksi}$ $E_{steel} = 29000 \text{ ksi}$

Wall friction: Percentage of Soil Friction = 0%

Steel wall capacities are calculated with ANSI/AISC 360-10

Concrete capacities are calculated with ACI 318-11

Note: With ultimate capacities you may have to use a structural safety factor.

Steel sheet pile properties

Table: Steel Sheet Pile Cross Sectional Properties

DES	Shape	W	A	h	t	b	s	I_{xx}	S_{xx}
AZ 48	Z	19	13.6	19.8	0.866	27.56	0.591	876	89

Wall section 1: DMM Wall

Company: Jacobs Engineer: A. Finney	
Wall sketch	Deep Excavation LCC
	DeepEX 2020
C:\Us\Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP	11/30/2021

Wall type: Soldier pile and tremied concrete (SPTC) wall

Top wall El: 30 ft Bottom wall El: -100 ft

Hor. wall spacing: 11.7 ft Wall thickness = 5 ft

Passive width below exc: 11.7 ft Active width below exc: 11.7 ft Swater= 11.7 ft

Steel members fy = 50 ksi Esteel = 29000 ksi

Wall friction: Percentage of Soil Friction = 0%

Steel wall capacities are calculated with ANSI/AISC 360-10

Concrete capacities are calculated with ACI 318-11

Note: With ultimate capacities you may have to use a structural safety factor.

Soldier pile and tremied concrete wall, soldier pile data

Table: Soldier Pile Properties

Name	Sectio	W	A	D	tw or t	bf	tf	k	Ixx	Sxx	rX	Iyy	Syy	rY	rT	Cw	fy
	(plf)	(in ²)	(in)	(in)	(in)	(in)	(in)	(in)	(in ⁴)	(in ³)	(in)	(in ⁴)	(in ³)	(in)	(in ⁶)	(ksi)	
W36x282	W36x2	282	82.9	37.1	0.885	16.6	1.57	2.52	19600	1050	15.4	1200	144	3.8	37800	50	

GENERAL WALL DATA

Hor wall spacing= Wall horizontal spacing

Passive width below exc= spacing for passive thrust pressure for classic analysis

f'c=fck= cylindrical concrete resistance

fyk=fy= steel rebar characteristic resistance

Econc= Concrete Elastic modulus

fctk= characteristic Concrete tension

Esteel= steel elastic modulus

TABULAR DATA (principal parameters)

1) Diaphragm wall (rectangular cross section)

N/A= data not available

Fy=fyk

F'c=fck

D=wall thickness

B=wall width

2)Steel sheet pile

DES=shape (Z or U)

W=width per unit of length

A=area

h=height

t=horizontal part thickness

b=width of the single sheet pile part

s=inclined part thickness

Ixx=strong axis inertia (per unit of length)

Sxx=strong axis section modulus (per unit of length)

3)Secant piles wall, Tangent piles wall, soldier piles, soldier piles and timber lagging

W=weight per unit of length

A=area

D=diameter

tw=web thickness

tp= pipe thickness

bf=flange width

tf= flange thickness

k= flange thickness+stem base height

Ixx= strong axis inertia modulus (per unit of length)

Sxx= strong axis section modulus (per unit of length)

rx=radius of gyration about X axis

ry=radius of gyration about Y axis

Iyy=weak axis inertia modulus (per unit of length)

Syy=weak axis section modulus (per unit of length)

rT=radius of gyration for torsion

Cw= warping constant

SUPPORTS PROPERTIES

Support 0: type = slab

X = 21.65 ft, Z = -22.5 ft, S = 5 ft

L = 60.35 ft

Uses concrete slab section: Tremie Slab H~5ft

Angle from horizontal plane α = -180 deg

Walls: AZ48-DMM Wall, Moment connect at walls (NL analysis only: 0% pin, 100% fixed)= 0

Stage No	Active	Prestress	Slab live load	User add. strain	Is base slab
	Yes/No	(k)	(ksf)	+expansion	Yes/No
0	No	-	0	0	No
1	No	-	0	0	No
2	No	-	0	0	No
3	No	-	0	0	No
4	No	-	0	0	No
5	No	-	0	0	No
6	No	-	0	0	No
7	No	-	0	0	No
8	No	-	0	0	No
9	No	-	0	0	No
10	No	-	0	0	No
11	No	-	0	0	No
12	No	-	0	0	No
13	Yes	-	0	0	No
14	Yes	-	0	0	No
15	Yes	-	0	0	No
16	Yes	-	0	0	No
17	Yes	-	0	0	No
18	Yes	-	0	0	No
19	Yes	-	0	0	No
20	Yes	-	0	0	No

Support 1: type = strut

X = 21.65 ft, Z = 24 ft, S = 20 ft

L = 60.35 ft

Uses steel strut section: PP24x0.500

Angle from horizontal plane α = -180 deg

Walls: AZ48-DMM Wall

Stage No	Active	Prestress	Slab live load	User add. strain	Is base slab
	Yes/No	(k)	(ksf)	+expansion	Yes/No
0	No	-	-	0	-
1	No	-	-	0	-
2	Yes	-	-	0	-
3	Yes	-	-	0	-
4	Yes	-	-	0	-
5	Yes	-	-	0	-
6	Yes	-	-	0	-
7	Yes	-	-	0	-
8	Yes	-	-	0	-
9	Yes	-	-	0	-
10	Yes	-	-	0	-
11	Yes	-	-	0	-
12	Yes	-	-	0	-
13	Yes	-	-	0	-
14	Yes	-	-	0	-
15	Yes	-	-	0	-
16	Yes	-	-	0	-
17	Yes	-	-	0	-
18	Yes	-	-	0	-
19	Yes	-	-	0	-
20	Yes	-	-	0	-

Support 2: type = tieback

X = 82 ft, Z = 16 ft, S = 11.7 ft

Lfree = 40 ft, Lfix = 35 ft, Rfix = 50 %

Uses tieback section: 6-Strands

Angle from horizontal plane α = 150 deg

Walls: DMM Wall

Stage No	Active	Prestress	Slab live load	User add. strain	Is base slab
	Yes/No	(k)	(ksf)	+expansion	Yes/No
0	No	-	-	-	-
1	No	-	-	-	-
2	No	-	-	-	-
3	No	-	-	-	-
4	Yes	40	-	-	-
5	Yes	-	-	-	-
6	Yes	-	-	-	-
7	Yes	-	-	-	-
8	Yes	-	-	-	-
9	Yes	-	-	-	-
10	Yes	-	-	-	-
11	Yes	-	-	-	-
12	Yes	-	-	-	-
13	Yes	-	-	-	-
14	Yes	-	-	-	-
15	Yes	-	-	-	-
16	Yes	-	-	-	-
17	Yes	-	-	-	-
18	Yes	-	-	-	-
19	Yes	-	-	-	-
20	Yes	-	-	-	-

Support 3: type = tieback

X = 82 ft, Z = 6 ft, S = 11.7 ft

Lfree = 40 ft, Lfix = 35 ft, Rfix = 50 %

Uses tieback section: 6-Strands

Angle from horizontal plane α = 150 deg

Walls: DMM Wall

Stage No	Active	Prestress	Slab live load	User add. strain	Is base slab
	Yes/No	(k)	(ksf)	+expansion	Yes/No
0	No	-	-	-	-
1	No	-	-	-	-
2	No	-	-	-	-
3	No	-	-	-	-
4	No	-	-	-	-
5	No	-	-	-	-
6	No	-	-	-	-
7	No	-	-	-	-
8	Yes	40	-	-	-
9	Yes	-	-	-	-
10	Yes	-	-	-	-
11	Yes	-	-	-	-
12	Yes	-	-	-	-
13	Yes	-	-	-	-
14	Yes	-	-	-	-
15	Yes	-	-	-	-
16	Yes	-	-	-	-
17	Yes	-	-	-	-
18	Yes	-	-	-	-
19	Yes	-	-	-	-
20	Yes	-	-	-	-

Support 4: type = strut

X = 21.65 ft, Z = 12 ft, S = 20 ft

L = 60.35 ft

Uses steel strut section: PP24x0.500

Angle from horizontal plane α = -180 deg

Walls: AZ48-DMM Wall

Stage No	Active	Prestress	Slab live load	User add. strain	Is base slab
	Yes/No	(k)	(ksf)	+expansion	Yes/No
0	No	-	-	0	-
1	No	-	-	0	-
2	No	-	-	0	-
3	No	-	-	0	-
4	No	-	-	0	-
5	No	-	-	0	-
6	Yes	-40	-	0	-
7	Yes	-	-	0	-
8	Yes	-	-	0	-
9	Yes	-	-	0	-
10	Yes	-	-	0	-
11	Yes	-	-	0	-
12	Yes	-	-	0	-
13	Yes	-	-	0	-
14	Yes	-	-	0	-
15	Yes	-	-	0	-
16	Yes	-	-	0	-
17	Yes	-	-	0	-
18	Yes	-	-	0	-
19	Yes	-	-	0	-
20	Yes	-	-	0	-

Support 5: type = strut

X = 21.65 ft, Z = -12 ft, S = 20 ft

L = 60.35 ft

Uses steel strut section: PP24x0.500

Angle from horizontal plane α = -180 deg

Walls: AZ48-DMM Wall

Stage No	Active	Prestress	Slab live load	User add. strain	Is base slab
	Yes/No	(k)	(ksf)	+expansion	Yes/No
0	No	-	-	0	-
1	No	-	-	0	-
2	No	-	-	0	-
3	No	-	-	0	-
4	No	-	-	0	-
5	No	-	-	0	-
6	No	-	-	0	-
7	No	-	-	0	-
8	No	-	-	0	-
9	No	-	-	0	-
10	No	-	-	0	-
11	No	-	-	0	-
12	No	-	-	0	-
13	No	-	-	0	-
14	No	-	-	0	-
15	No	-	-	0	-
16	No	-250	-	0	-
17	No	-250	-	0	-
18	No	-225	-	0	-
19	Yes	-500	-	0	-
20	Yes	-	-	0	-

Support 6: type = tieback

X = 82 ft, Z = -3 ft, S = 11.7 ft

Lfree = 40 ft, Lfix = 35 ft, Rfix = 50 %

Uses tieback section: 6-Strands

Angle from horizontal plane α = 150 deg

Walls: DMM Wall

Stage No	Active	Prestress	Slab live load	User add. strain	Is base slab
	Yes/No	(k)	(ksf)	+expansion	Yes/No
0	No	-	-	-	-
1	No	-	-	-	-
2	No	-	-	-	-
3	No	-	-	-	-
4	No	-	-	-	-
5	No	-	-	-	-
6	No	-	-	-	-
7	No	-	-	-	-
8	No	-	-	-	-
9	No	-	-	-	-
10	No	-	-	-	-
11	No	-	-	-	-
12	No	-	-	-	-
13	No	-	-	-	-
14	No	-	-	-	-
15	No	75	-	-	-
16	No	80	-	-	-
17	Yes	80	-	-	-
18	Yes	-	-	-	-
19	Yes	-	-	-	-
20	Yes	-	-	-	-

Support 7: type = strut

X = 21.65 ft, Z = 0 ft, S = 20 ft

L = 60.35 ft

Uses steel strut section: PP24x0.500

Angle from horizontal plane α = -180 deg

Walls: AZ48-DMM Wall

Stage No	Active	Prestress	Slab live load	User add. strain	Is base slab
	Yes/No	(k)	(ksf)	+expansion	Yes/No
0	No	-	-	0	-
1	No	-	-	0	-
2	No	-	-	0	-
3	No	-	-	0	-
4	No	-	-	0	-
5	No	-	-	0	-
6	No	-	-	0	-
7	No	-	-	0	-
8	No	-	-	0	-
9	No	-	-	0	-
10	No	-	-	0	-
11	No	-	-	0	-
12	No	-	-	0	-
13	No	-	-	0	-
14	No	-	-	0	-
15	Yes	-225	-	0	-
16	Yes	-	-	0	-
17	Yes	-	-	0	-
18	Yes	-	-	0	-
19	Yes	-	-	0	-
20	Yes	-	-	0	-

Support type

LEGEND for Supports

General data

Z=support level

S=horizontal distance between each support

Lfree= free length

Lfix= rigid body length for tiebacks

Rfix=% effective part of the rigid body length for tiebacks

Stage No= Excavation stage number

Active= Support status (YES=active)

Post stress= Preload force (on each support, + tension for tiebacks, - compression for struts)

GENERAL ANALYSIS CRITERIA

Summary of stage assumptions: Left Wall

Name	Analysis	Drive	ka-Mult	Htr T/B	Resist	Res	Contle
	Method	Press		(%)	Press	Mult	Method
Stage 0	Springs-Up	Ka	N/A	N/A	Kp	N/A	
Stage 1	Springs-Up	Ka	N/A	N/A	Kp	N/A	
Stage 2	Springs-Up	Ka	N/A	N/A	Kp	N/A	
Stage 3	Springs-Up	Ka	N/A	N/A	Kp	N/A	
Stage 4	Springs-Up	Ka	N/A	N/A	Kp	N/A	
Stage 5	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 6	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 7	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 8	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 9	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 10	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 11	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 12	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 13	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 14	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 15	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 16	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 17	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 18	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 19	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 20	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	

Name	Support	Axial	Used	Min Toe	Toe	Toe
	Model	Incl	FSwall	FDtoe	FSrot	FSpas
Stage 0		N/A	1.5	N/A	N/A	N/A
Stage 1		N/A	1.5	N/A	N/A	N/A
Stage 2		N/A	1.5	N/A	N/A	N/A
Stage 3		N/A	1.5	N/A	N/A	N/A
Stage 4		N/A	1.5	N/A	N/A	N/A
Stage 5		N/A	1.5	N/A	N/A	N/A
Stage 6		N/A	1.5	N/A	N/A	N/A
Stage 7		N/A	1.5	N/A	N/A	N/A
Stage 8		N/A	1.5	N/A	N/A	N/A
Stage 9		N/A	1.5	N/A	N/A	N/A
Stage 10		N/A	1.5	N/A	N/A	N/A
Stage 11		N/A	1.5	N/A	N/A	N/A
Stage 12		N/A	1.5	N/A	N/A	N/A
Stage 13		N/A	1.5	N/A	N/A	N/A
Stage 14		N/A	1.5	N/A	N/A	N/A
Stage 15		N/A	1.5	N/A	N/A	N/A
Stage 16		N/A	1.5	N/A	N/A	N/A
Stage 17		N/A	1.5	N/A	N/A	N/A
Stage 18		N/A	1.5	N/A	N/A	N/A
Stage 19		N/A	1.5	N/A	N/A	N/A
Stage 20		N/A	1.5	N/A	N/A	N/A

Name=excavation stage name

Analysis method

Springs = Elastoplastic spring analysis used

DR = Drained condition for CLAY model

U = Undrained condition for CLAY model for all the soils

Up = Undrained condition just for selected soil

Limit equilibrium analysis settings

Drive press:

Ka (Active pressure diagram), Ka-Trap = Trapezoid apparent diagram from active pressures x multiplier,

FHWA= Federal Highway Administration apparent pressure diagrams.

Ko = At-rest lateral earth pressures.

Peck = Peck 1969 Apparent earth pressure diagrams.

2 Step rect = Two step rectangular apparent earth pressure diagram.

User def. = User defined apparent earth pressure diagram.

Ka+d (and so on) indicates that wall friction is applied

ka mult = multiplication factor for Ka when Ka-Trap is selected

Htr T/B (%) = trapezoidal pressure scheme, top and bottom triangular percentage of excavation depth H

Resit press = Kp (passive earth pressures)

Res Mult = Safety factor applied directly on resisting pressures (

COntle Method = cantilever analysis method for limit equilibrium analysis.

Support Model: Method for calculating support reactions in limit-equilibrium analysis.

Beam= support reactions beam analysis (uses Blum's method).

Trib= support reactions from tributary height calculations (Can be applied with apparent diagrams).

Axial Incl = Axial loads included for structural design

Used FS wall = Safety factor for axial+bending wall resistance to divide ultimate wall capacities.

Min FD Toe= embedded minimum safety factor (for limit equilibrium analysis)

Toe FS rot= rotation safety factor (classic for limit equilibrium analysis)

Toe FSpas= driving/resisting pressure safety factor (for limit equilibrium analysis)

Summary of stage assumptions: 1

Name	Analysis	Drive	ka-Mult	Htr T/B	Resist	Res	Contle
	Method	Press		(%)	Press	Mult	Method
Stage 0	Springs-Up	Ka	N/A	N/A	Kp	N/A	
Stage 1	Springs-Up	Ka	N/A	N/A	Kp	N/A	
Stage 2	Springs-Up	Ka	N/A	N/A	Kp	N/A	
Stage 3	Springs-Up	Ka	N/A	N/A	Kp	N/A	
Stage 4	Springs-Up	Ka	N/A	N/A	Kp	N/A	
Stage 5	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 6	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 7	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 8	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 9	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 10	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 11	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 12	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 13	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 14	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 15	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 16	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 17	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 18	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
Stage 19	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	
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Name	Support	Axial	Used	Min Toe	Toe	Toe
	Model	Incl	FSwall	FDtoe	FSrot	FSpas
Stage 0		N/A	1.5	N/A	N/A	N/A
Stage 1		N/A	1.5	N/A	N/A	N/A
Stage 2		N/A	1.5	N/A	N/A	N/A
Stage 3		N/A	1.5	N/A	N/A	N/A
Stage 4		N/A	1.5	N/A	N/A	N/A
Stage 5		N/A	1.5	N/A	N/A	N/A
Stage 6		N/A	1.5	N/A	N/A	N/A
Stage 7		N/A	1.5	N/A	N/A	N/A
Stage 8		N/A	1.5	N/A	N/A	N/A
Stage 9		N/A	1.5	N/A	N/A	N/A
Stage 10		N/A	1.5	N/A	N/A	N/A
Stage 11		N/A	1.5	N/A	N/A	N/A
Stage 12		N/A	1.5	N/A	N/A	N/A
Stage 13		N/A	1.5	N/A	N/A	N/A
Stage 14		N/A	1.5	N/A	N/A	N/A
Stage 15		N/A	1.5	N/A	N/A	N/A
Stage 16		N/A	1.5	N/A	N/A	N/A
Stage 17		N/A	1.5	N/A	N/A	N/A
Stage 18		N/A	1.5	N/A	N/A	N/A
Stage 19		N/A	1.5	N/A	N/A	N/A
Stage 20		N/A	1.5	N/A	N/A	N/A

Name=excavation stage name

Analysis method

Springs = Elastoplastic spring analysis used

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2 Step rect = Two step rectangular apparent earth pressure diagram.

User def. = User defined apparent earth pressure diagram.

Ka+d (and so on) indicates that wall friction is applied

ka mult = multiplication factor for Ka when Ka-Trap is selected

Htr T/B (%) = trapezoidal pressure scheme, top and bottom triangular percentage of excavation depth H

Resit press = Kp (passive earth pressures)

Res Mult = Safety factor applied directly on resisting pressures (

COntle Method = cantilever analysis method for limit equilibrium analysis.

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Trib= support reactions from tributary height calculations (Can be applied with apparent diagrams).

Axial Incl = Axial loads included for structural design

Used FS wall = Safety factor for axial+bending wall resistance to divide ultimate wall capacities.

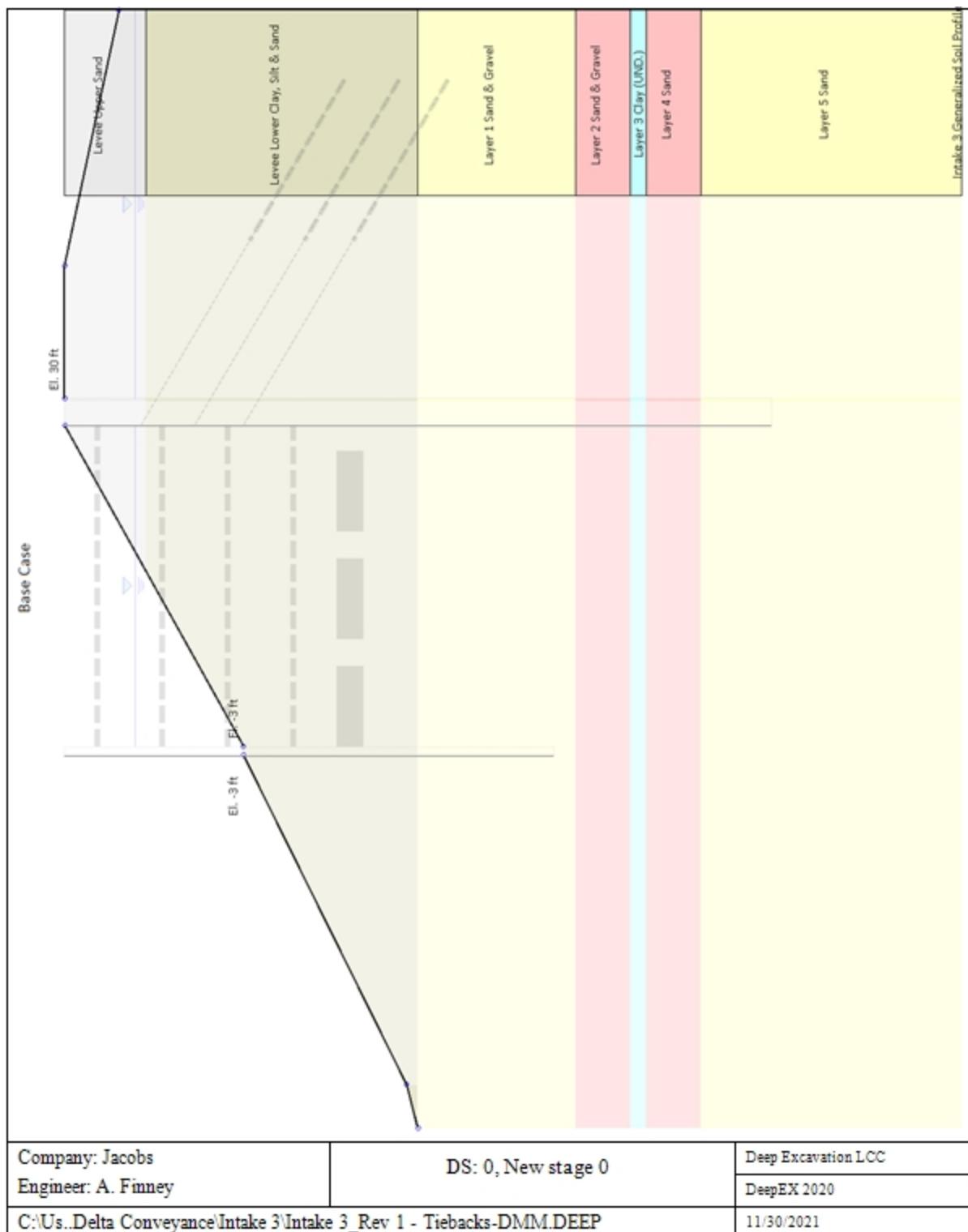
Min FD Toe= embedded minimum safety factor (for limit equilibrium analysis)

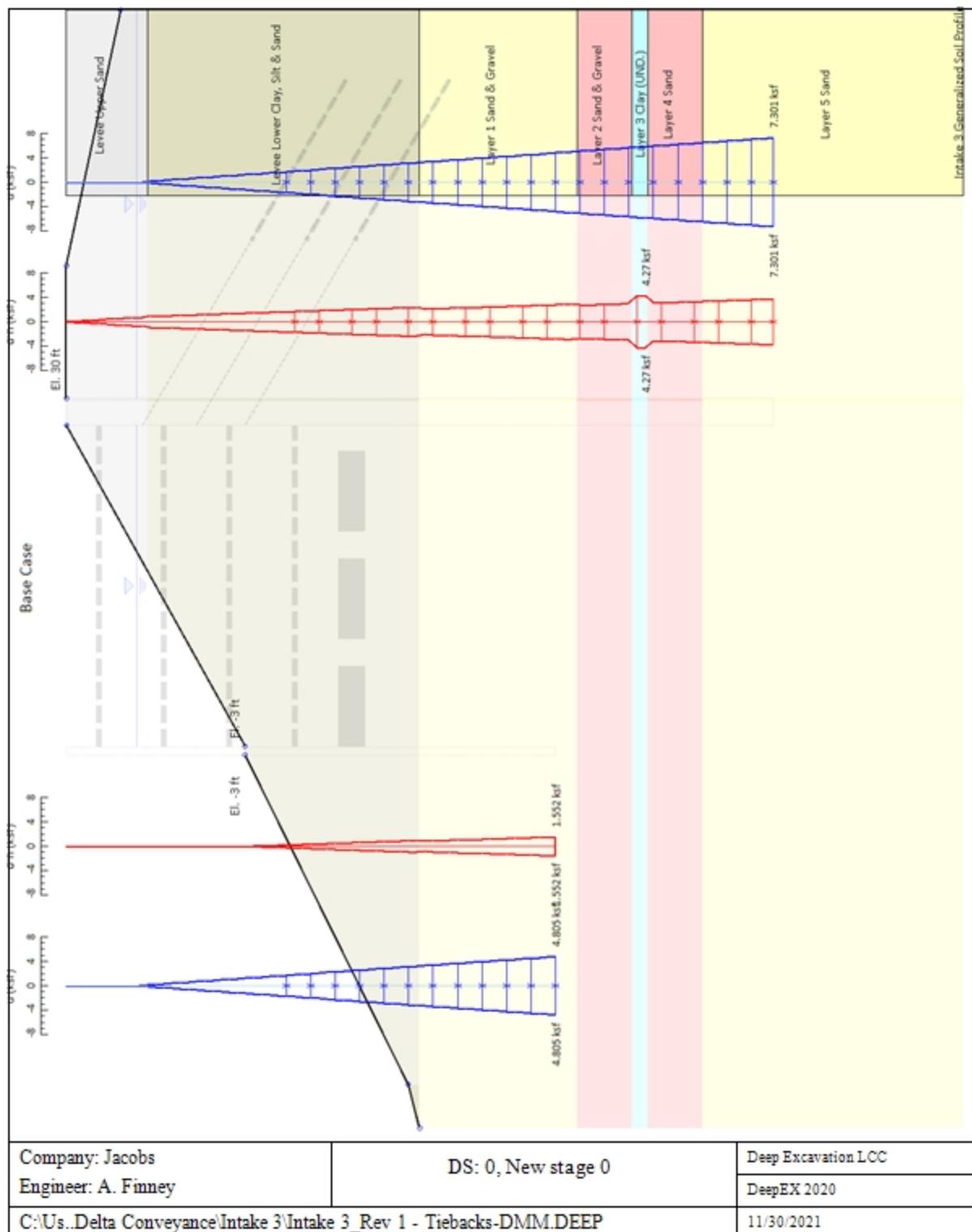
Toe FS rot= rotation safety factor (classic for limit equilibrium analysis)

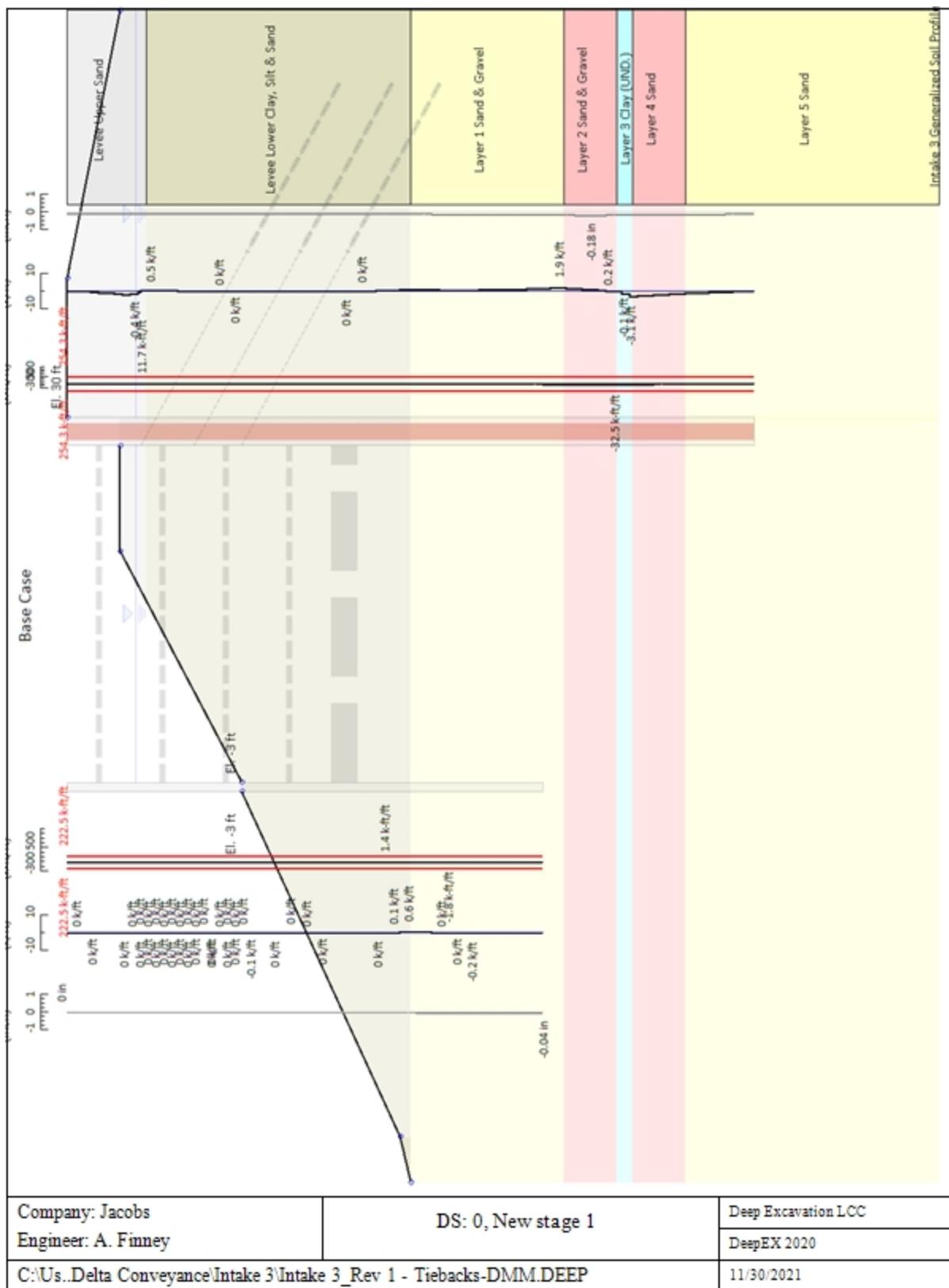
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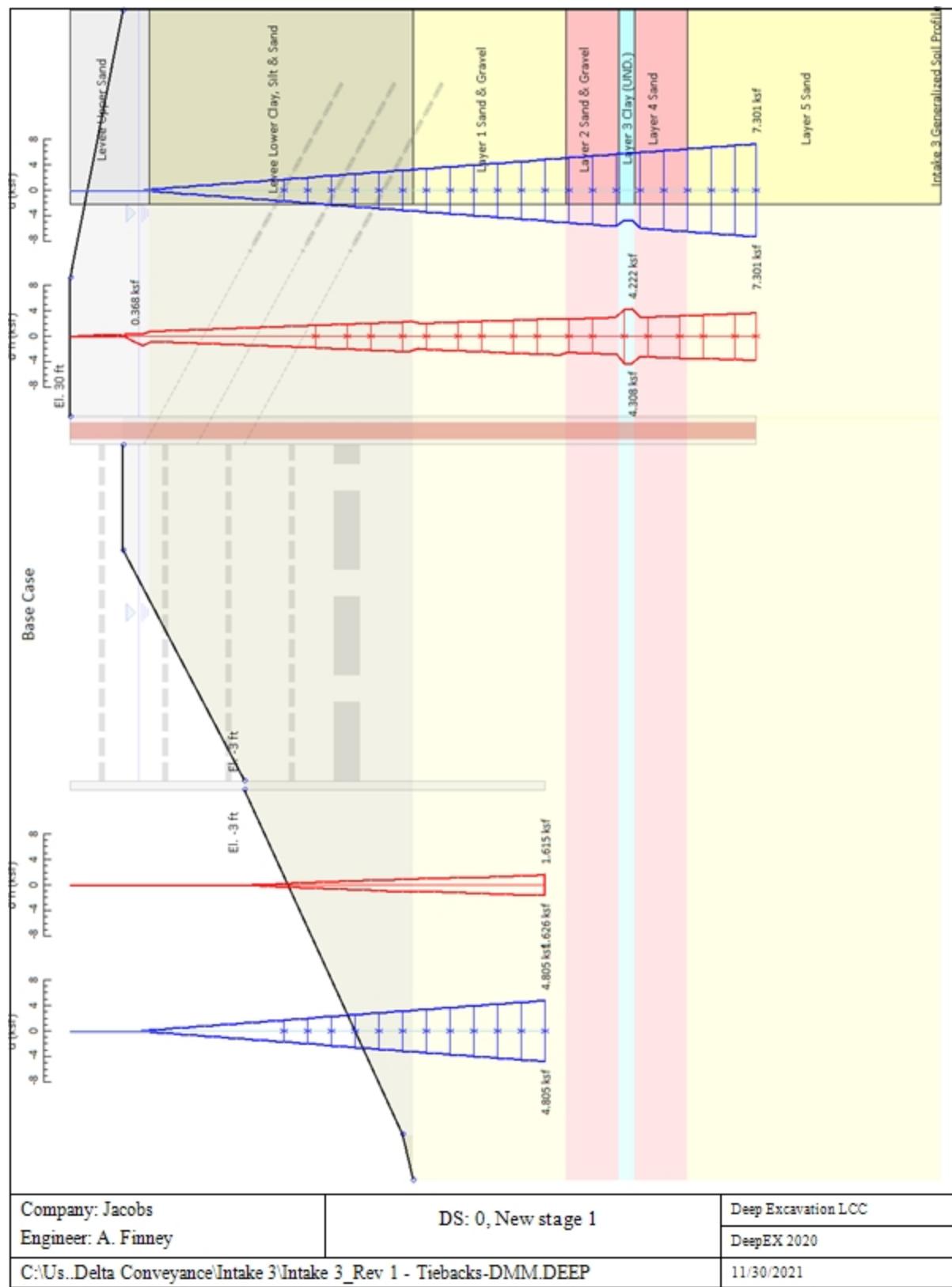
EXCAVATION STAGES SKETCHES

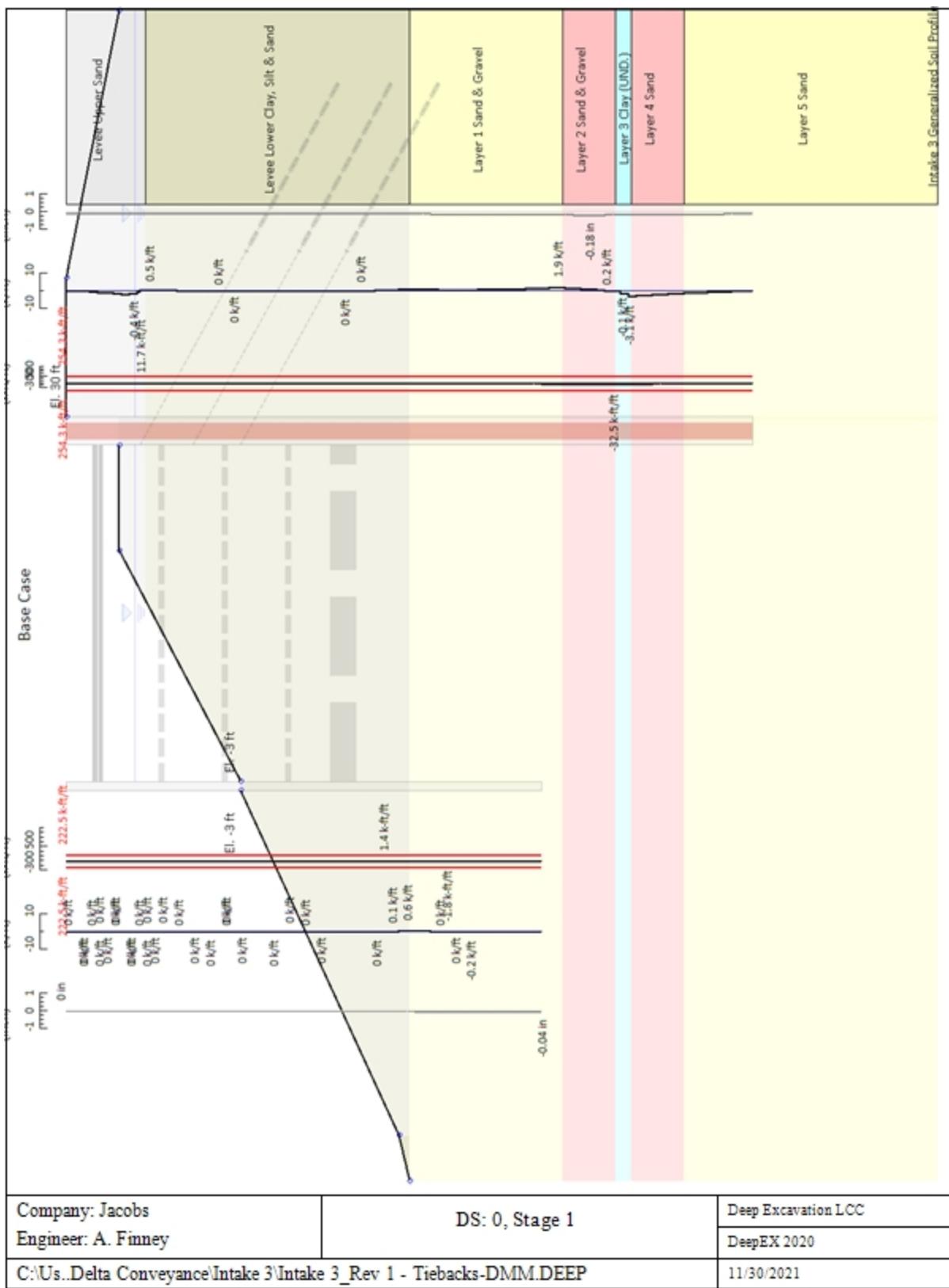
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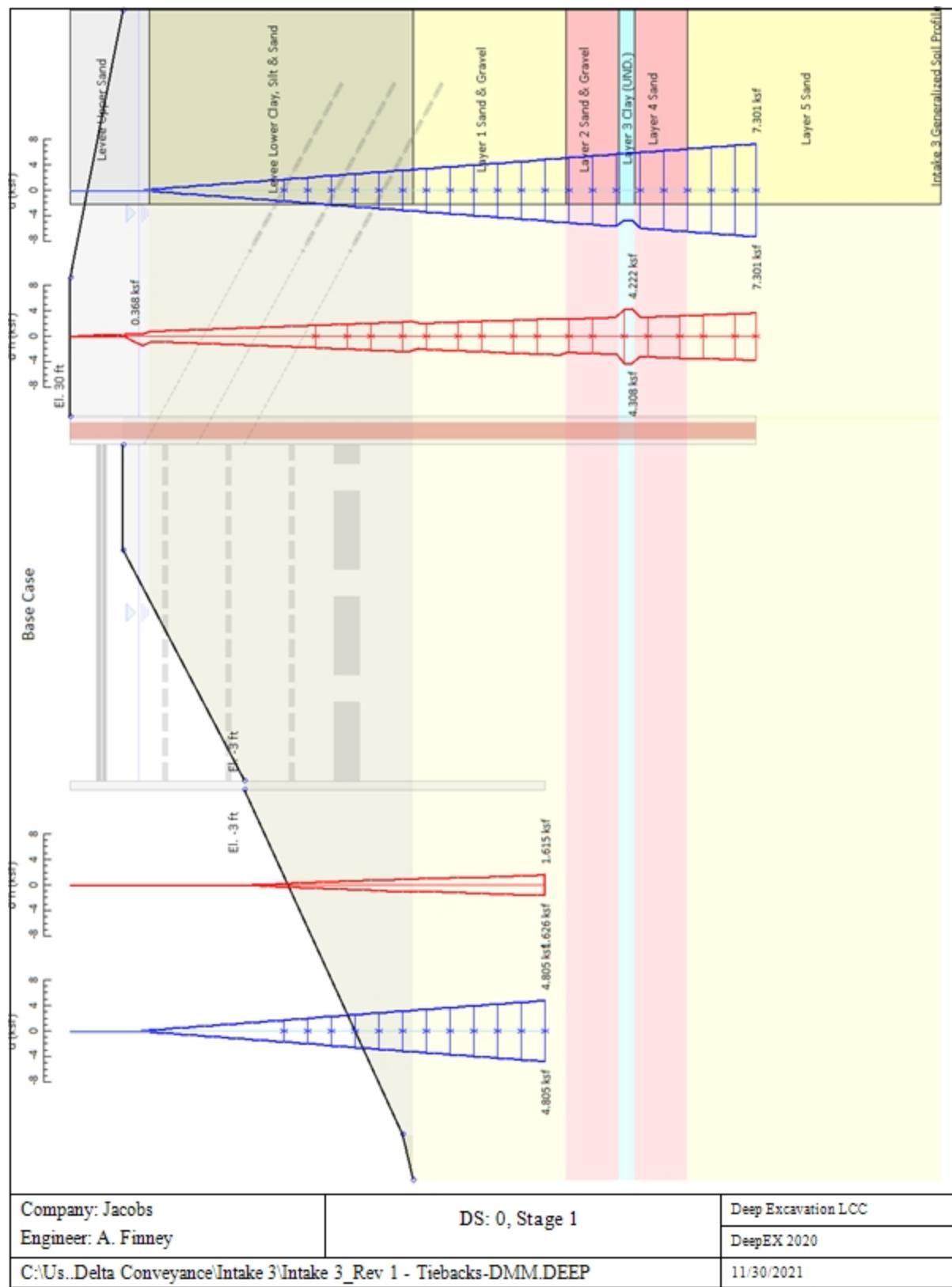


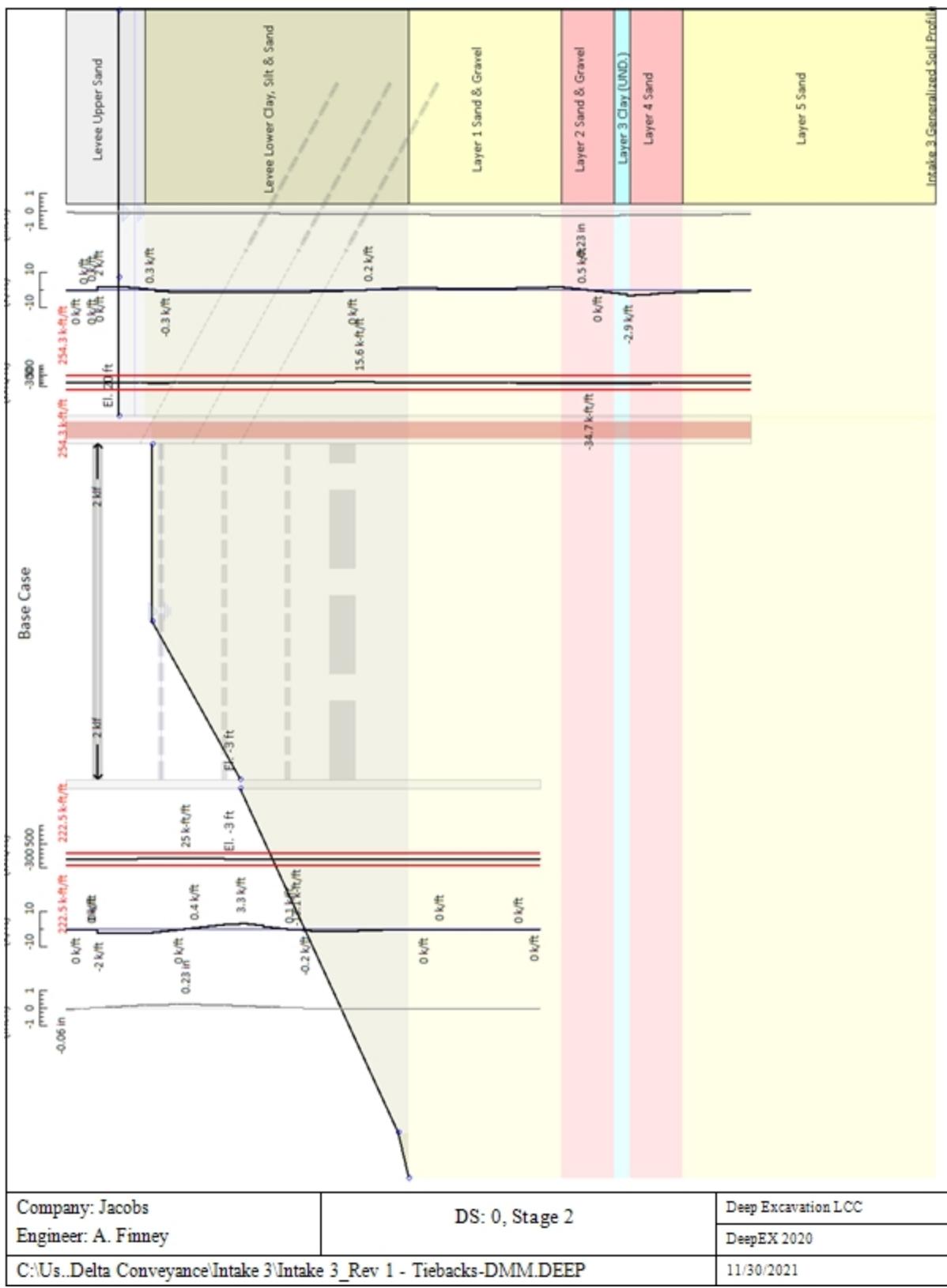


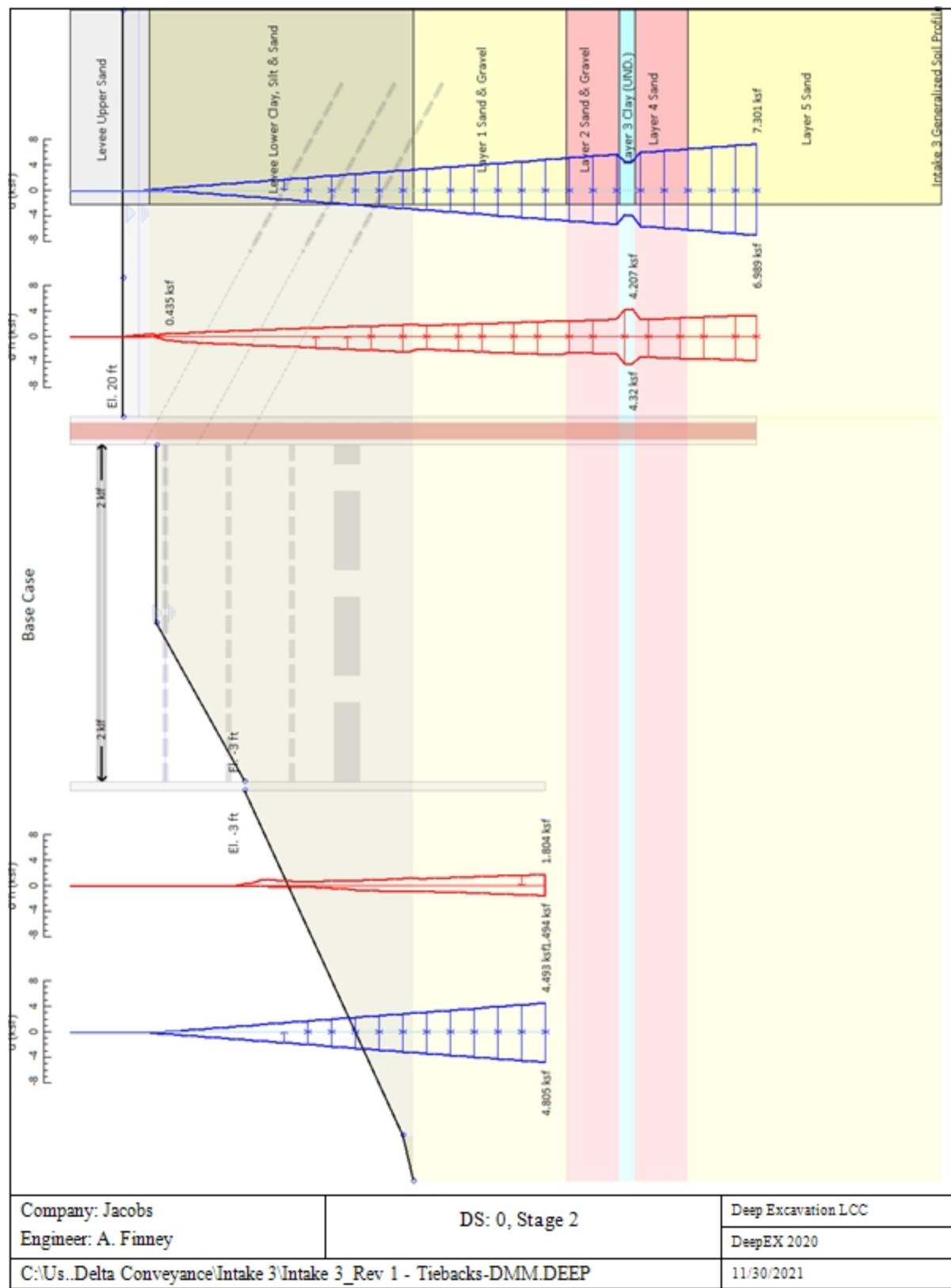


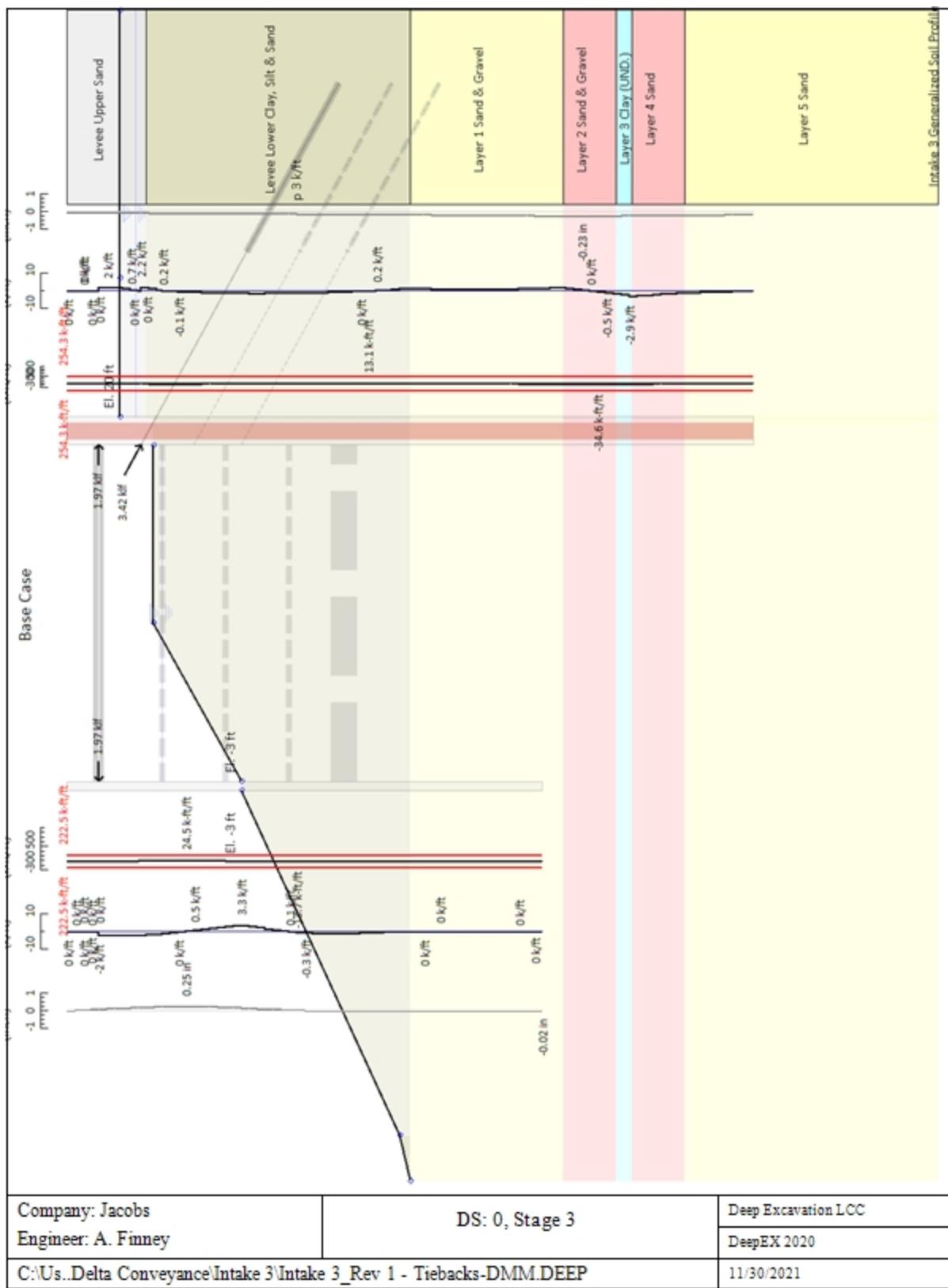


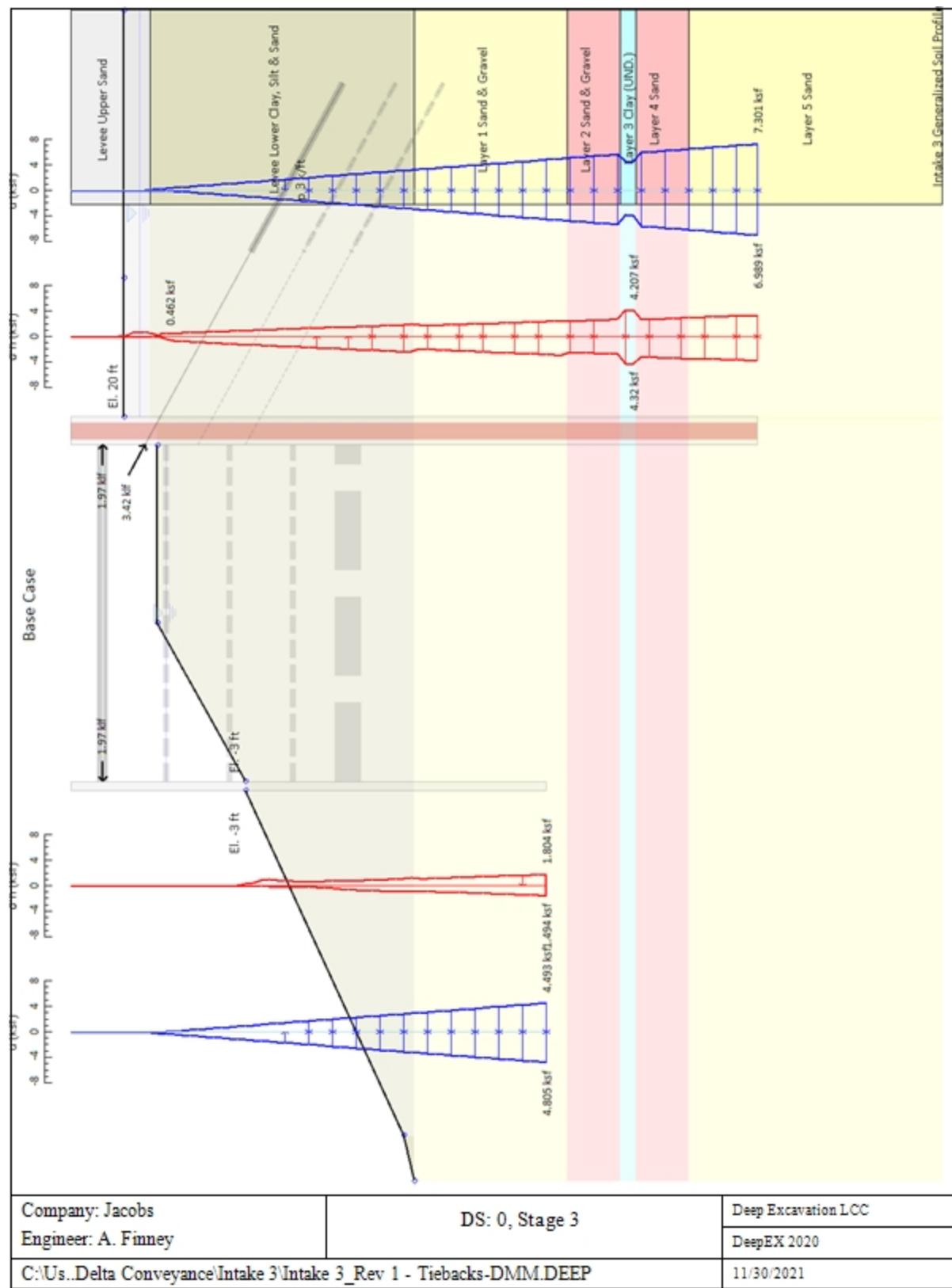


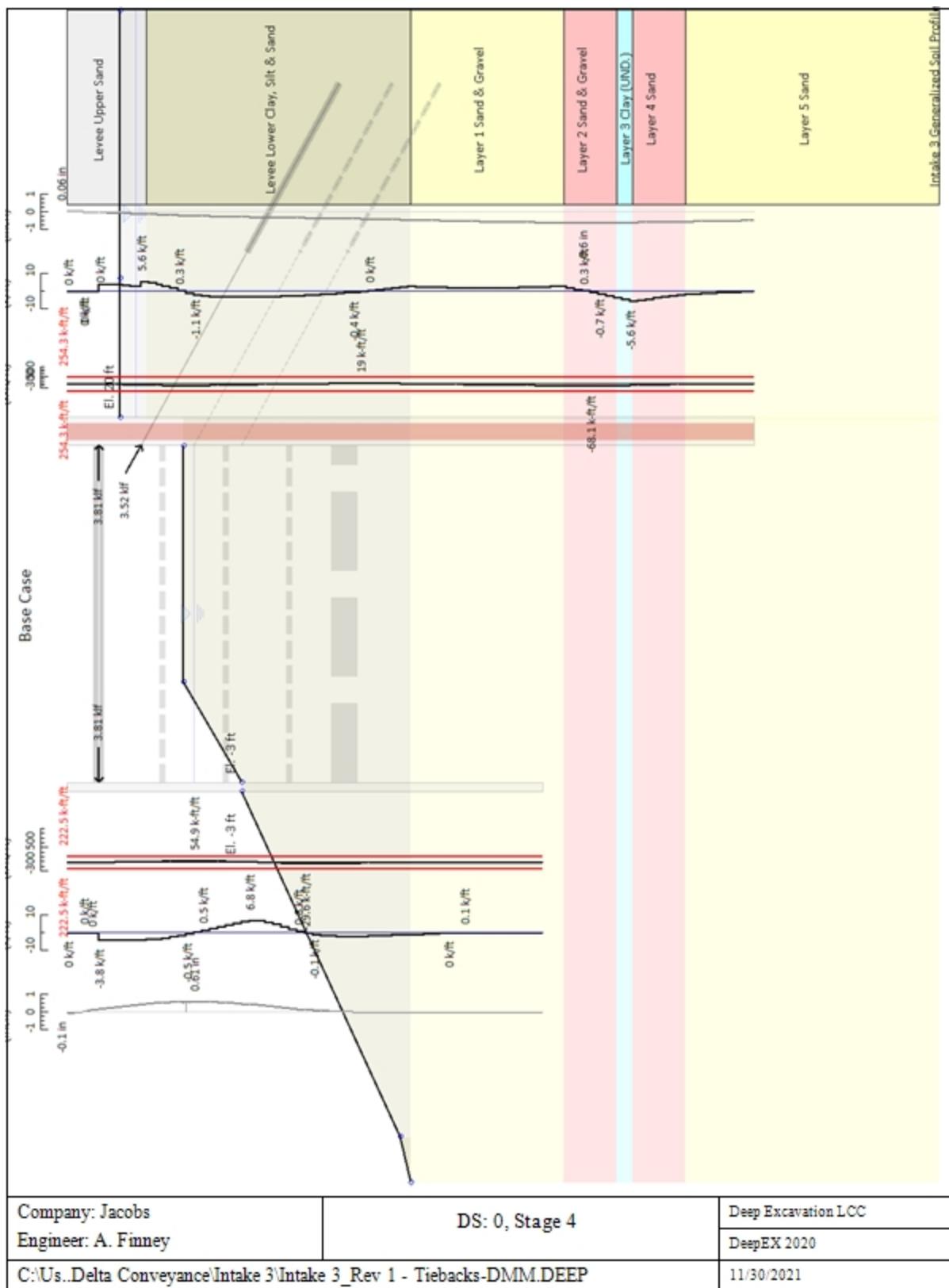


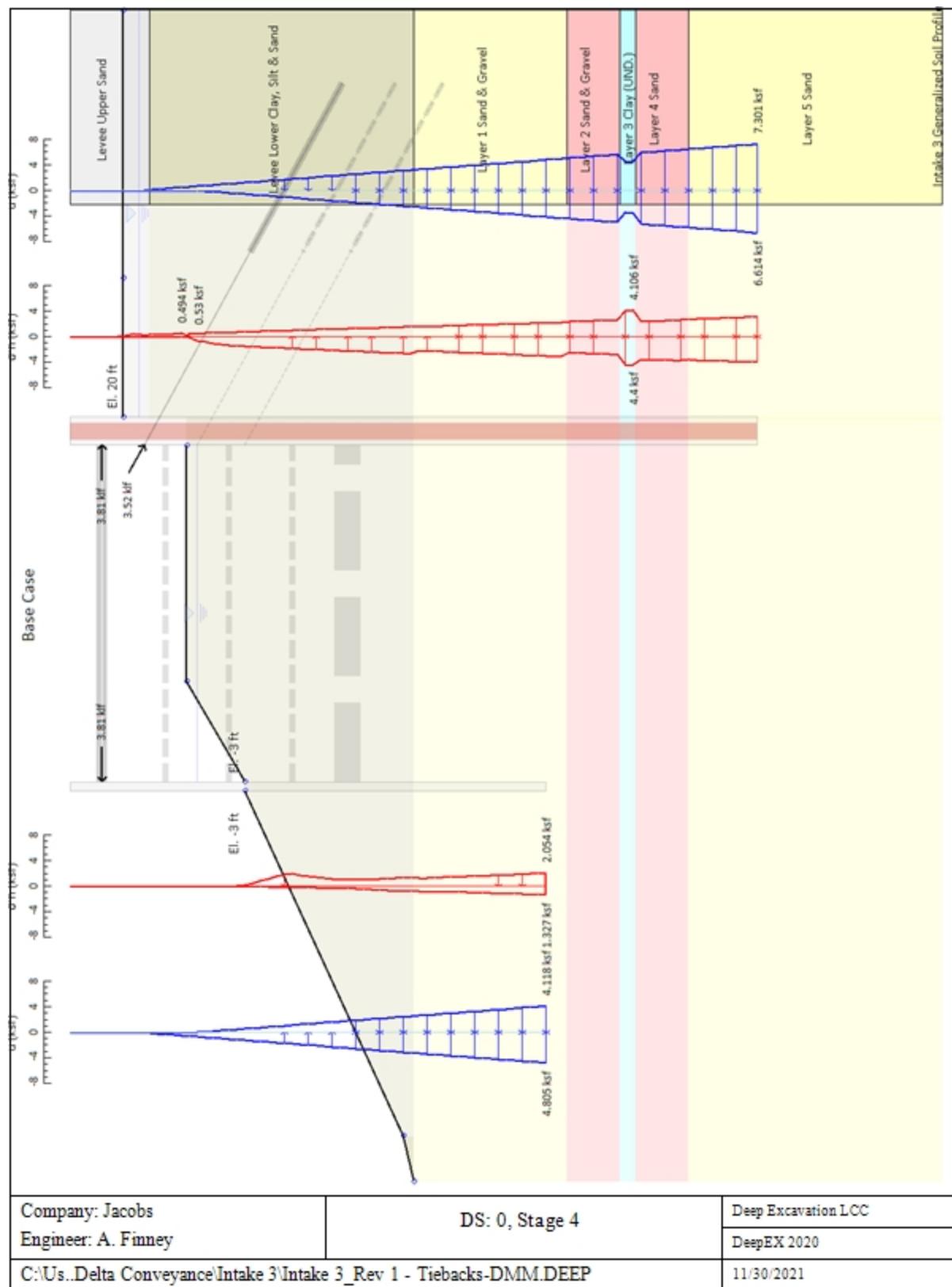


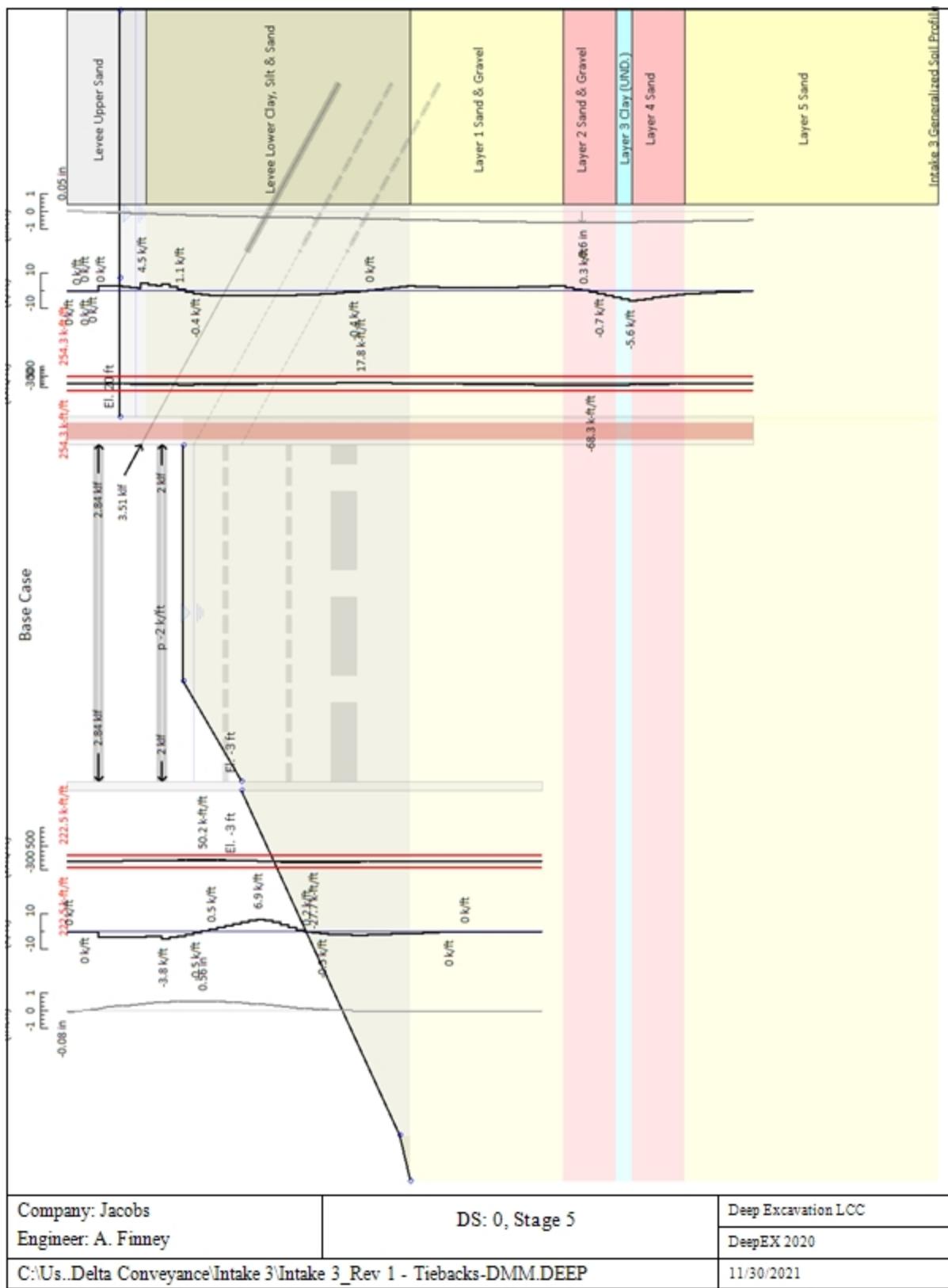


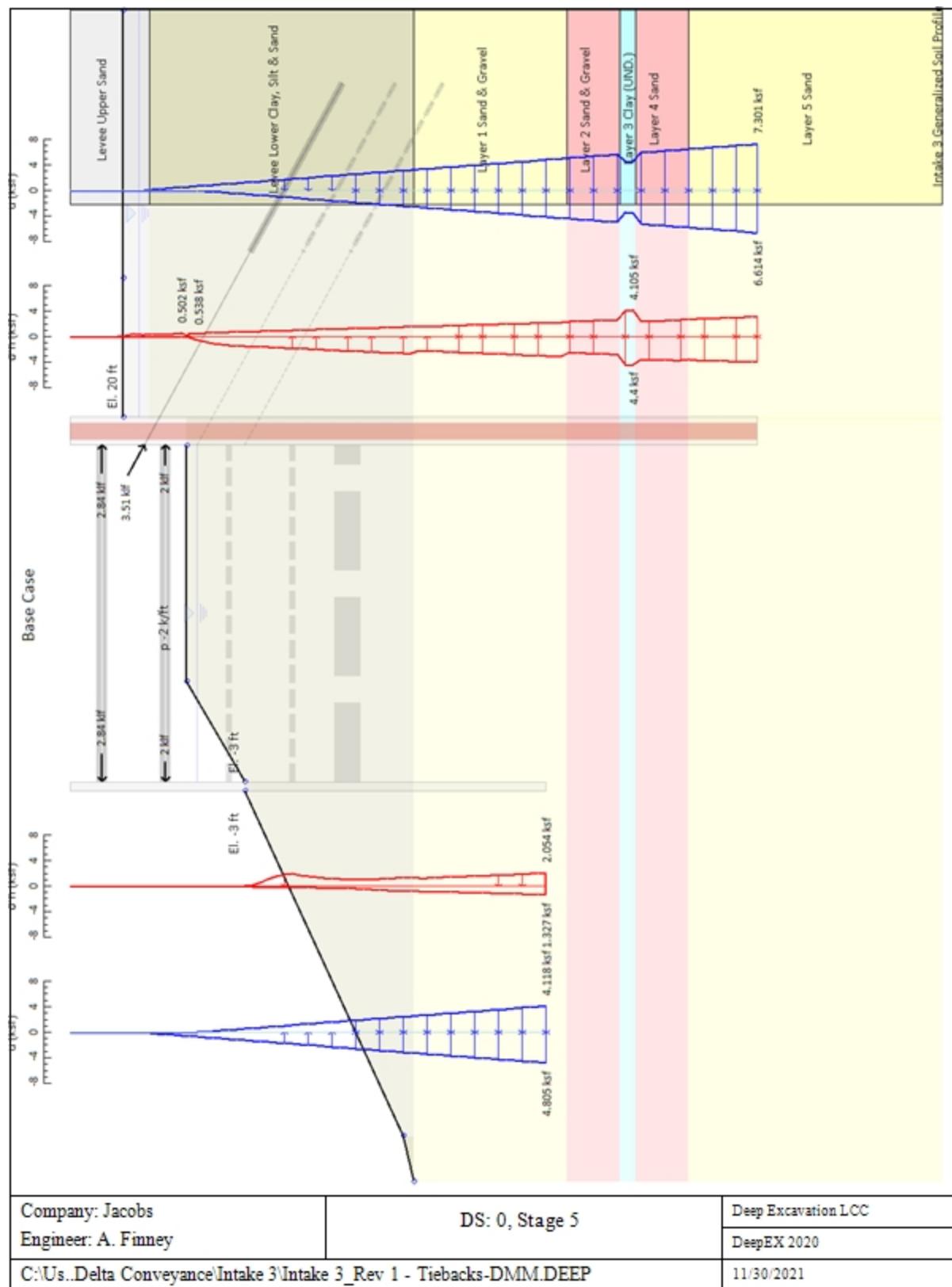


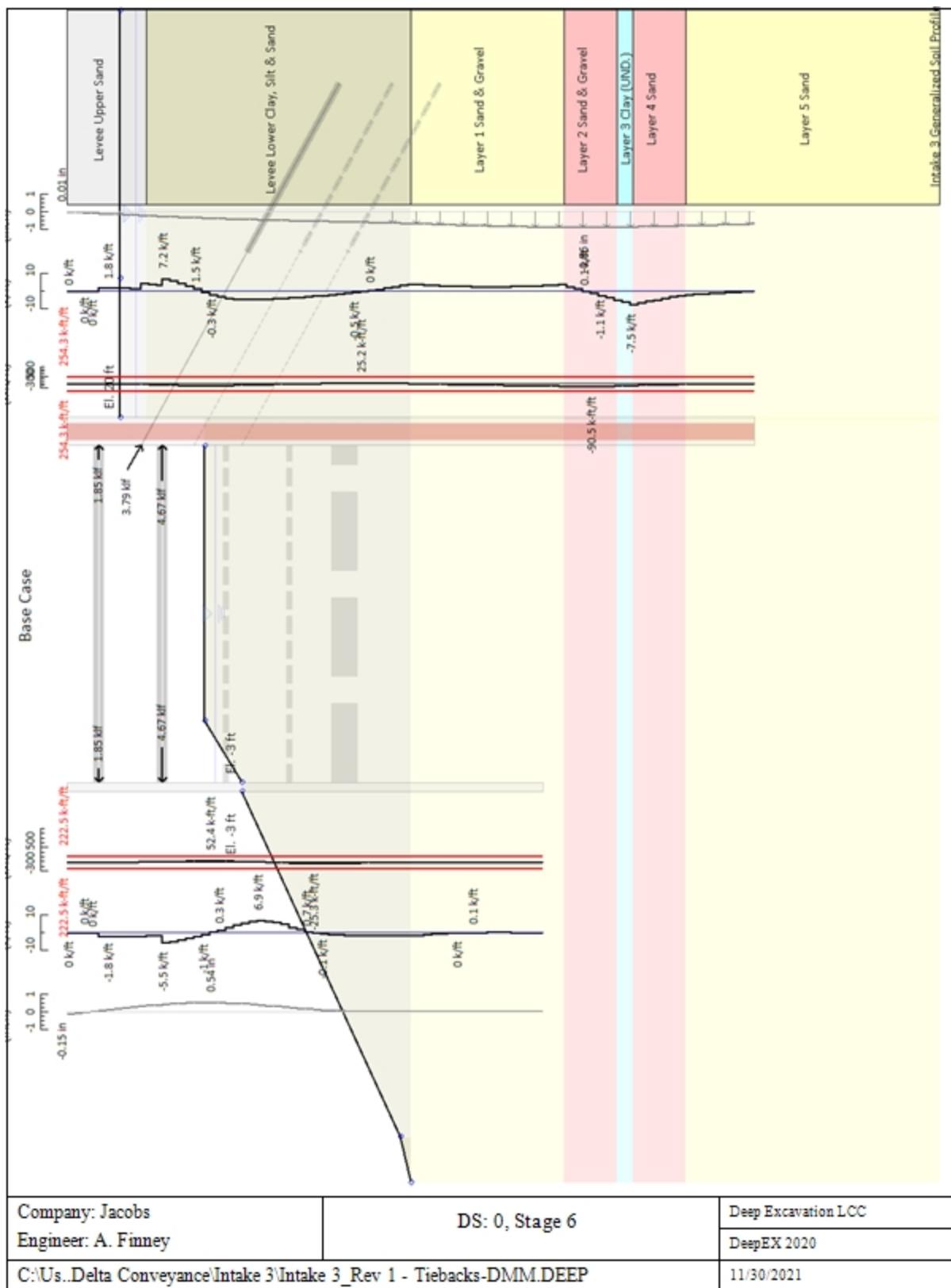


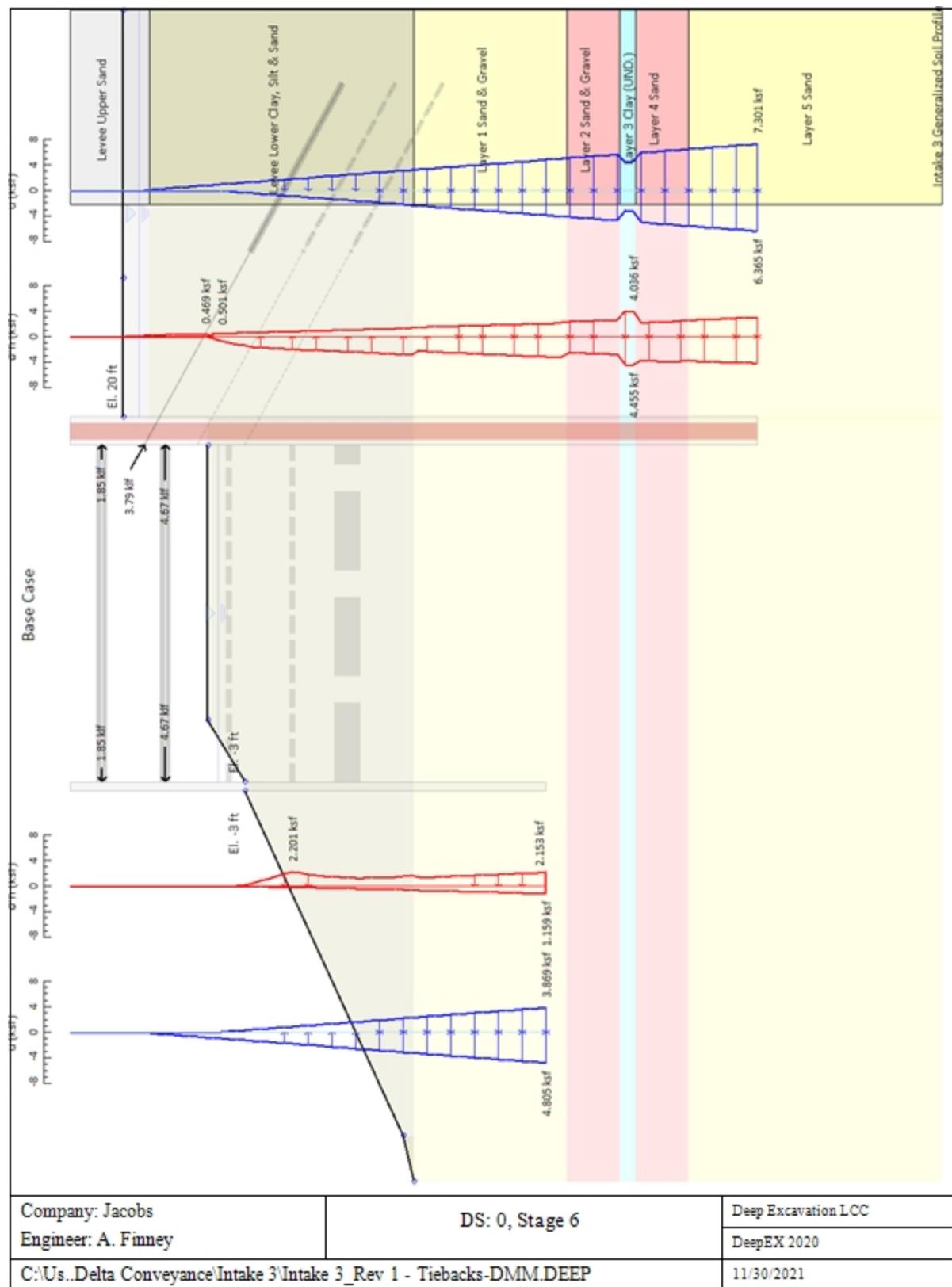


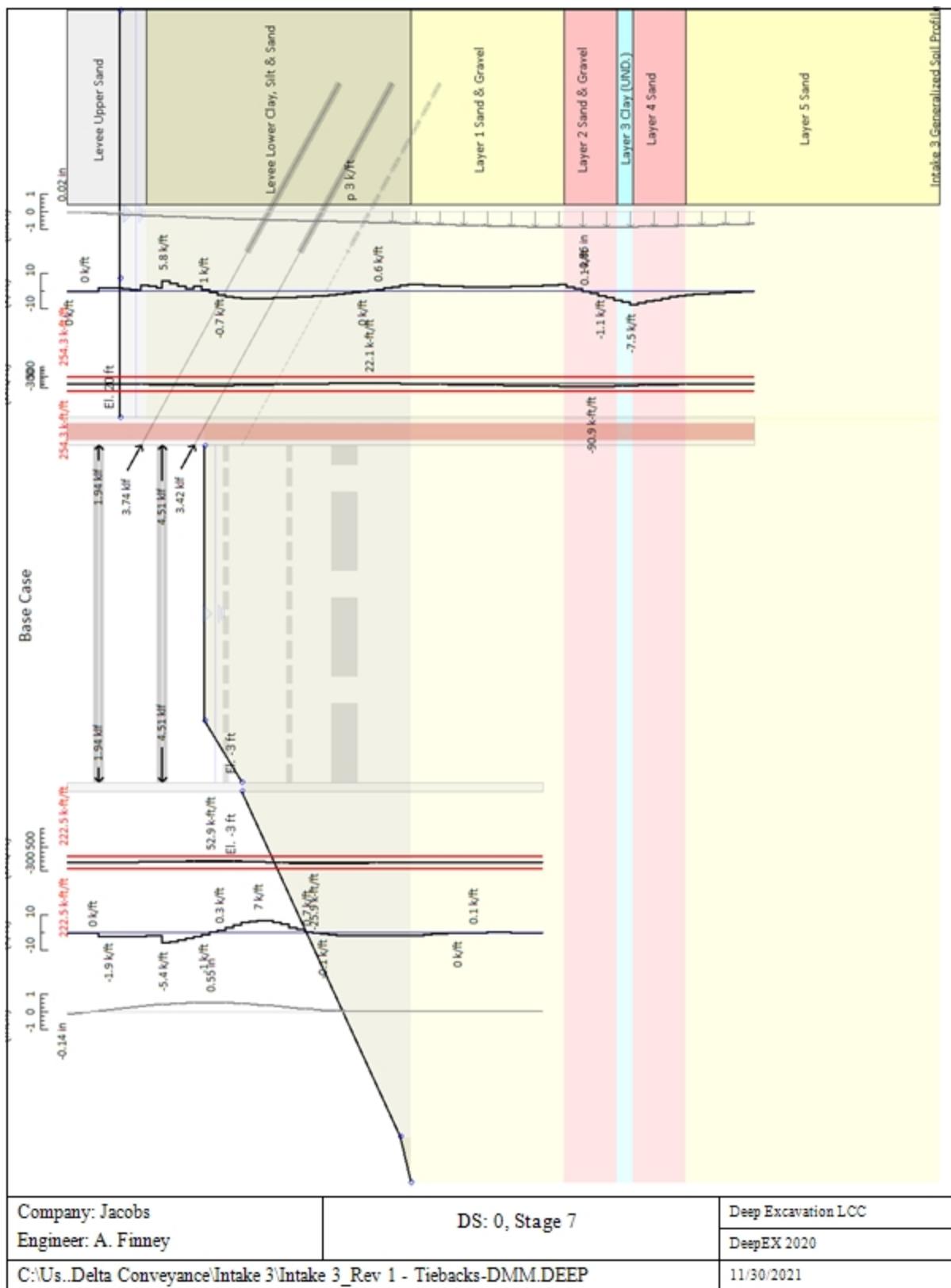


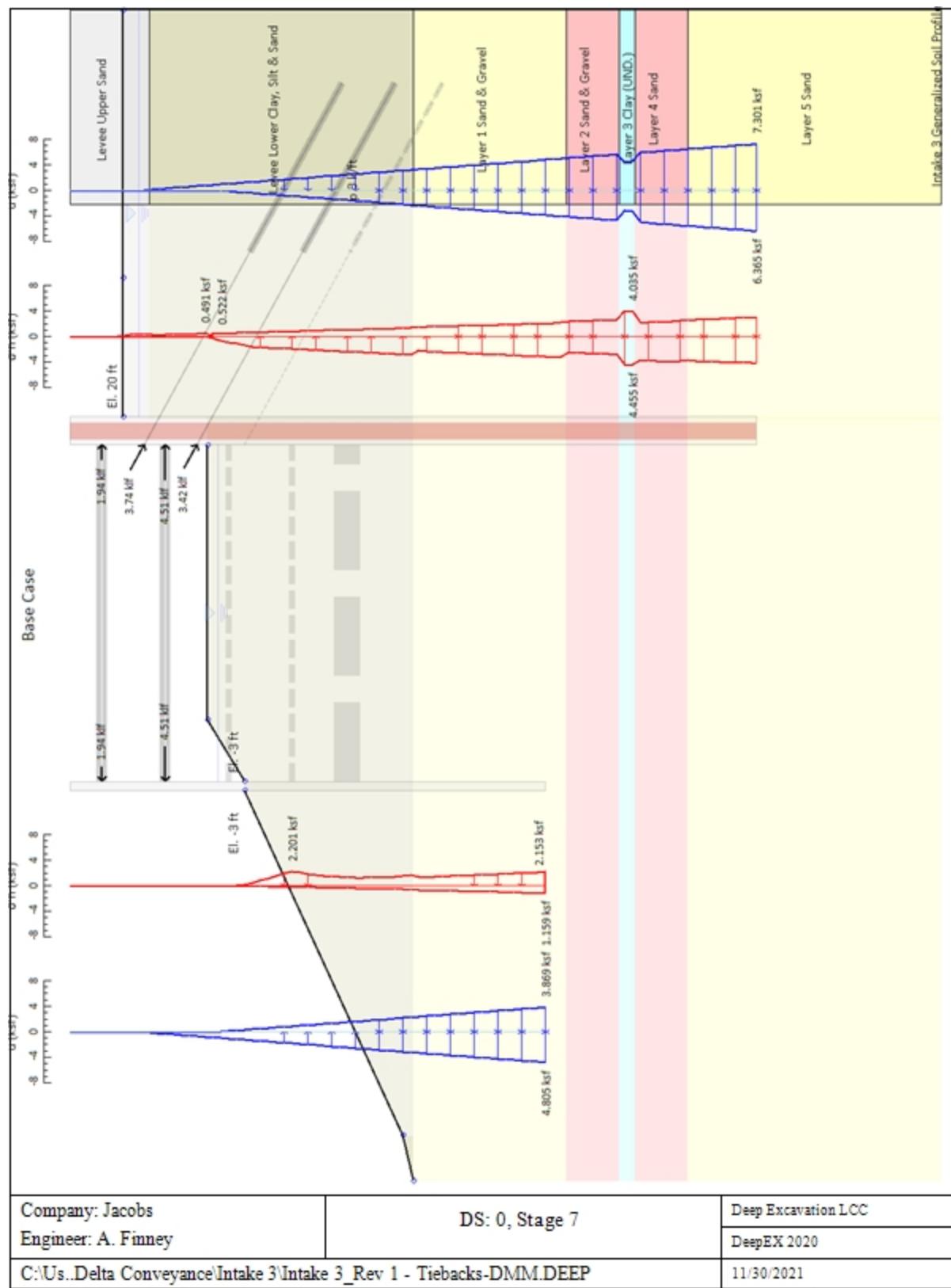


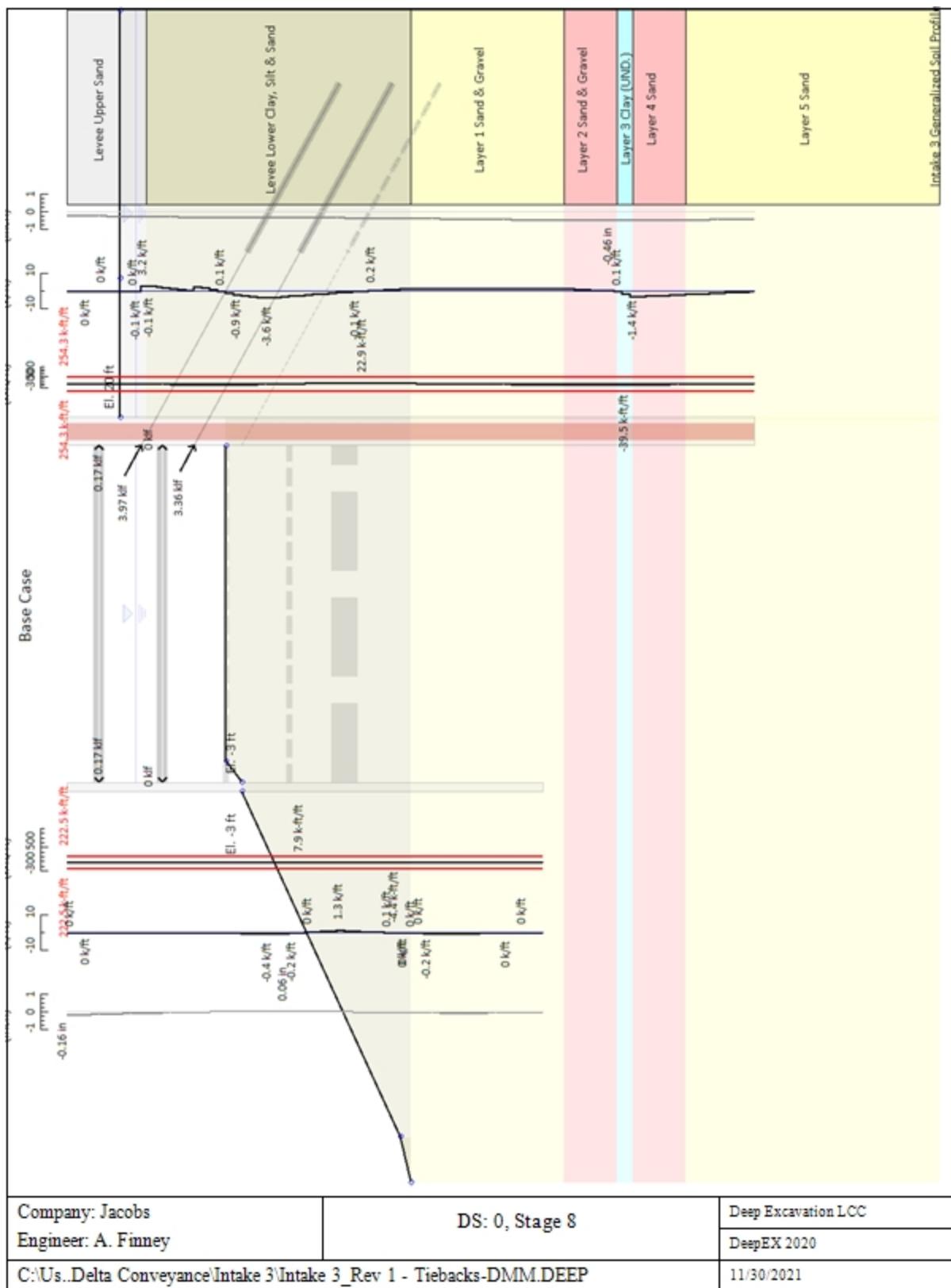


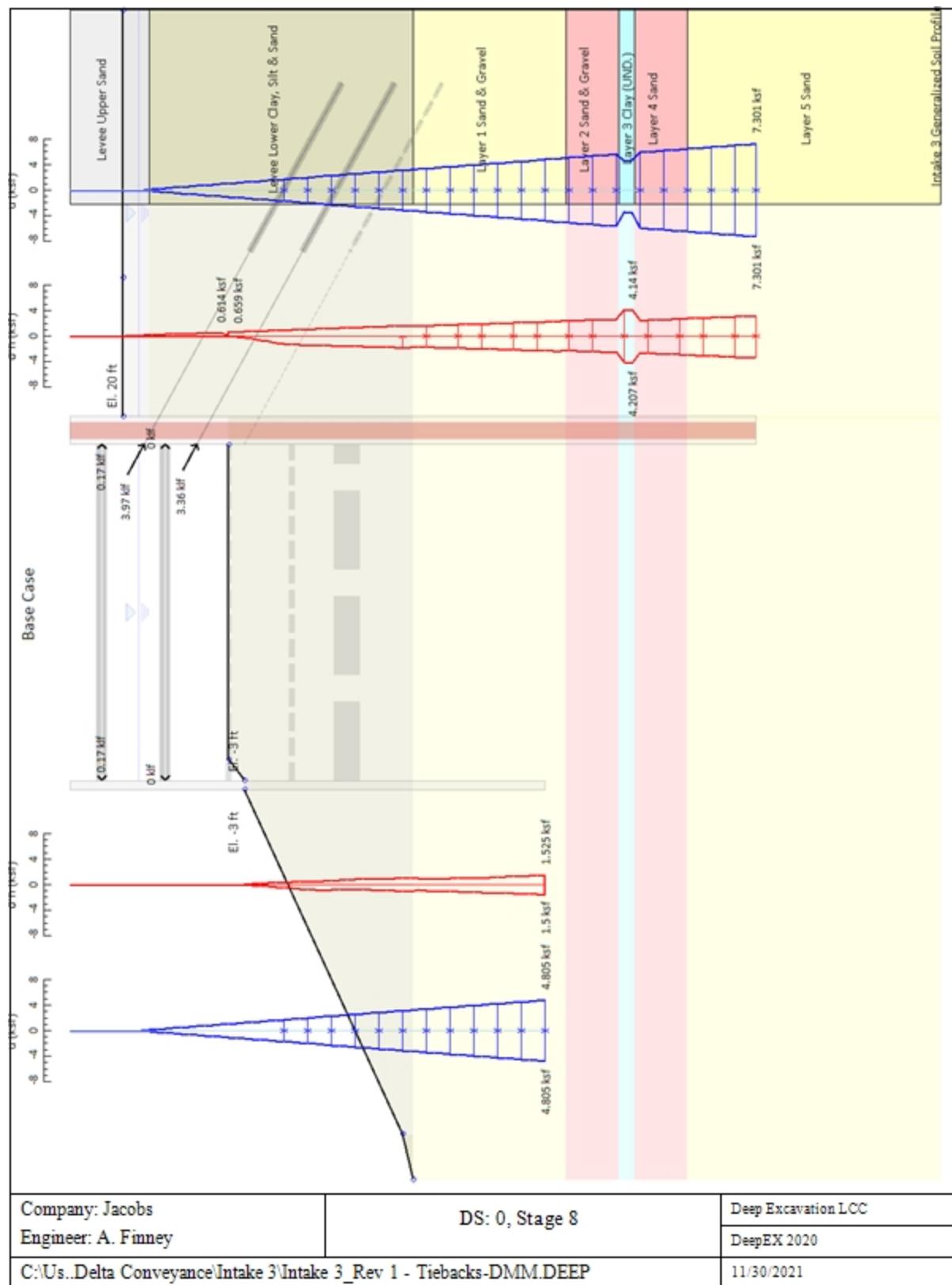


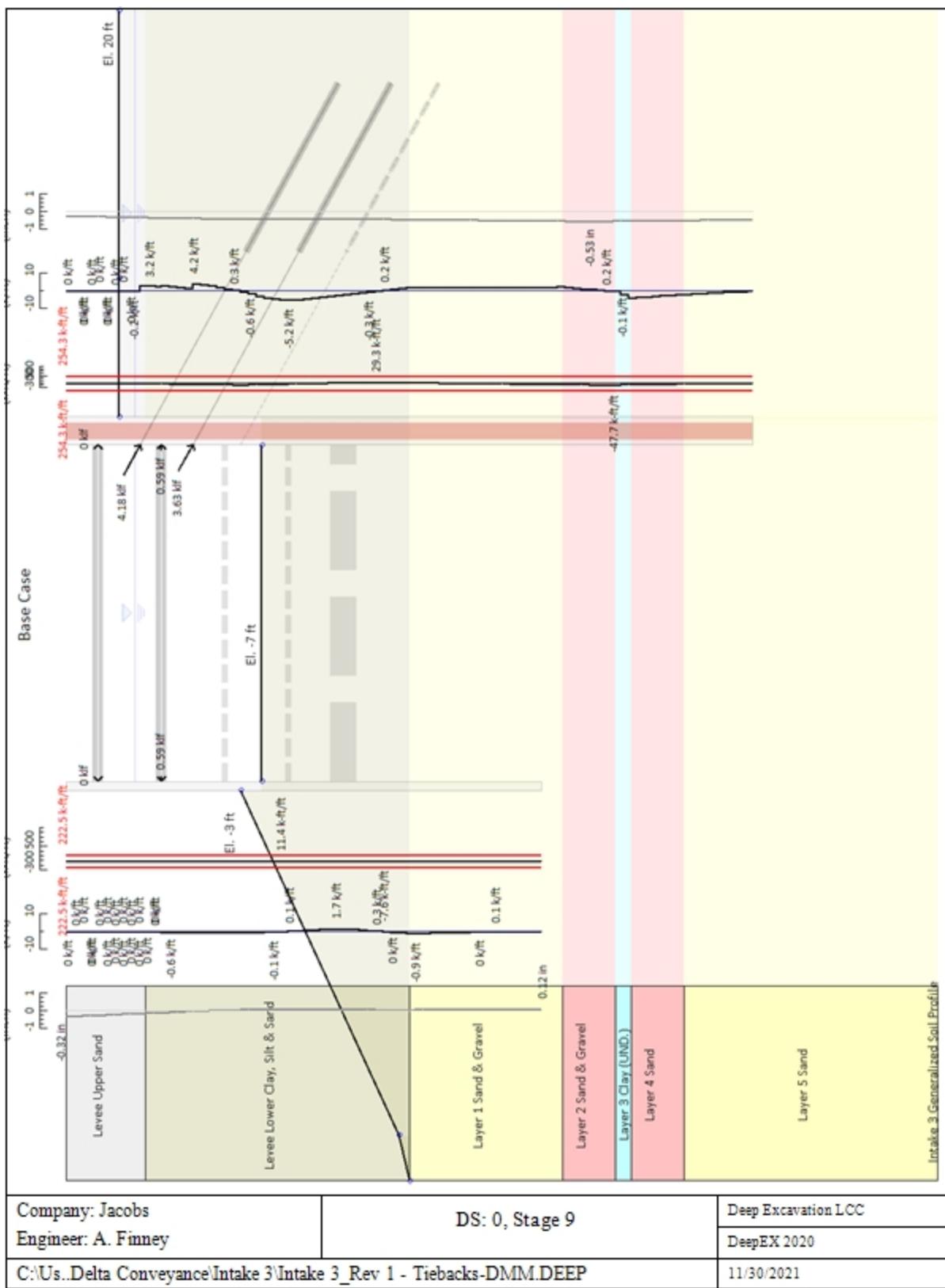


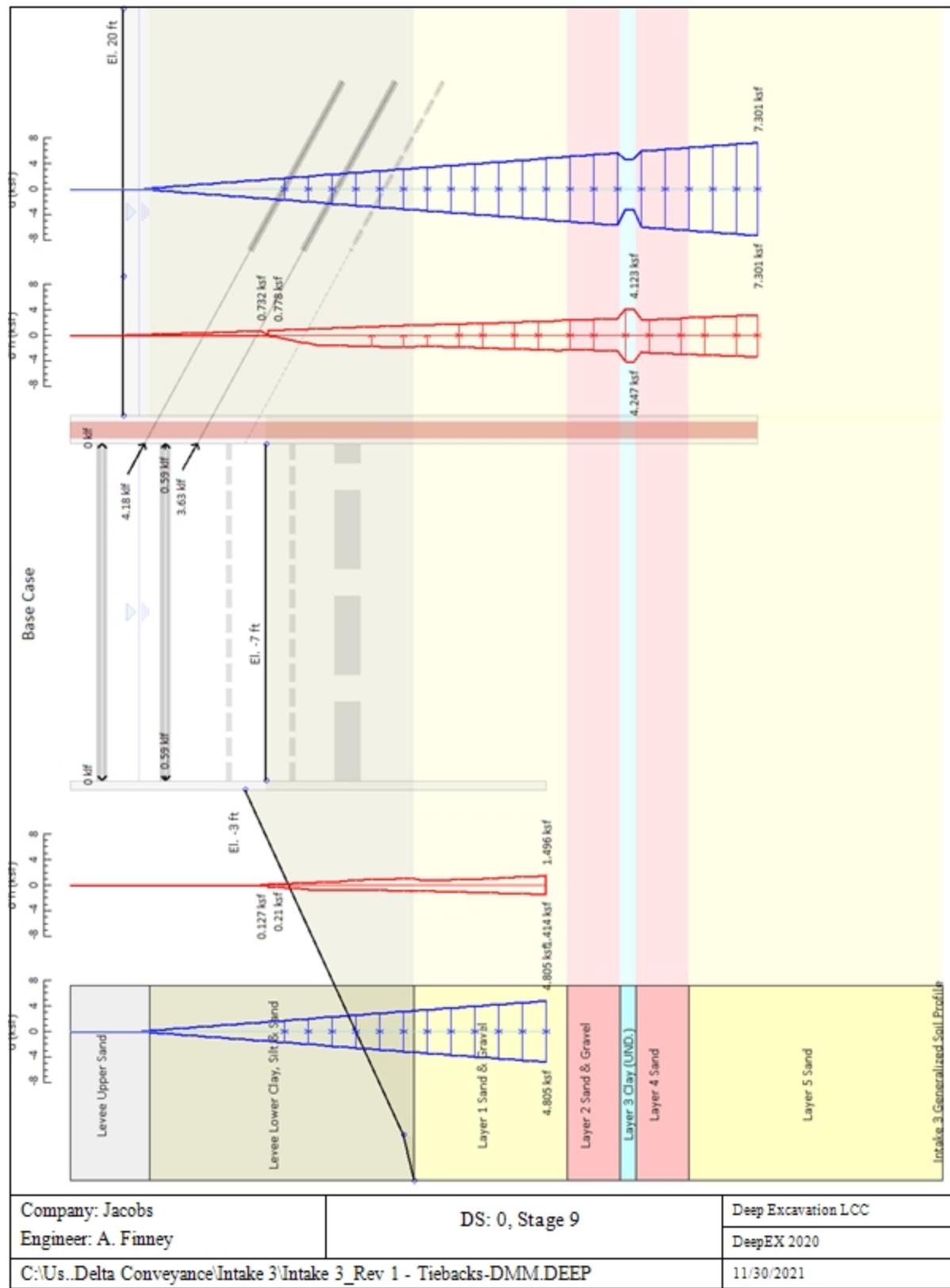


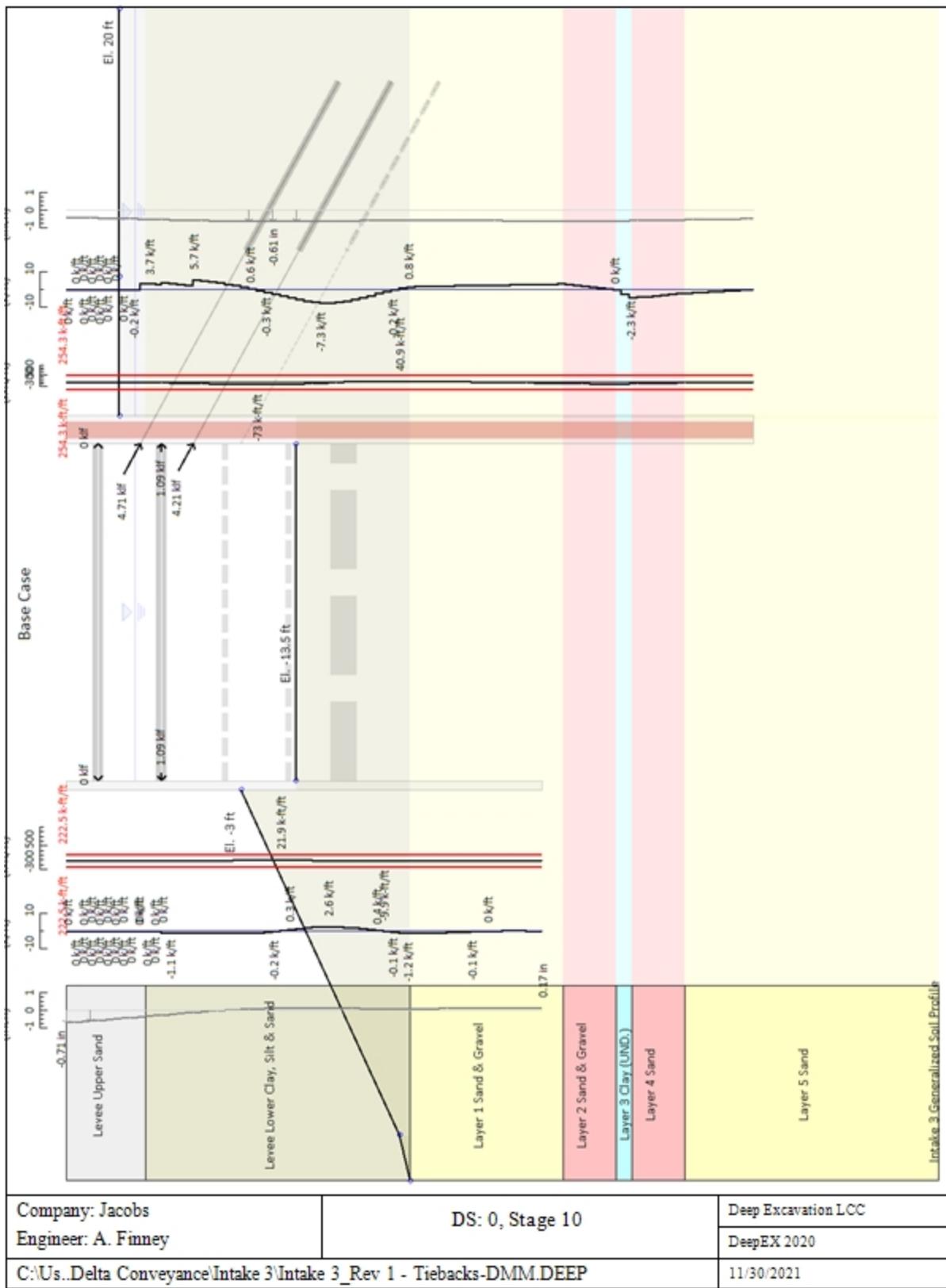


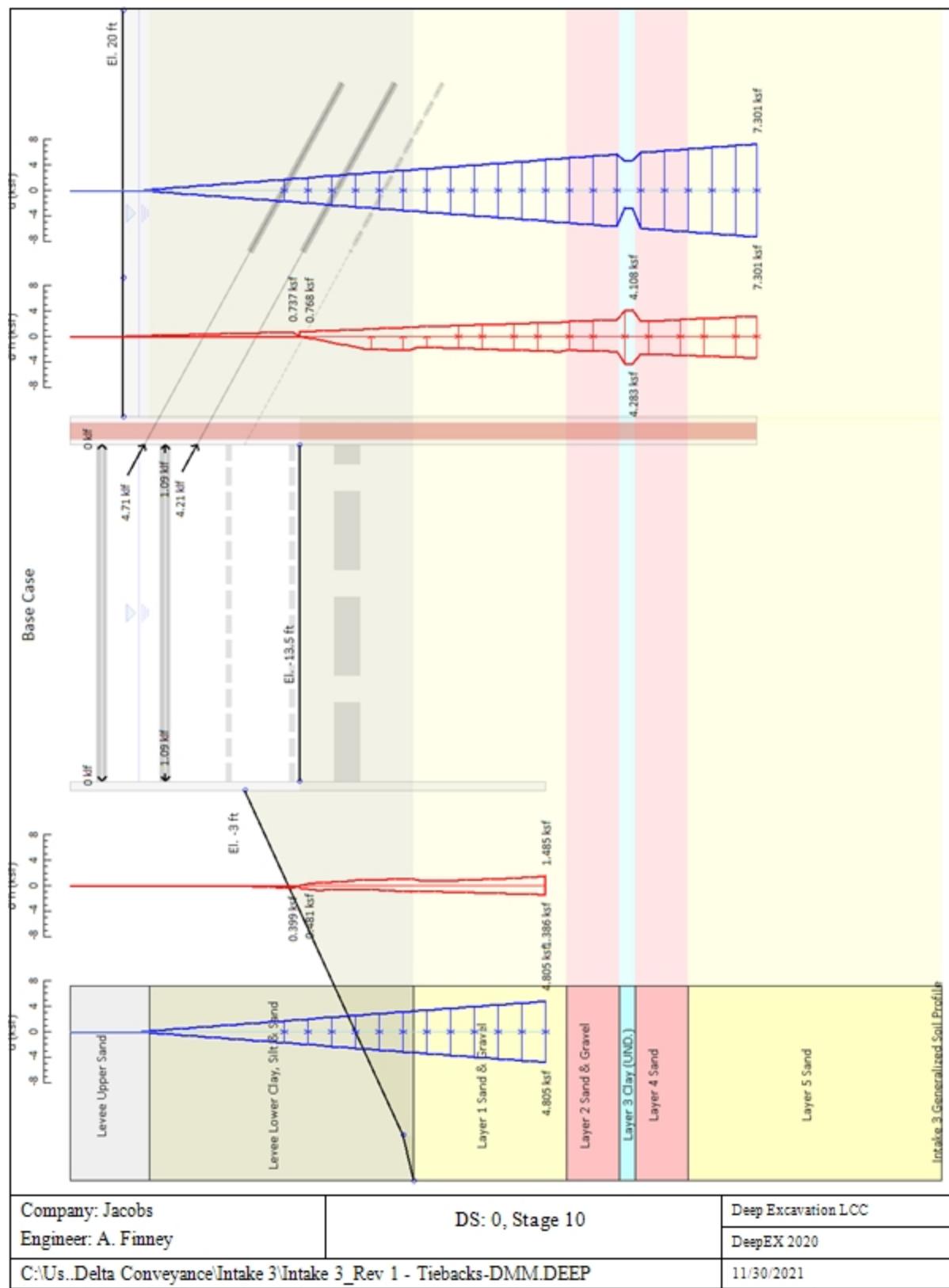


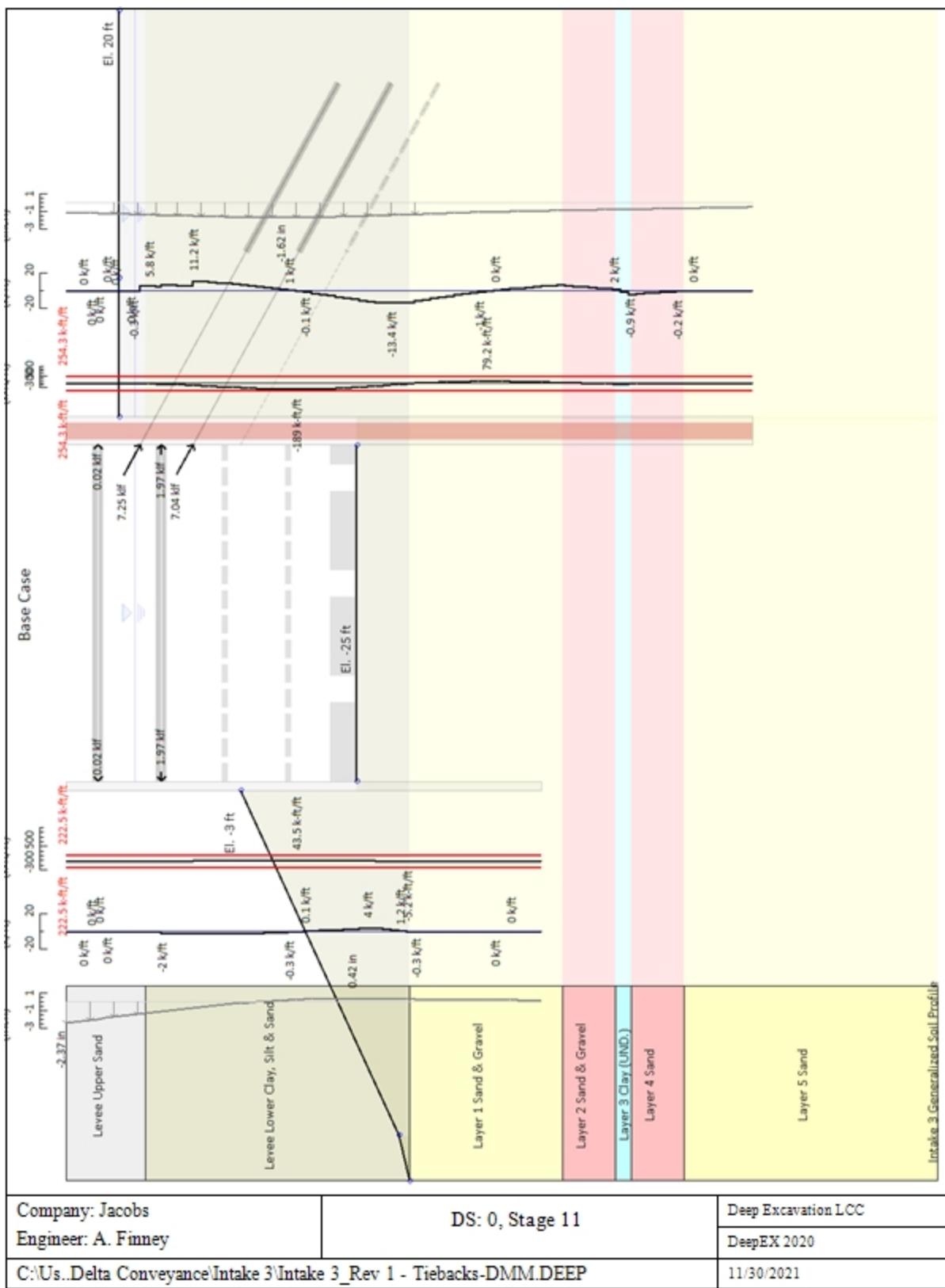


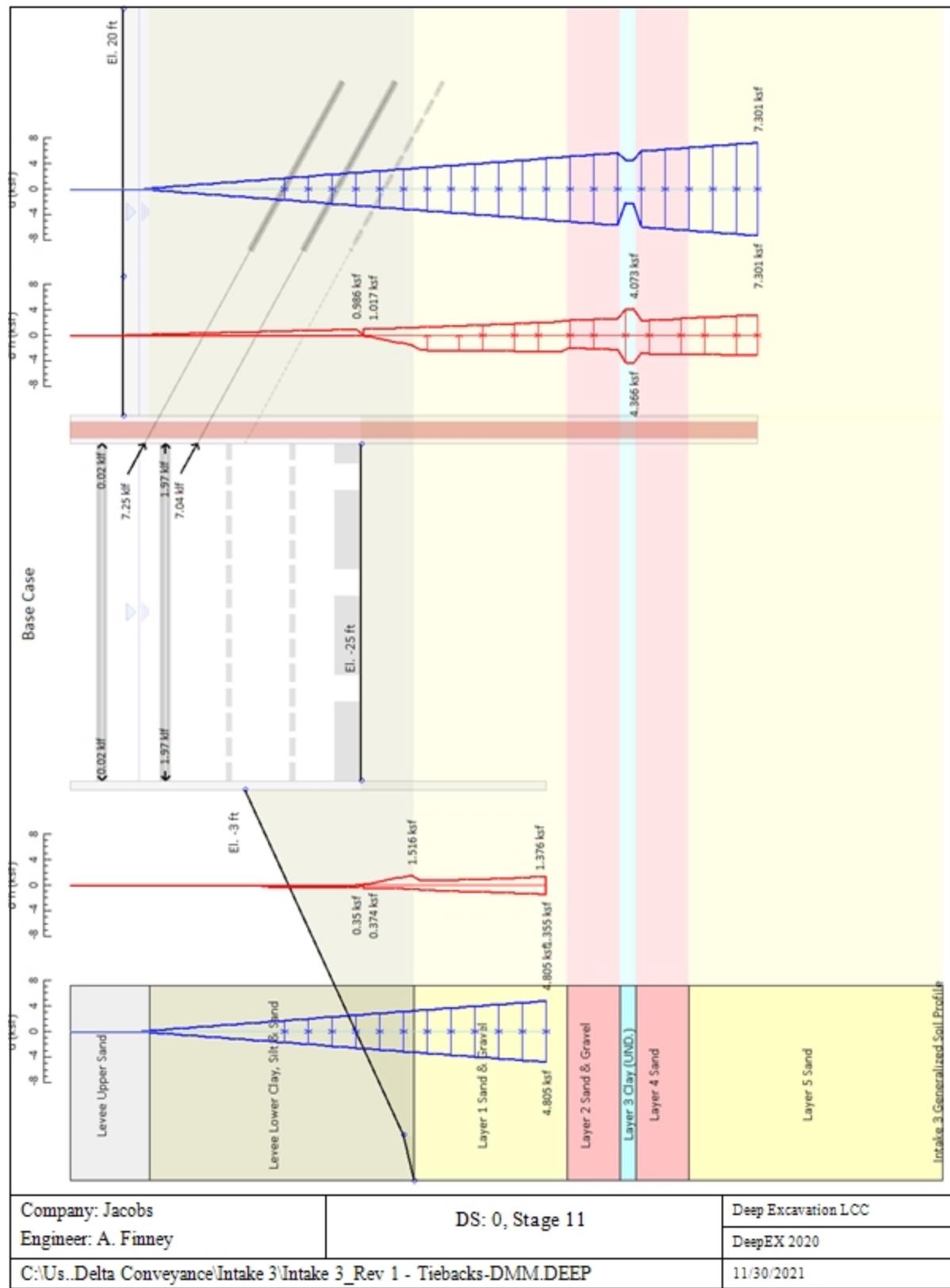


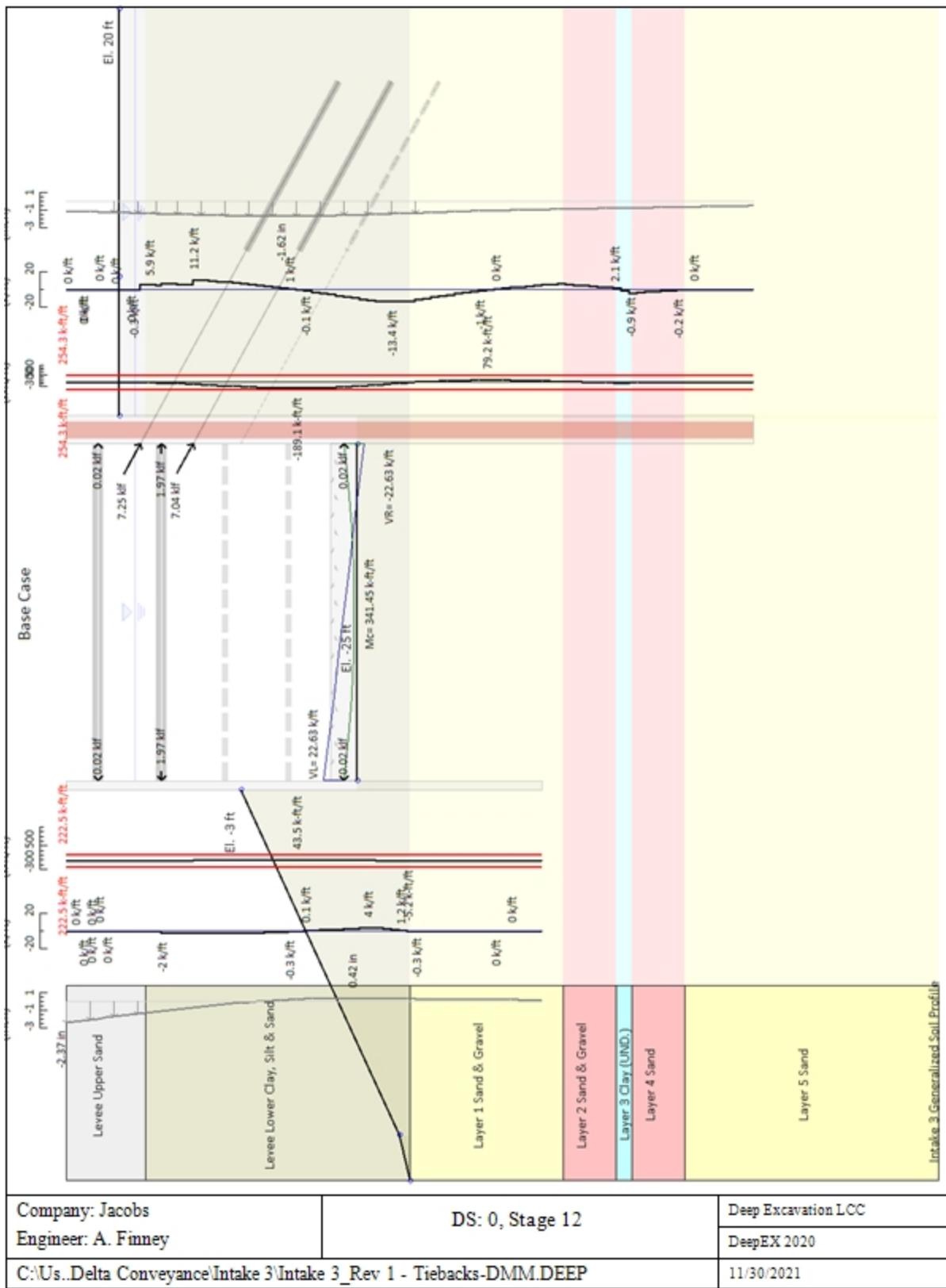


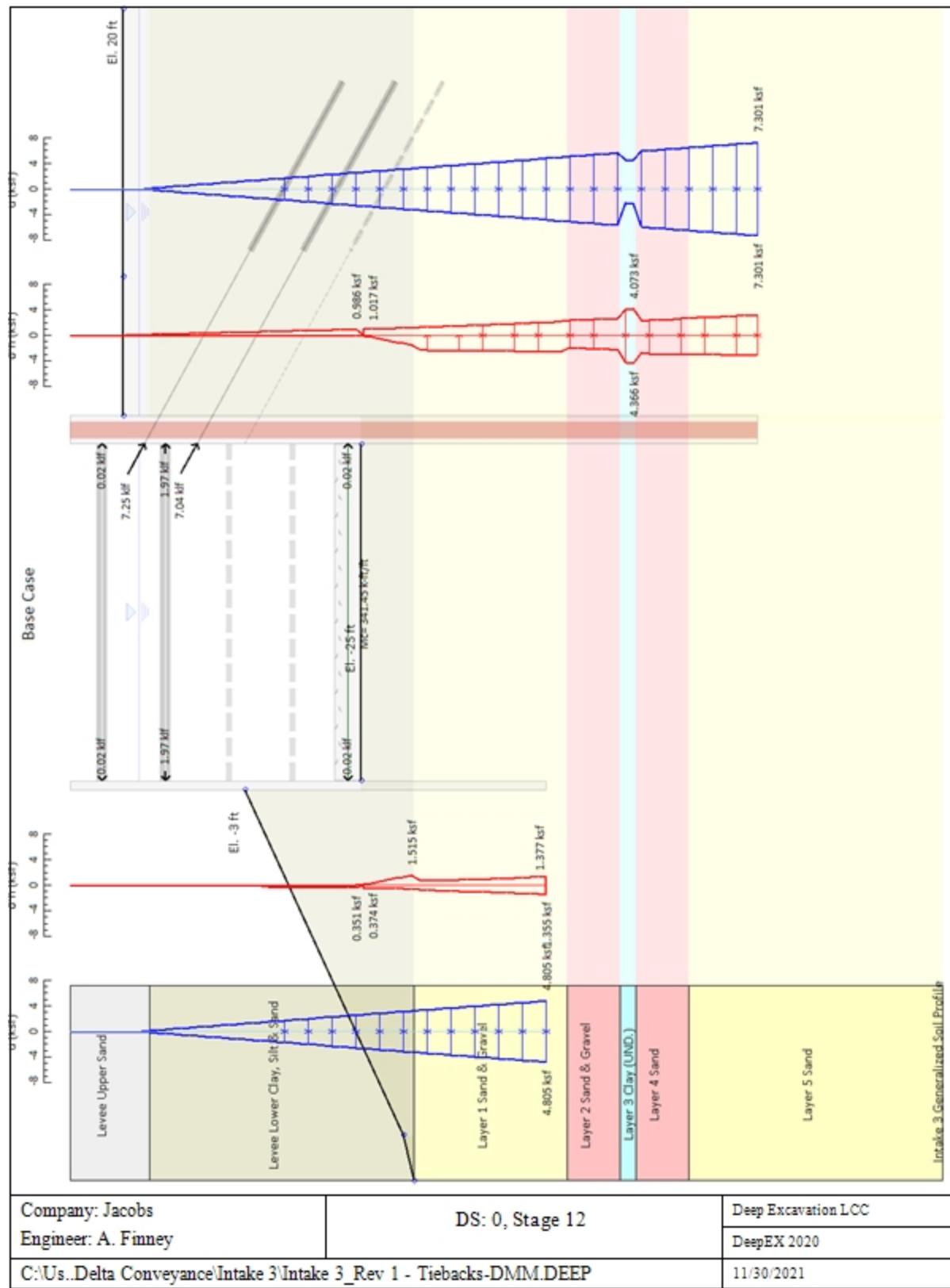


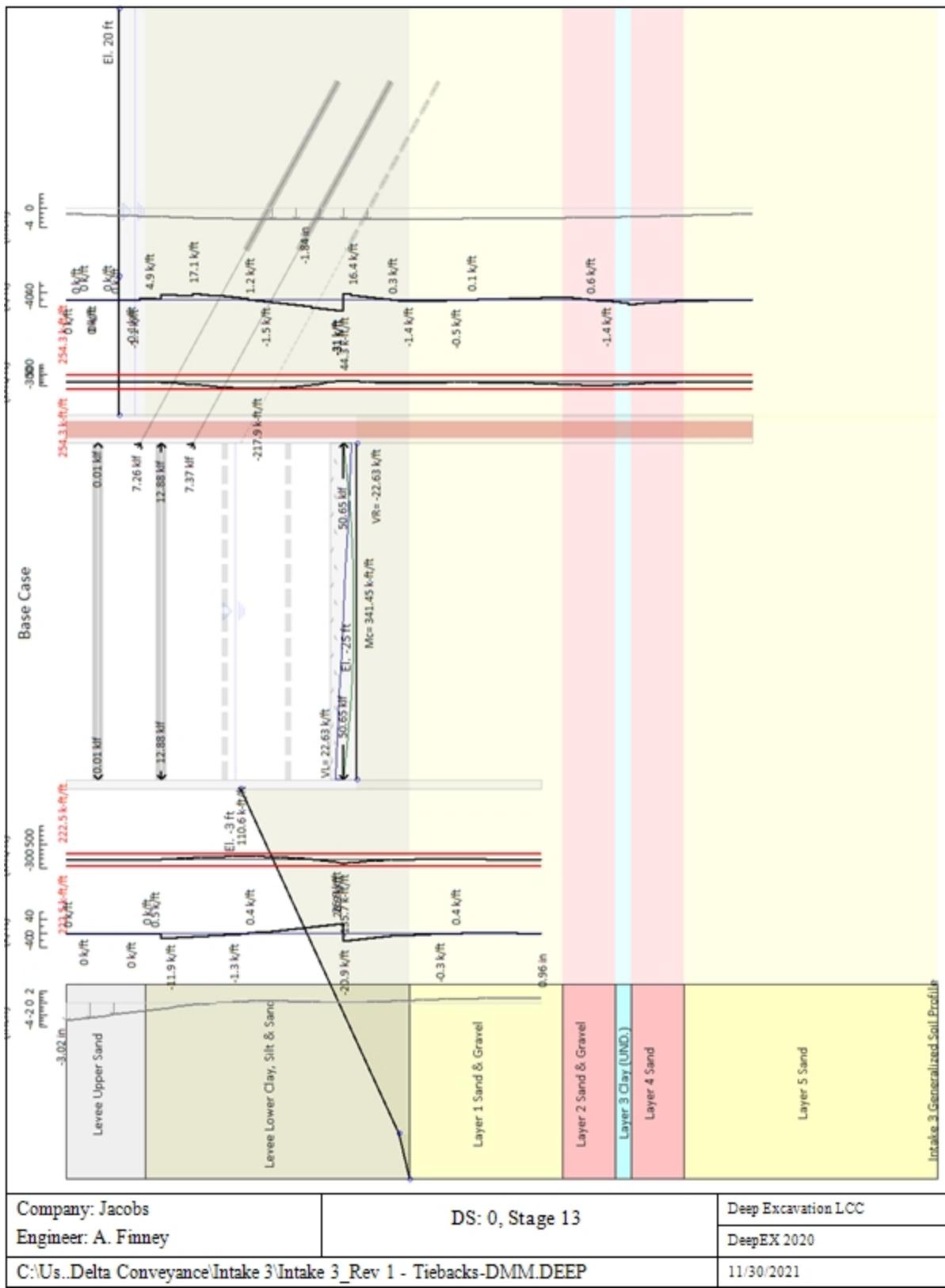


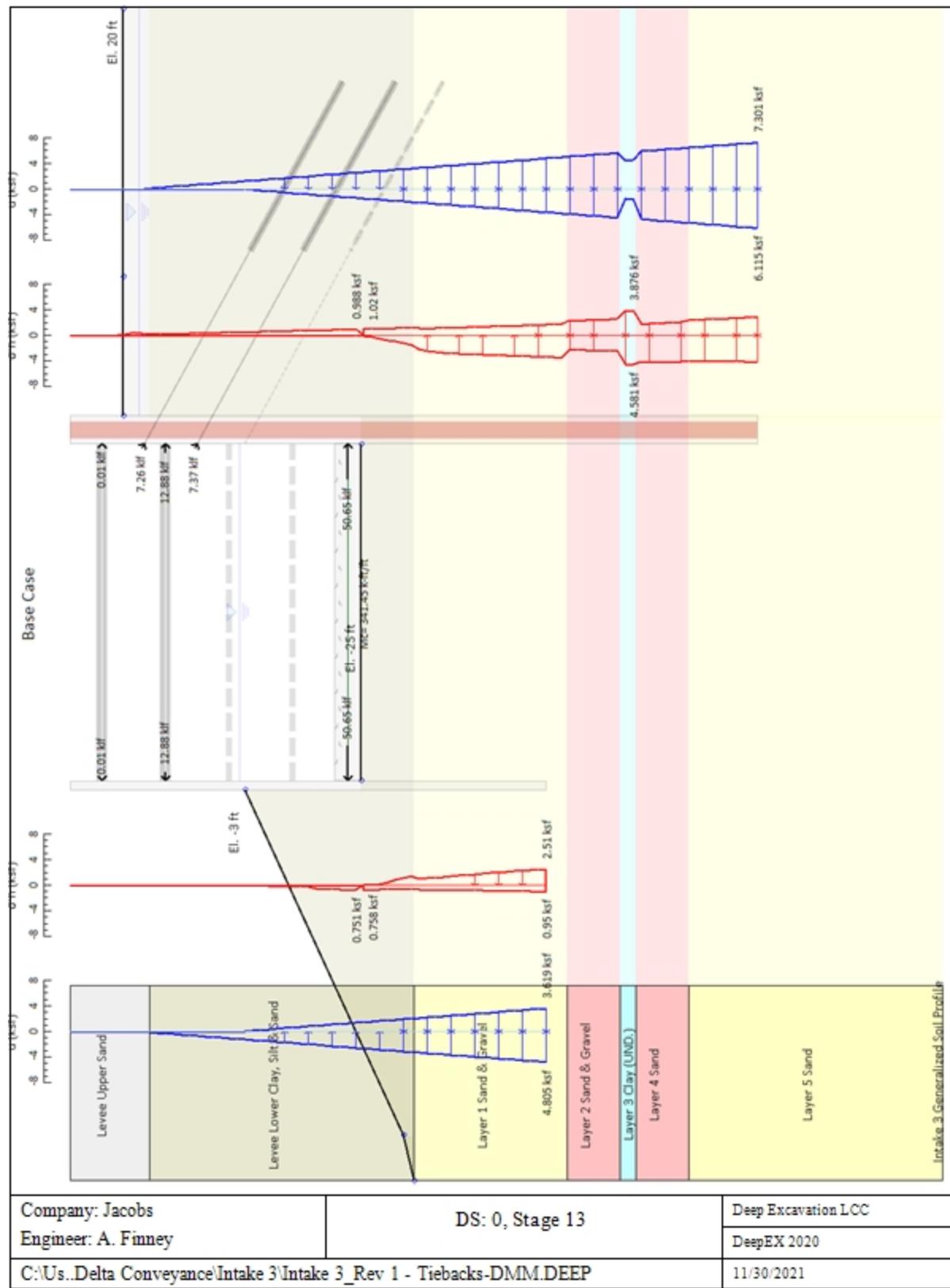


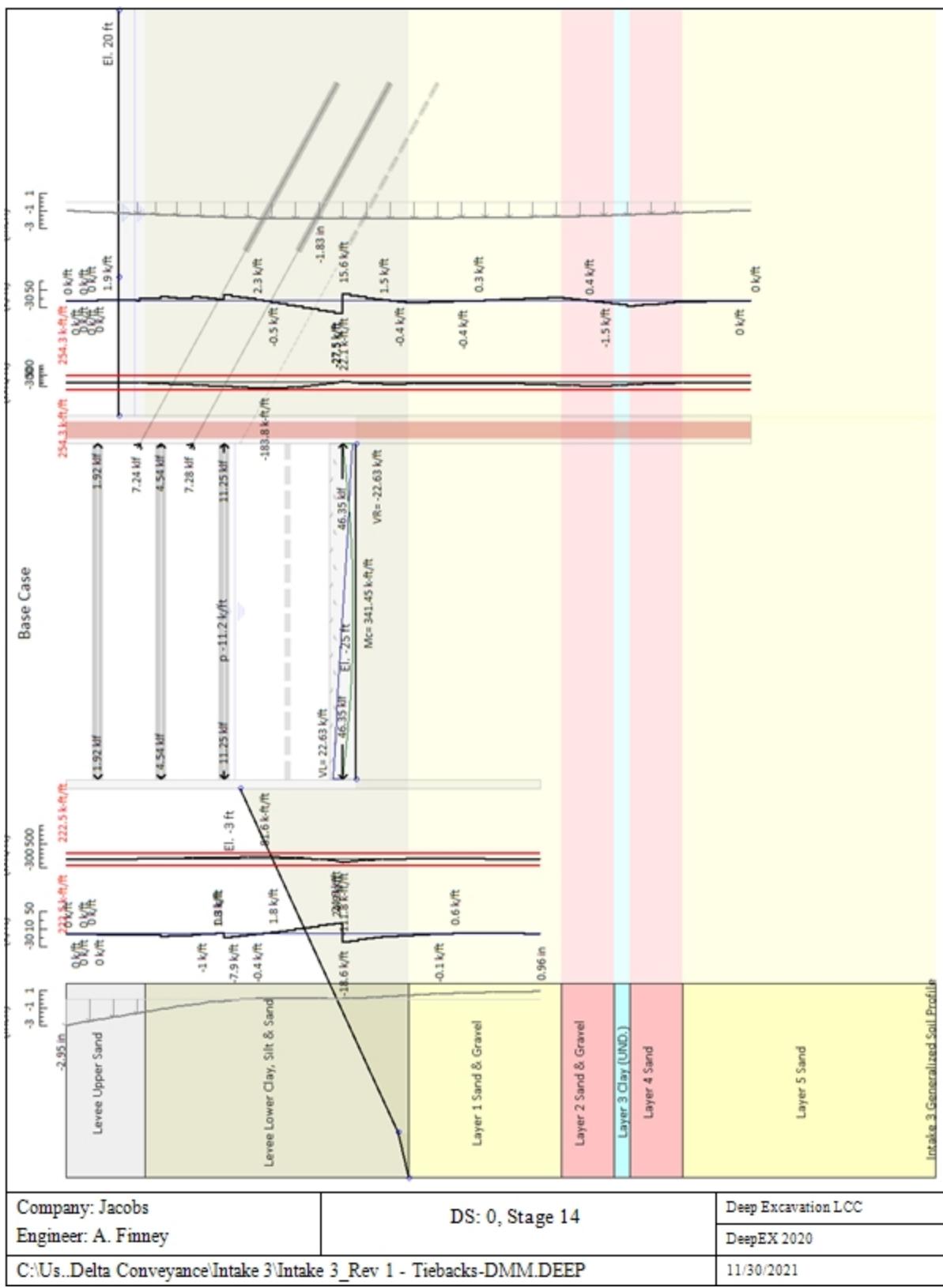


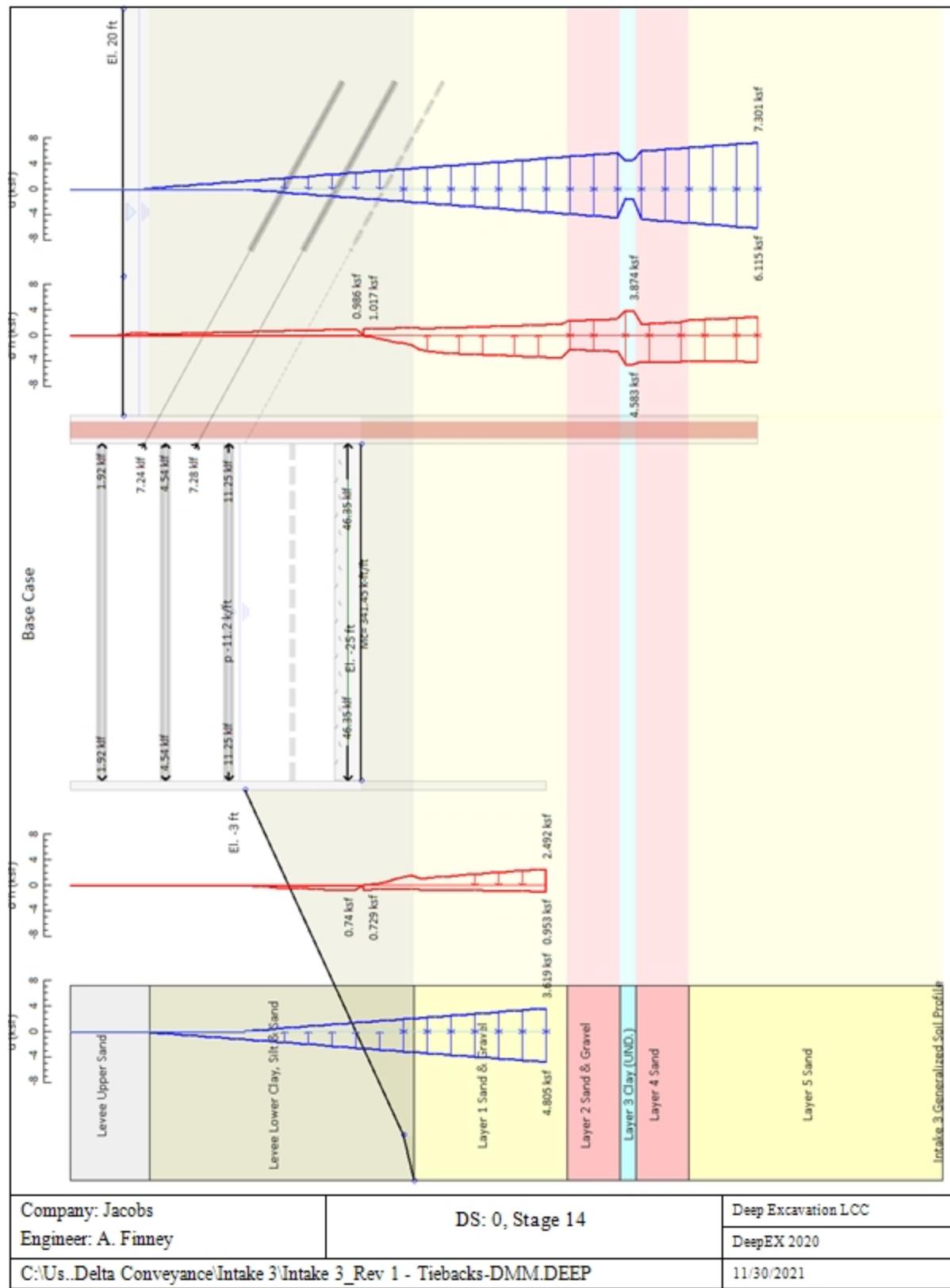


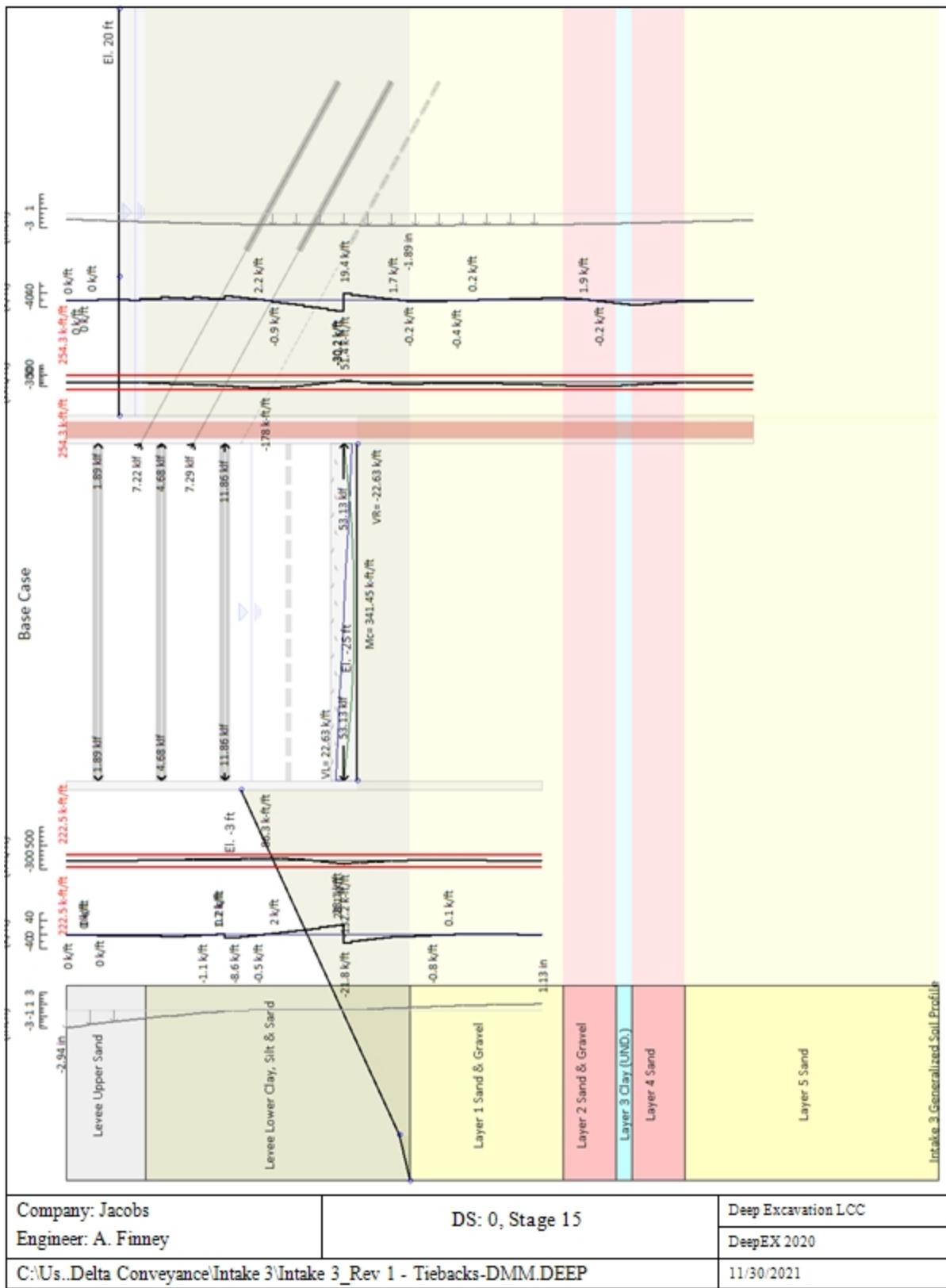


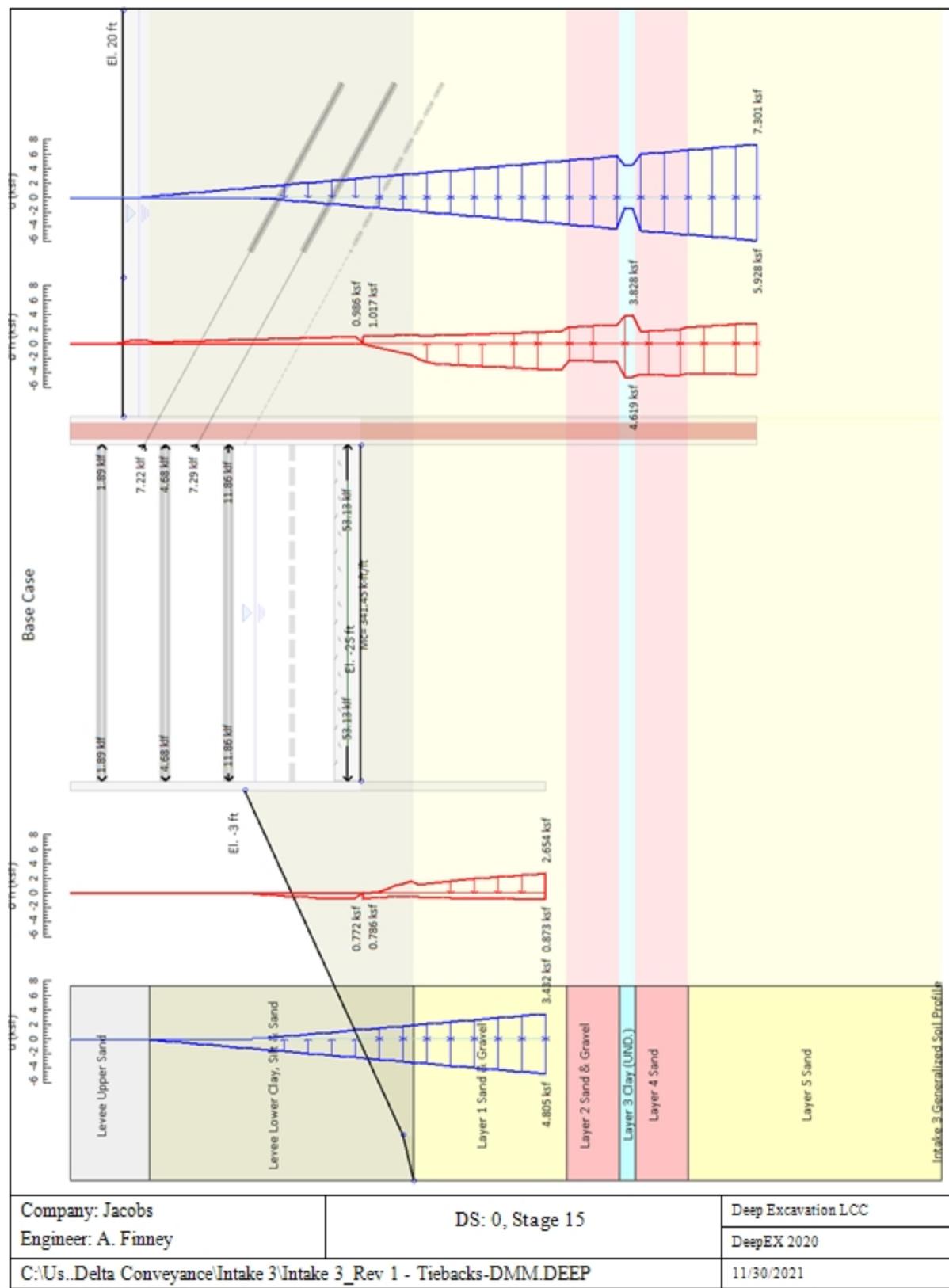


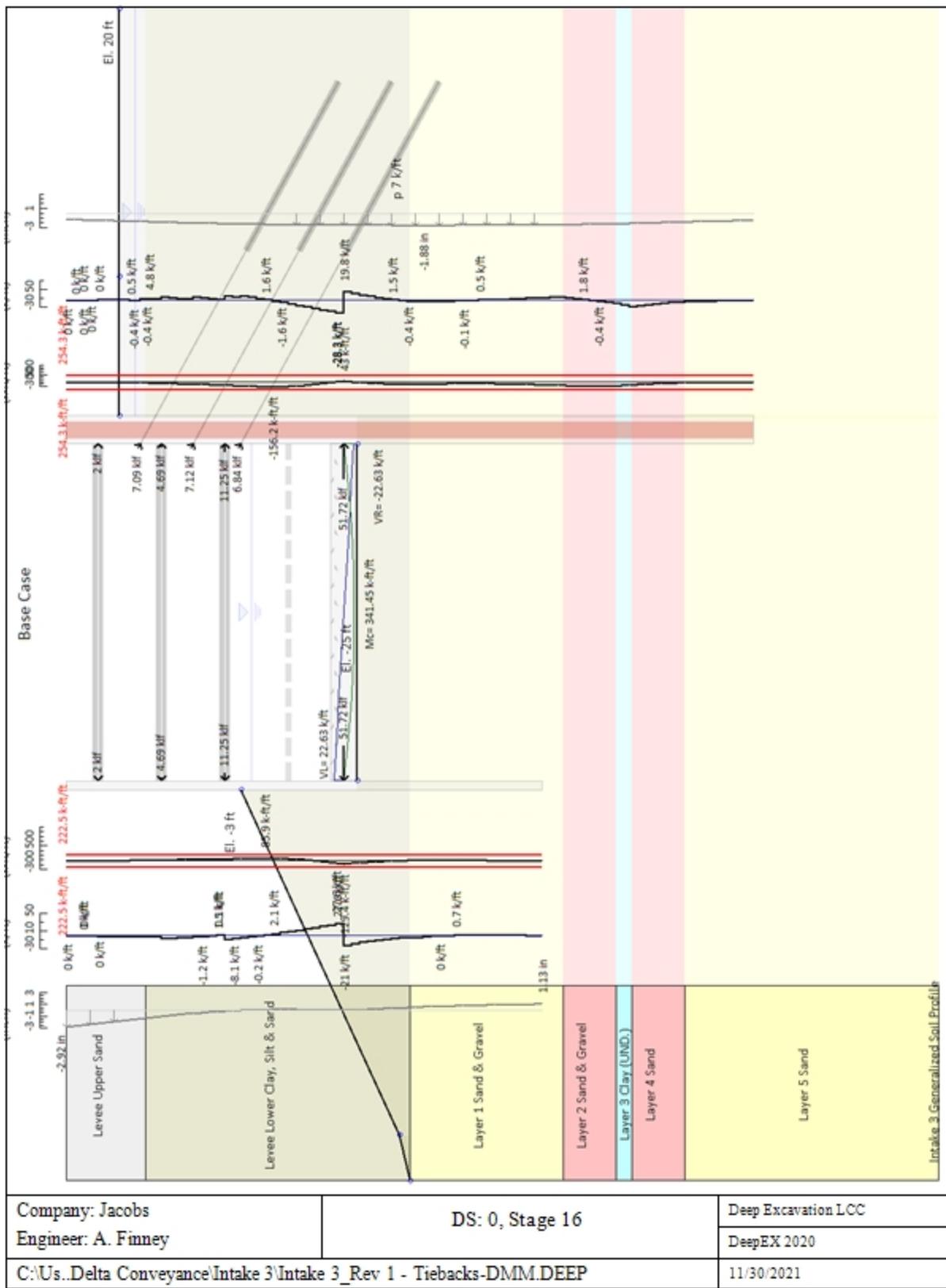


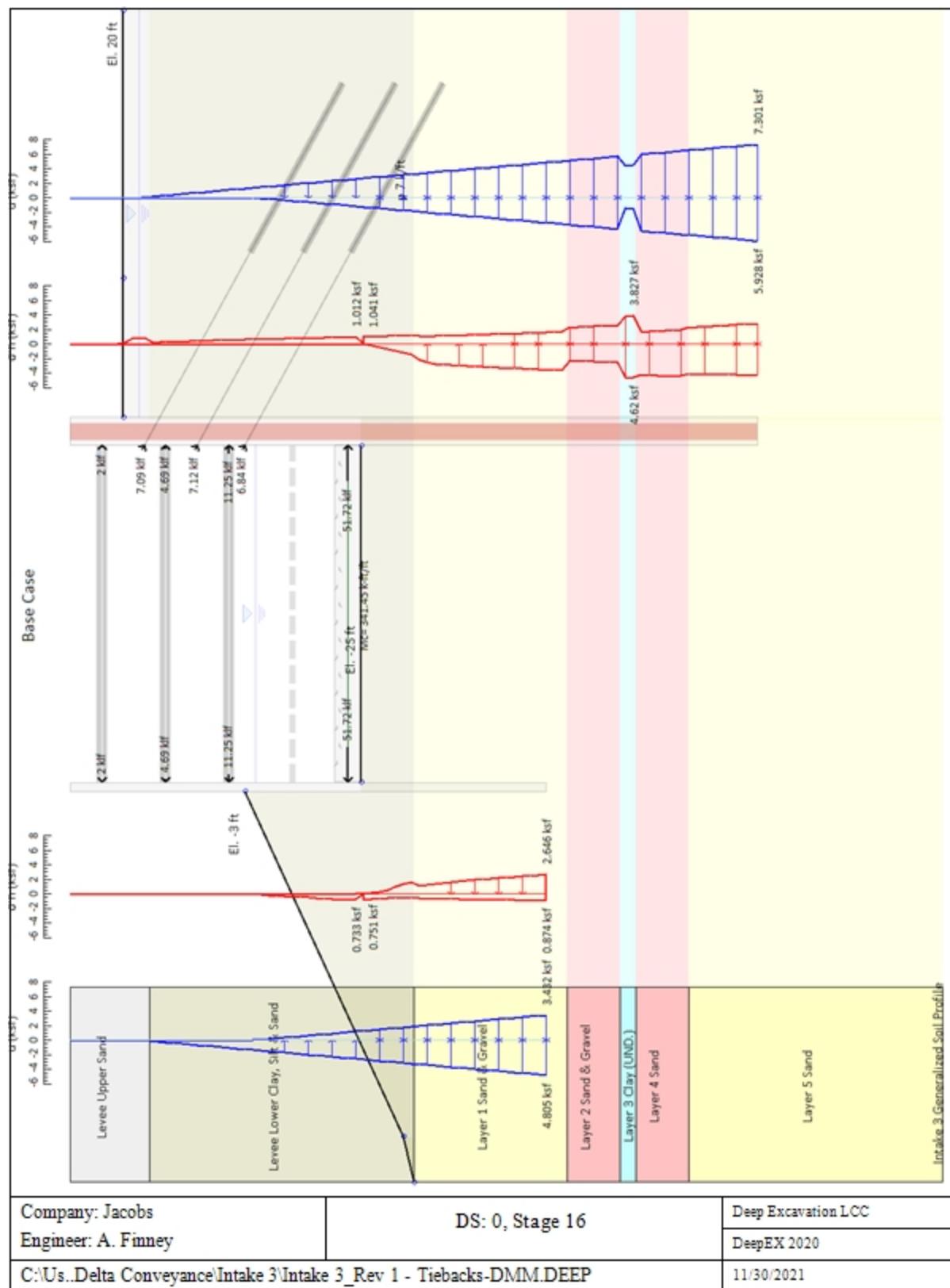


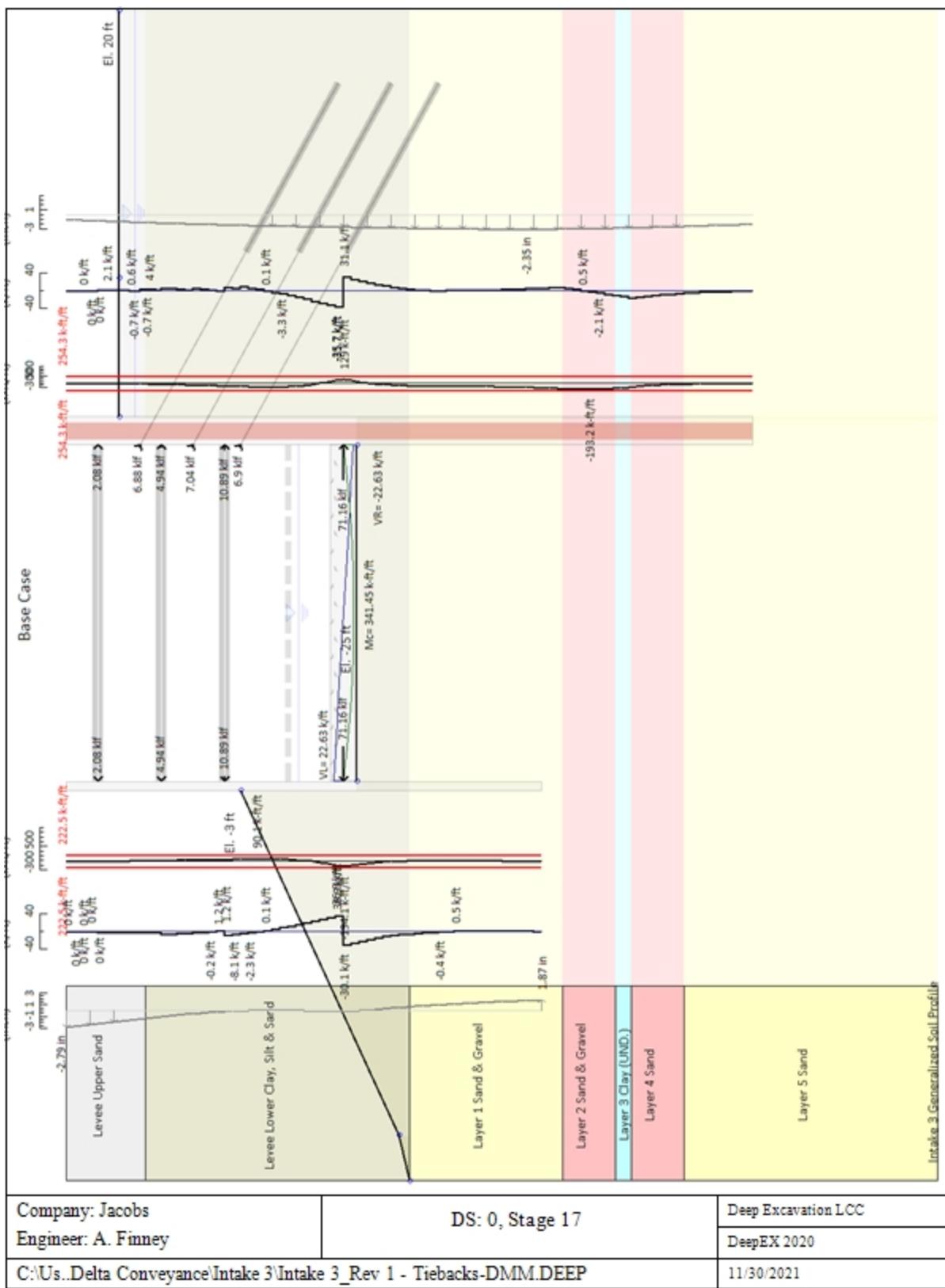


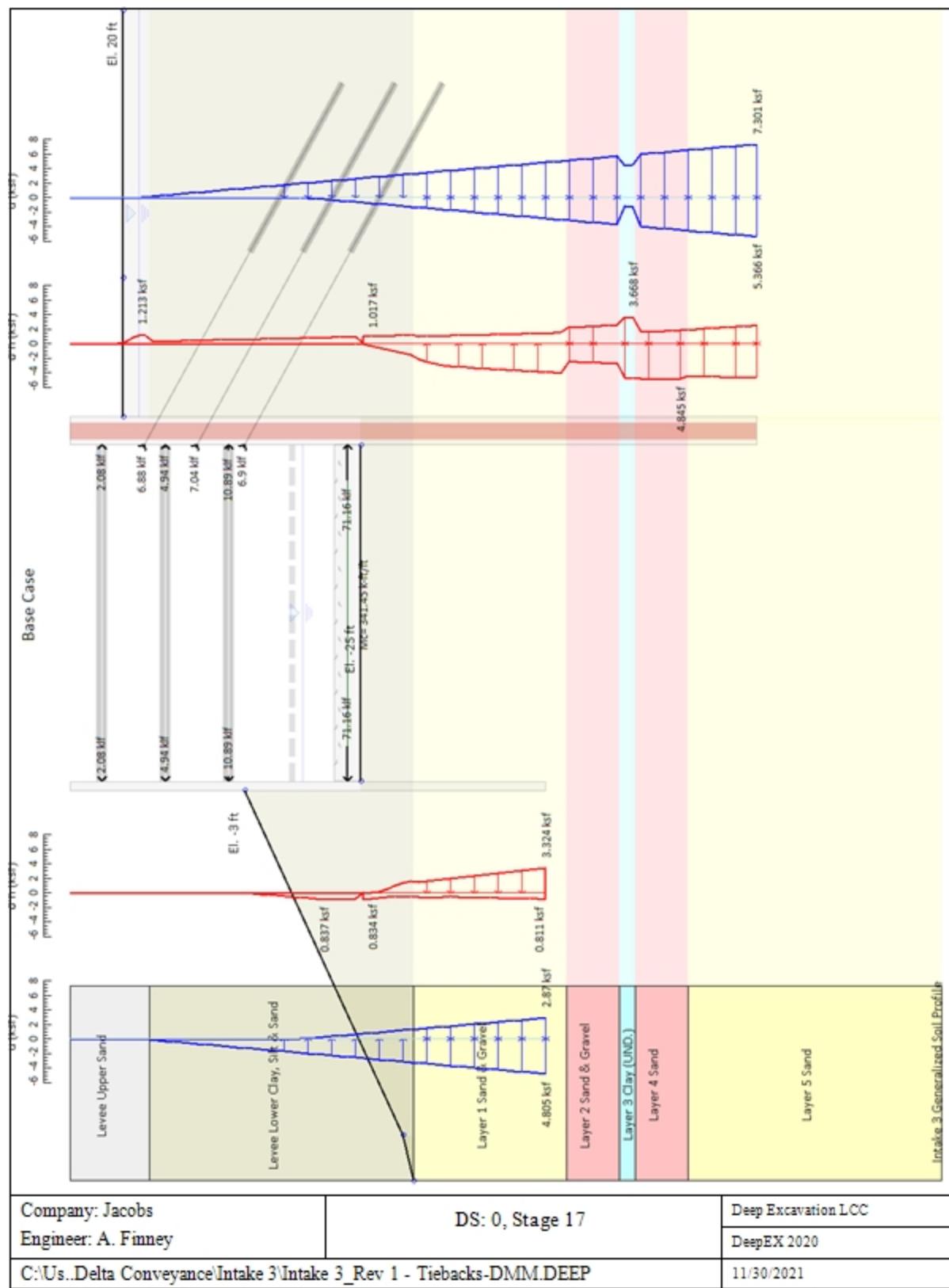


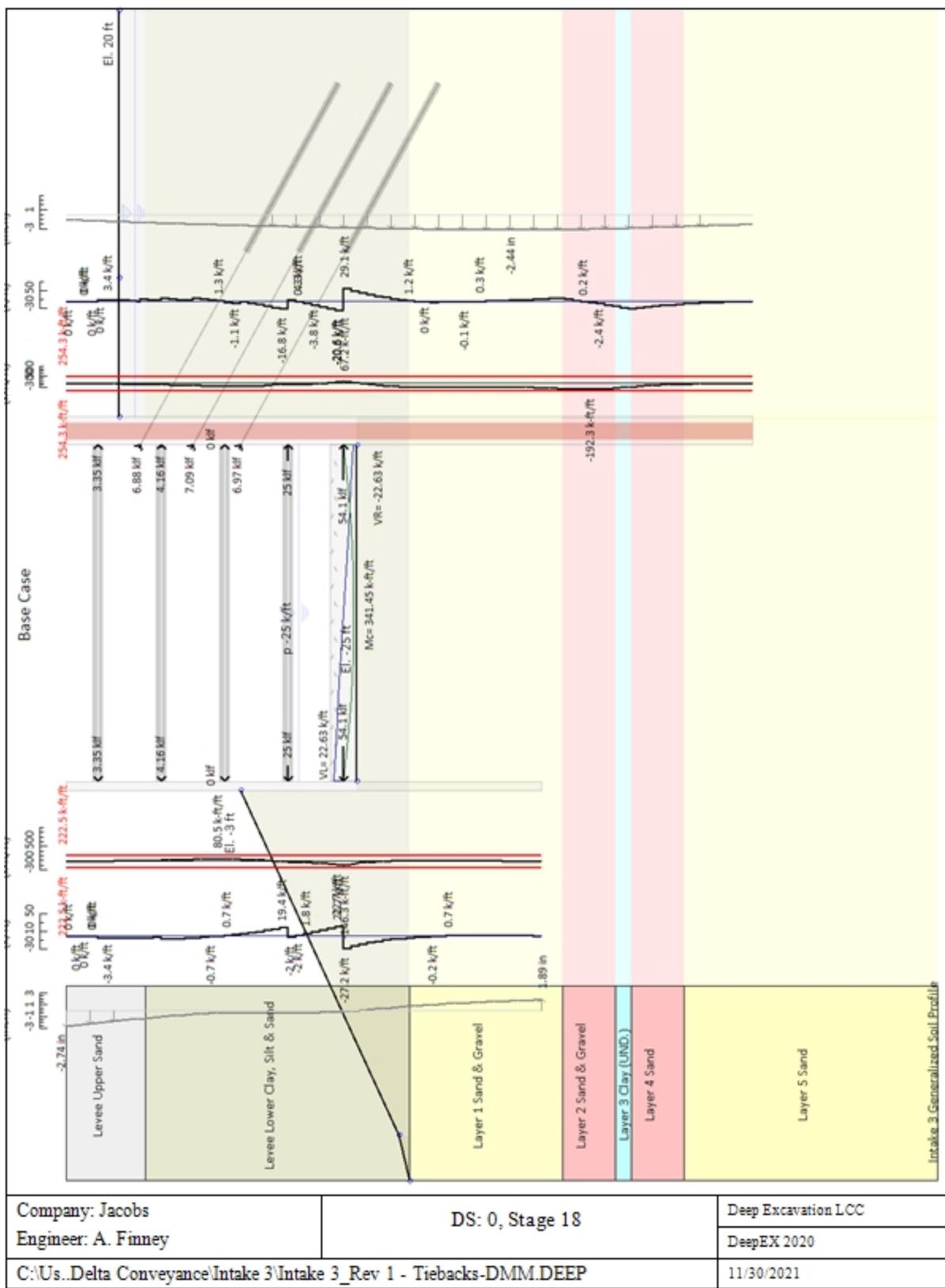


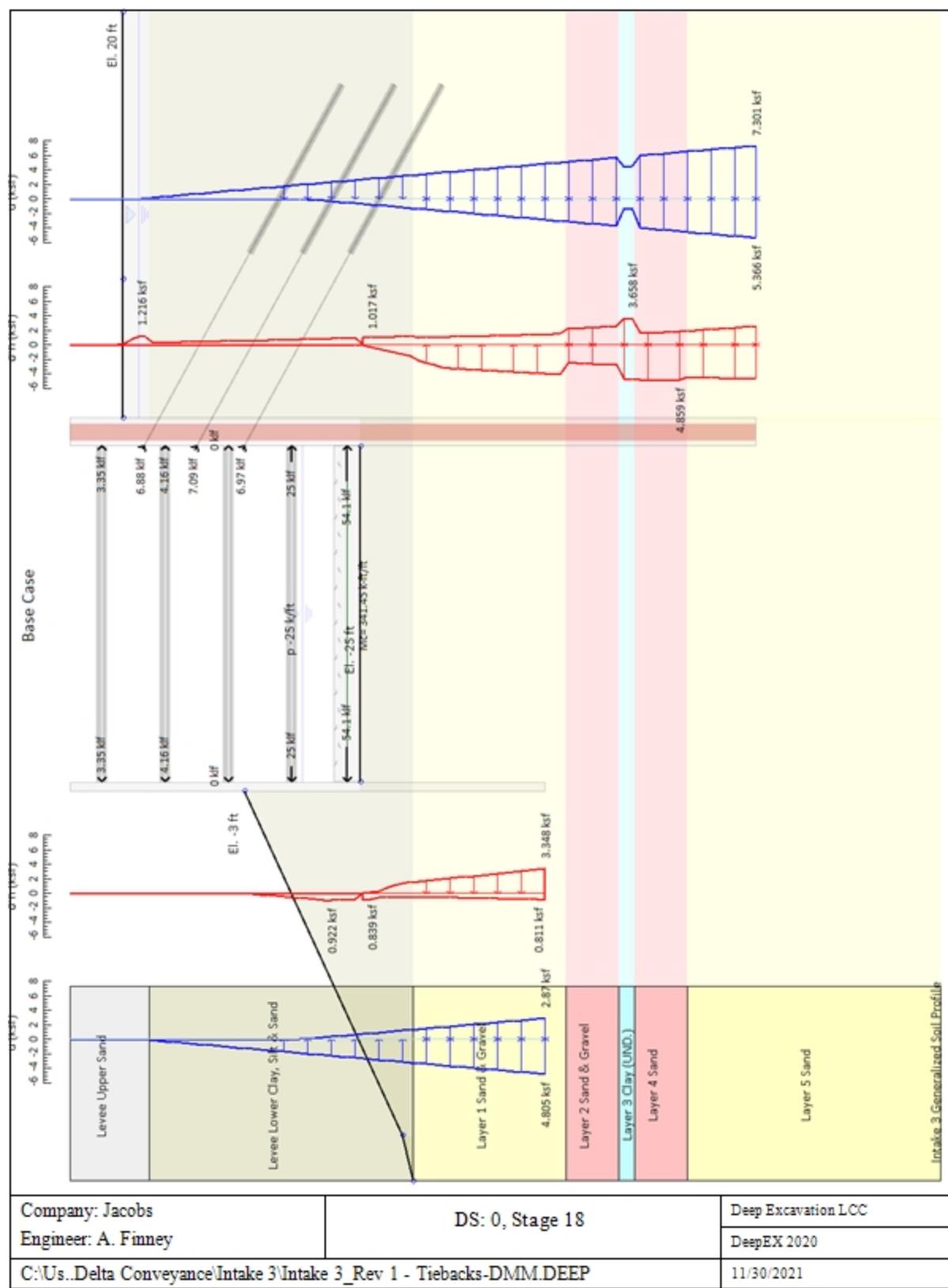


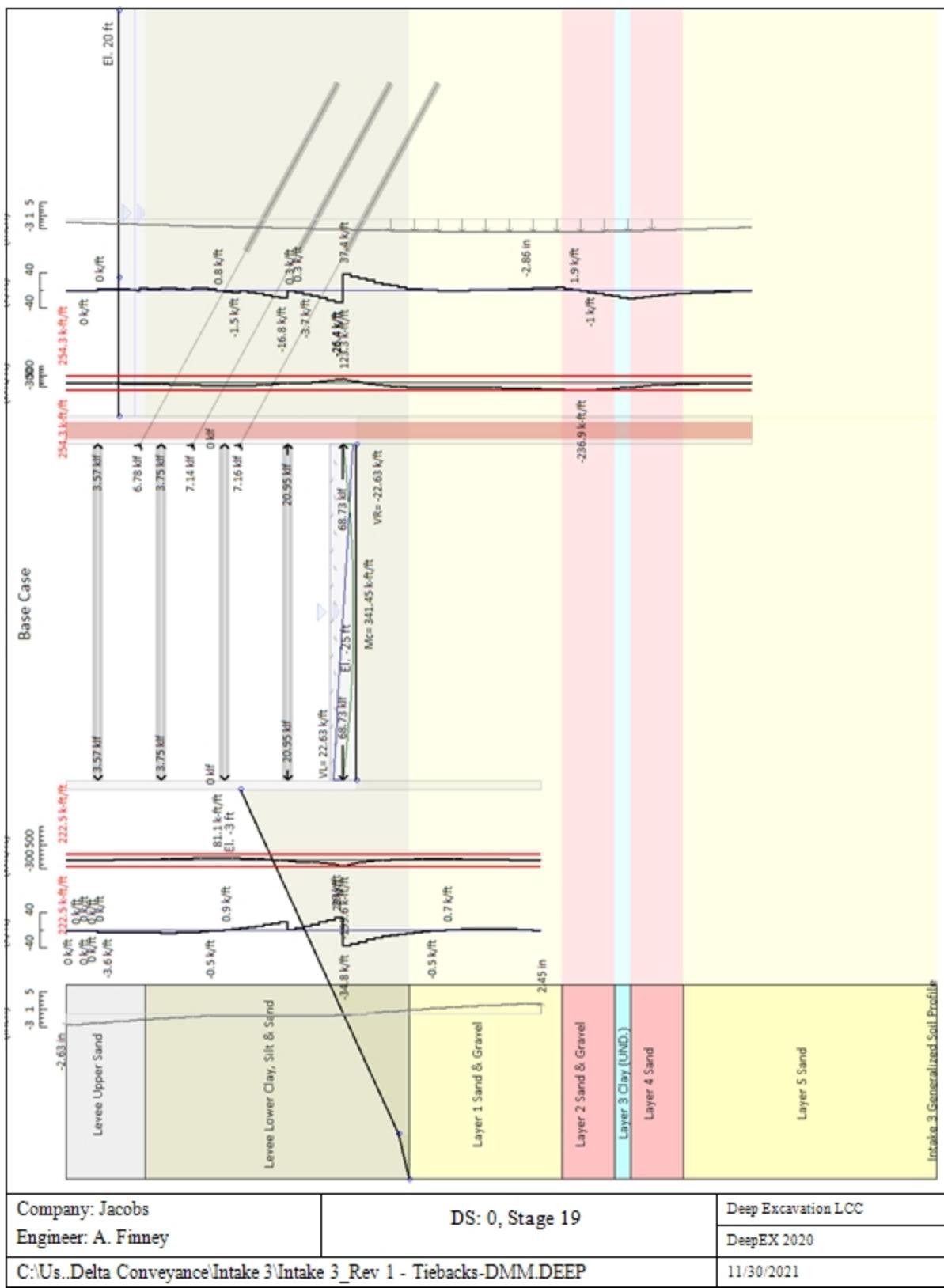


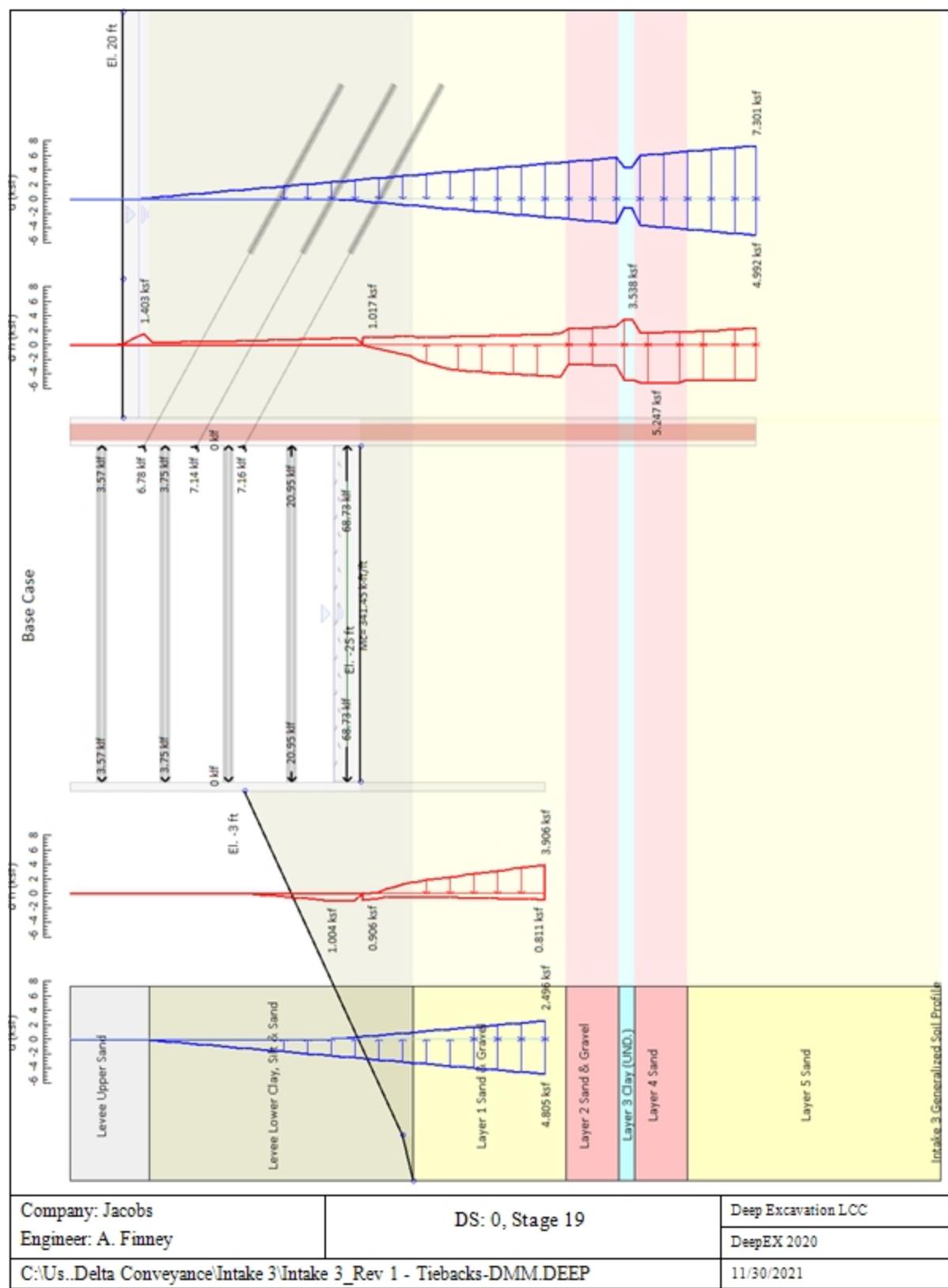












Toe stability

Embedment FS vs Stage (left wall)

	Min Toe FS	FS1 Passive	FS2 Rotation	FS3 Length (from FS1, FS2)	FS4 Mobilized Passive	FS5 Actual Drive Thrust / Theory
Stage 0	N/A	N/A	N/A	N/A	19.322	1.891
Stage 1	N/A	N/A	N/A	N/A	8.746	2.023
Stage 2	N/A	N/A	N/A	N/A	8.746	2.023
Stage 3	N/A	N/A	N/A	N/A	6.608	1.731
Stage 4	N/A	N/A	N/A	N/A	6.602	1.732
Stage 5	N/A	N/A	N/A	N/A	4.927	1.455
Stage 6	N/A	N/A	N/A	N/A	4.973	1.466
Stage 7	N/A	N/A	N/A	N/A	4.209	1.248
Stage 8	N/A	N/A	N/A	N/A	4.205	1.248
Stage 9	N/A	N/A	N/A	N/A	8.968	2.086
Stage 10	N/A	N/A	N/A	N/A	5.889	1.895
Stage 11	N/A	N/A	N/A	N/A	4.929	1.796
Stage 12	N/A	N/A	N/A	N/A	3.703	1.462
Stage 13	N/A	N/A	N/A	N/A	3.704	1.462
Stage 14	N/A	N/A	N/A	N/A	2.478	1.378
Stage 15	N/A	N/A	N/A	N/A	2.397	1.468
Stage 16	N/A	N/A	N/A	N/A	2.272	1.458
Stage 17	N/A	N/A	N/A	N/A	2.251	1.401
Stage 18	N/A	N/A	N/A	N/A	1.902	1.446
Stage 19	N/A	N/A	N/A	N/A	1.831	1.447
Stage 20	N/A	N/A	N/A	N/A	1.665	1.489

Embedment FS vs Stage (right wall)

	Min Toe FS	FS1 Passive	FS2 Rotation	FS3 Length (from FS1, FS2)	FS4 Mobilized Passive	FS5 Actual Drive Thrust / Theory
Stage 0	N/A	N/A	N/A	N/A	5.951	1.846
Stage 1	N/A	N/A	N/A	N/A	5.296	1.475
Stage 2	N/A	N/A	N/A	N/A	5.296	1.475
Stage 3	N/A	N/A	N/A	N/A	4.914	1.592
Stage 4	N/A	N/A	N/A	N/A	4.928	1.606
Stage 5	N/A	N/A	N/A	N/A	4.265	1.464
Stage 6	N/A	N/A	N/A	N/A	4.274	1.467
Stage 7	N/A	N/A	N/A	N/A	3.91	1.355
Stage 8	N/A	N/A	N/A	N/A	3.924	1.367
Stage 9	N/A	N/A	N/A	N/A	4.81	1.477
Stage 10	N/A	N/A	N/A	N/A	4.384	1.433
Stage 11	N/A	N/A	N/A	N/A	4.042	1.381
Stage 12	N/A	N/A	N/A	N/A	3.422	1.317
Stage 13	N/A	N/A	N/A	N/A	3.422	1.317
Stage 14	N/A	N/A	N/A	N/A	2.746	1.199
Stage 15	N/A	N/A	N/A	N/A	2.74	1.205
Stage 16	N/A	N/A	N/A	N/A	2.67	1.177
Stage 17	N/A	N/A	N/A	N/A	2.674	1.2
Stage 18	N/A	N/A	N/A	N/A	2.452	1.138
Stage 19	N/A	N/A	N/A	N/A	2.434	1.135
Stage 20	N/A	N/A	N/A	N/A	2.29	1.11

Legend: Wall embedment safety factors (toe)

Min Toe FS= Minimum wall embedment safety factor (from all analysis methods)

Limit-equilibrium analysis methods: The following safety factors may not be applicable for all stages.

FS1 Passive: Horizontal force safety factor, FS1= Resisting/Driving force

FS2 Rotation: Rotational safety factor about lowest support, FS2= Resisting moment/Driving moment

FS3 Length (from FS1, FS2): Program determines maximum required wall embedment for safety factor of 1 for methods

FS1 and FS2 (say length LFS1). Then FS length= Provided wall embedment/LFS1.

Non-linear elastoplastic analysis safety factors:

FS4 Mobilized Passive: Safety factor on mobilized passive resistance, FS4= Available passive soil resistance/Mobilized passive soil force on excavation side.

FS5 Active Drive Thrust/Theory Active: Ratio of soil thrust on retained side/ Active condition theoretical minimum thrust.

This factor is not as critical, and indicates how close to active conditions the model is.

General recommendations on wall embedment (excluding FS5):

When then excavation is designed with allowable standards, engineers generally use minimum safety factors from 1.2 to 1.5 depending on the level of confidence. A minimum safety factor of 1.2 is generally applied on FS3.

With ultimate limit state designs (such as Eurocode 7, and LRFD) the required safety factor must generally be greater than 1.0. In non-linear solutions it might be impossible to achieve exactly 1 on FS4 as this would likely trigger overall failure.