Appendix B10. Conceptual Intake Cofferdam Construction (Final Draft)

1. Introduction and 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 The initial, now superseded, conceptual approach is presented in Attachment 1.

The Project includes two tee screen intake structures, C-E-3 and C-E-5, located at river mile (RM) 39.4 and 36.8 on the Sacramento River, each capable of conveying up to 3,000 cubic feet per second for a total Project flow capacity of 6,000 cubic-feet-per-second (cfs). Temporary in-river cofferdam structures are planned at the two Intakes 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

- Introduction and Purpose
- Subsurface Conditions
- Approach
- Analysis
- Results
- Duration
- Intake Structure Configuration
- References
- Attachment 1 – Pile Driving Analysis for Cofferdam Construction *
  - 1-1 Boring Logs
  - 1-2 GES Note on Sheet Pile Drivability with Vibratory Methods
  - 1-3 GRLWEAP Output Reports
- Attachment 2 – Results of Analysis by DeepEx

* *Note: initial conceptual cofferdam approach, now superseded*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-3

The Intake C-E-3 structure would be located 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.

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.

2.2 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, DCR-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 217,056 blows for the Intake C-E-3 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).

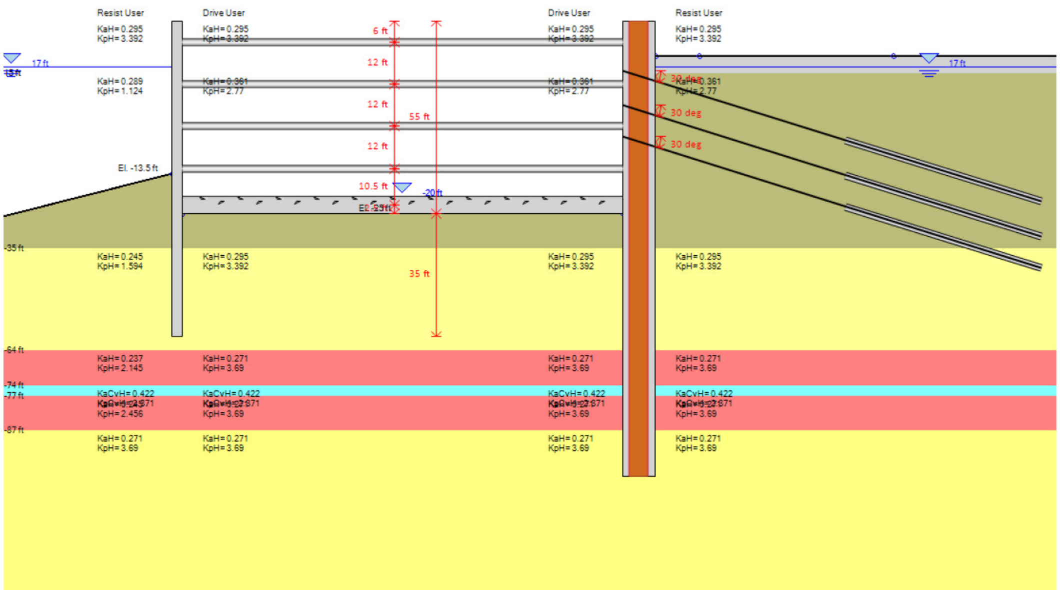


Figure 2. Revised Conceptual Cofferdam Concept

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

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 utilizing tee fish screens using an elastoplastic analysis with the software package DeepEx 2018 (Deep Excavation LLC, 2018). 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-3 and C-E-5

Intake	Estimated Pile Tip Elevation (feet)	Flow (cfs)	Screen Type	Number of sheetpile pairs	Blows[a]	Total Number of Blows On-land	Total Number of Blows In-water	Time[b] (minutes)	Total Time (hours)[c]
C-E-3	-60	3,000	Tee[e]	420	19	-	7,980	2[d]	15
C-E-5	-55	3,000	Tee[e]	410	10	-	4,100	2[d]	14

[a] Estimated per sheetpile pair from Figures 1 through 2 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.

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 210 hours, or roughly 4 weeks for Intake 5, assuming five 10-hour workdays per week. During this 4-week period there would be a total of 840 minutes (14 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 9 weeks and 14 hours of impact driving for Intake 3. This approach would result in 14 hours of impact driving during a roughly 9-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.

Attachment 1
Pile-driving Analyses for Cofferdam Construction at Intakes C-E-3 and C-E-5

Attachment 1 Pile Driving Analyses for Cofferdam Construction at Intakes C-E-3 and C-E-5 (Draft)

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 C-E-3 and C-E-5 for the Delta Conveyance Project (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

2. Subsurface Conditions

2.1 Intake C-E-3

The Intake C-E-3 structure would be located 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.

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 in our analyses for conservatism. Based on this borehole, the upper soil layer at Intake C-E-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 A contains the boring DCR3-DH-014 log.

2.2 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 (River Road) along the east bank of the Sacramento River. Three overwater borings (DCR5-DH-013, DCR-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 C-E-5 in our analyses for conservatism. Based on this boring, the upper soil layer at Intake C-E-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 A 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 On-land[a]	Linear Footage of Piles In-water[a]	Sheet Pile Tip Elevation (feet)	Mudline Elevation (feet)	Number of King Piles Required (by type) On Land[b]	Number of Sheet Pile Pairs Required (by type) On Land[b]	Number of King Piles Required (by type) In-Water[b]	Number of Sheet Pile Pairs Required (by type) In-Water[b]
C-E-3	1563	2151	-60	-32.5	256	256	352	352
C-E-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 B.

3.2 Impact Pile Driving

Where vibratory installation was rated as "moderate to difficult" or "difficult" (Attachment B), 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 C-E-3.

Table 2. Summary of Empirical Analysis of Vibratory Pile Installation Considerations at Intake C-E-3

Depth Below Mudline From (feet)	Depth Below Mudline To (feet)	Elevation From (feet)	Elevation To (feet)	Reported Blow Counts (SPT "n" in blows per foot)	Soil Type (USCS)	Vibratory Drivability Assessment[a]
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 A 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 2, 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 3 summarizes the results of the empirical analysis of vibratory pile installation at Intake C-E-5.

Table 3. Summary of Empirical Analysis of Vibratory Pile Installation Considerations at Intake C-E-5

Depth Below Mudline From (feet)	Depth Below Mudline To (feet)	Elevation From (feet)	Elevation To (feet)	Reported Blow Counts (SPT "n" in blows per foot)	Soil Type (USCS)	Vibratory Drivability Assessment[a]
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 A 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 36 feet. Below this depth, impact methods would probably to 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 Intake C-E-5, the model assumed a full hammer stroke height of 11.5 feet. For Intake C-E-3, the model assumed a full hammer stroke height of 6.8 feet to reduce driving stress on the piles. Figures 1 and 2 include drivability model results with pile tip elevations versus cumulative pile strikes (hammer blows). Table 4 summarizes the results for both the intake locations. Attachment C contains GRLWEAP output reports.

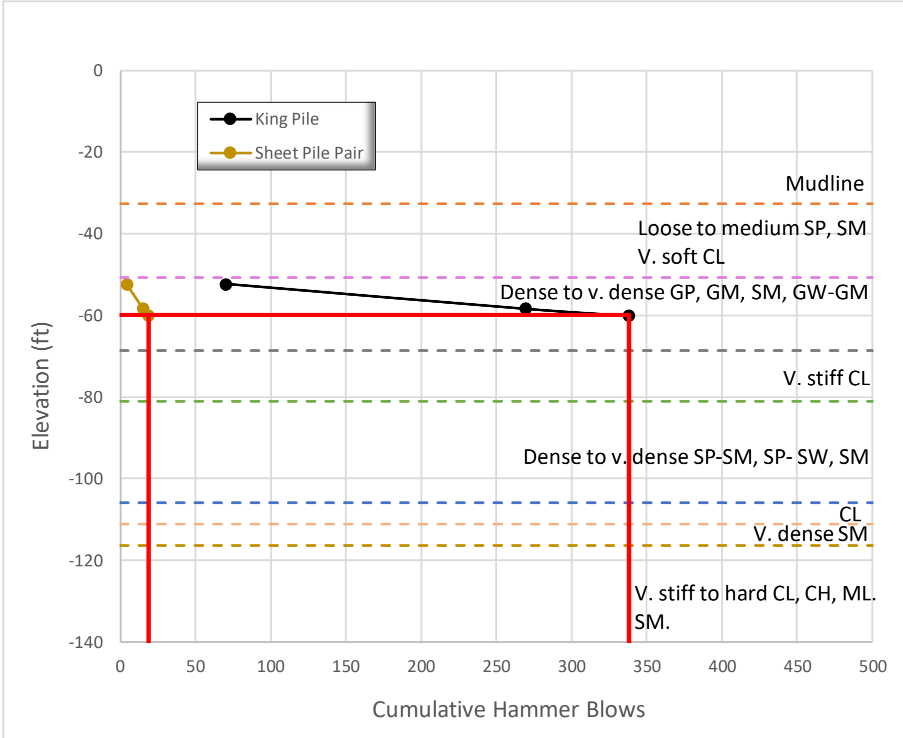


Figure 1. Impact Hammer Pile Drivability Plot for Intake C-E-3

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

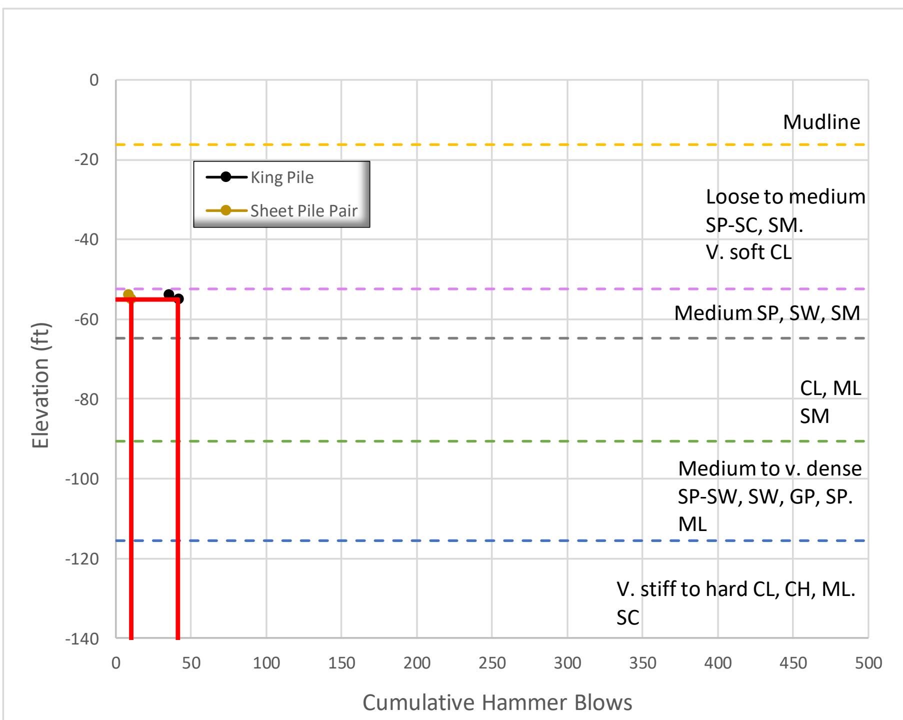


Figure 2. Impact Hammer Pile Drivability Plot for Intake C-E-5

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

4.1.1 Pile Drivability Summary

Table 4 summarizes the pile drivability evaluation for Intakes C-E-3 and C-E-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 4. Summary of Pile Drivability Evaluations for Intakes C-E-3 and C-E-5

Intake	Estimated Blows per King Pile[a]	Estimated Blows per Sheet Pile Pair[a]	Total Number of Blows On-Land[b]	Total Number of Blows In-Water[b]	Driving Time per King Pile (minutes)	Driving Time per Sheet Pile Pair (minutes)	Total Driving On-Land Time (hours)[c]	Total Driving In-Water Time (hours)[c]
C-E-3	338	19	91,392	125,664	6	2[d]	35	50
C-E-5	41	10	13,923	18,615	2	2[d]	20	25

[a] From Figures 1 and 2.

[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 C-E-3 and C-E-5 would be approximately 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 C-E-3 and C-E-5 will be approximately 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 significant unsupported length is too great for the augers to handle structurally at both 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.

Attachment A
Boring Logs

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**	
[X] VERTICAL	[ ] 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)	

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	Water Content % (LABORATORY DATA)	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
10	0		0.0 to 4.9' Top barge deck to water line.														
5	5		4.9 to 43.0' Sacramento River.														
0	10																
-5	15																
	20																

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

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: Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
-10	20		4.9 to 43.0' Sacramento River. *(Continued)*														
-15	25																
-20	30																
-25	35																
-30	40																
	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
	45																

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

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	Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
-35	45		43.0 to 50.0' Soft river bottom muck. No Sample Taken. *(Continued)*	Rotary	NSD												
-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.		SPT	73	2 5 4	9	11								S01A-050.0-051.5
	51.4	SM	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	43											P01A-052.5-053.0
-45	55				SPT	67	1 1 4	5	6								S02A-055.0-056.5
	57.8	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	80				0.5P							P02A-057.8-058.2
-50	59.5	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.		SPT	87	2 4 8	12	15								S03A-060.0-061.5
	61.1	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	14											End Drilling 8/22/2012 Start Drilling 8/23/2012
-55	65				SPT	100	29 45 36	81	98								S04A-065.2-066.1
	66.1	(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%.												13		S04B-066.1-066.5
	68				PCORE	100											P04A-068.0-068.5
	69.6	(SM)g	*Description on next page.*														
	70																

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

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	Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
-60	70	(SM)g	69.6 to 74.5' SILTY SAND with Gravel, (SM)g: About 65% fine to coarse, subangular sand; about 20% fine, subangular to subrounded gravel; about 15% nonplastic fines; medium dense, gray, wet; no reaction with HCl. *(Continued)*	Rotary	SPT	53	10 14 15	29	35								S05A-070.0-071.5
	72.5		From 72.5' About 50% fine to coarse sand; about 35% fine gravel; about 15% nonplastic fines.		PCORE	63											
-65	74.5	GW-GM	74.5 to 76.7' Poorly Graded GRAVEL with Silt and Sand, (GW-GM): About 55% fine, subrounded gravel; about 35% fine to coarse sand; about 10% nonplastic fines; very dense, greenish gray, wet; no reaction with HCl; trace coarse subrounded gravel.		SPT	33	9 22 28	50	60								S06A-075.0-076.5
	76.7	SM	76.7 to 79.0' SILTY SAND, (SM): About 80% fine to medium sand; about 10% fine, subrounded gravel; about 10% nonplastic fines; greenish gray, moist; no reaction with HCl.		PCORE	54											P06A-077.9-078.4
-70	79.0	CL	79.0 to 84.0' LEAN CLAY, (CL): About 90% low plasticity, medium dry strength, slow dilatancy, low toughness fines; about 10% fine sand; stiff, greenish gray, moist; no reaction with HCl.		SPT	73	12 14 16	30	36	1.5P							S07A-080.0-081.5
	81.5		From 81.5' hard.		PCORE	37				>4.5P							
-75	84.0	(CL)s	84.0 to 91.5' LEAN CLAY with Sand, (CL)s: About 80% low plasticity, low dry strength, slow dilatancy, low toughness fines; about 20% fine sand; very stiff, light greenish gray, moist; no reaction with HCl.		SPT	73	8 10 11	21	25	2.5P		29	39	19	82		S08A-085.0-086.5 Lab. Classification: LEAN CLAY with SAND (CL)
	86.6		From 86.6' hard, greenish gray.		PCORE	9											
-80	90				PITCHER	100											T01A-090.0-092.6
	91.5	SP-SM	91.5 to 101.0' Poorly Graded SAND with Silt, (SP-SM): About 90% fine to medium sand; about 10% nonplastic fines; dense, dark greenish gray, moist; no reaction with HCl.														P10A-092.6-093.1
	93				PCORE	67											
	95																

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

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	Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
-85	95–97	SP-SM	91.5 to 101.0' Poorly Graded SAND with Silt, (SP-SM): About 90% fine to medium sand; about 10% nonplastic fines; dense, dark greenish gray, moist; no reaction with HCl. *(Continued)* At 96.3' 0.3' layer containing coarse sand.	Rotary	SPT	93	6 11 21	32	39		Yes				11		S09A-095.0-096.5
	97–100	SP-SM	From 98.0' light greenish gray.	Rotary	PCORE	94											
-90	100–101	SP-SM	From 100.5' dark greenish gray.	Rotary	SPT	93	14 18 25	43	52		Yes						S10A-100.0-101.5
	101–105	SP	101.0 to 106.0' Poorly Graded SAND, (SP): About 95% fine sand; about 5% nonplastic fines; very dense, light greenish gray, moist; no reaction with HCl. From 103.0' fine to medium sand; trace coarse sand and trace fine subrounded gravels.	Rotary	PCORE	37											
-95	105–106.5	SP		Rotary	SPT	100	10 26 28	54	65		Yes						S11A-106.0-106.5
	106–109	(SW)g	106.0 to 109.0' Well-Graded SAND with Gravel, (SW)g: About 75% fine to coarse, subangular sand; about 20% fine, subangular to subrounded gravel; about 5% nonplastic fines; very dense, greenish gray, moist; no reaction with HCl.	Rotary	PCORE	40					Yes						P13A-106.9-107.4
-100	109–113.5	SP-SM	109.0 to 113.5' Poorly Graded SAND with Silt, (SP-SM): About 90% fine to medium sand; about 10% nonplastic fines; dense, greenish gray, moist; no reaction with HCl.	Rotary	SPT (110–111.5)	73	10 19 21	40	48		Yes				11		S12A-110.0-111.5
				Rotary	PCORE (111.5–115)	20											End Drilling 8/23/2012 Start Drilling 8/24/2012
-105	113.5–116.4	SM	113.5 to 116.4' SILTY SAND, (SM): About 65% fine to medium sand; about 35% nonplastic fines; very dense, dark greenish gray, moist; no reaction with HCl.	Rotary	SPT (115–116.5)	73	17 35 42	77	93		Yes						S13A-115.0-116.5
	116.4–120	(CL)s	116.4 to 121.5' LEAN CLAY with Sand, (CL)s: About 80% low plasticity, low dry strength, no dilatancy, low to medium toughness fines; about 20% fine sand; hard, light greenish gray, moist; no reaction with HCl.	Rotary	PCORE	74				>4.5P	Yes						P15A-118.0-118.5

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

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	Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
-110	120–121.5	(CL)s		Rotary	PITCHER	83											T02A-120.0-121.8
	121.5	SM	121.5 to 126.7' SILTY SAND, (SM): About 70% fine sand; about 30% nonplastic fines; very dense, greenish gray, moist; no reaction with HCl.	Rotary						>4.5P							Very hard below 121.5'
	122–125	SM		Rotary	PCORE	91											
-115	125–126.5	SM		Rotary	SPT	60	20 32 48	80	97								S14A-125.0-126.5
	126.7	s(ML)	126.7 to 129.6' SANDY SILT, s(ML): About 65% no to low plasticity fines; about 35% fine sand; greenish gray, moist; no reaction with HCl; slightly indurated.	Rotary	PCORE	100											
	129	s(ML)		Rotary													P17A-129.0-129.5
	129.5	s(ML)		Rotary													P17B-129.5-130.0
	129.6	SM	129.6 to 130.0' SILTY SAND, (SM): About 70% fine sand; about 30% nonplastic fines; greenish gray, moist; no reaction with HCl.	Rotary													
-120	130–131.5	ML	130.0 to 132.4' SILT, (ML): About 90% no to low plasticity, rapid dilatancy, low toughness fines; about 10% fine sand; very stiff, light greenish gray, moist; no reaction with HCl.	Rotary	SPT	100	10 15 17	32	39	3.0P		45	NP	NP			S15A-130.0-131.5
	132.4	CL	132.4 to 140.0' LEAN CLAY, (CL): About 90% low plasticity, low dry strength, slow dilatancy, low toughness fines; about 10% fine sand; hard, moist; no reaction with HCl.	Rotary	PCORE	83				4.0P							
	133.5	CL		Rotary													P18A-133.5-134.0
-125	135–136.5	CL	At 135.0' 1.2 foot long vertical calcite vein runs through SPT sample and reacts strong to HCL.	Rotary	SPT	80	9 19 22	41	50								S16A-135.0-136.5
	137–140	CL	From 137.0' calcium carbonate inclusions, react strong to HCl.	Rotary	PCORE												
-130	140–142.5	CH	140.0 to 151.2' FAT CLAY, (CH): About 90% medium plasticity, medium dry strength, slow dilatancy, medium toughness fines; about 10% fine sand; very stiff, dark greenish gray, moist; no reaction with HCl.	Rotary	PITCHER	100						57	77	50		CR UU XR	T03A-140.0-142.5
	142.5	CH		Rotary						3.5P							P20A-142.5-143.0
	143–145	CH		Rotary	PCORE	100											

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

Elevation, feet	Depth, feet	Graphic Log	FIELD CLASSIFICATION AND DESCRIPTION
-135	145–151.2	CH	140.0 to 151.2' FAT CLAY, (CH): About 90% medium plasticity, medium dry strength, slow dilatancy, medium toughness fines; about 10% fine sand; very stiff, dark greenish gray, moist; no reaction with HCl. *(Continued)* From 147.0' hard. From 149.0' very stiff.
-140	151.2–151.7	SM	151.2 to 151.7' SILTY SAND, (SM):.
	151.7–154.1	s(ML)	151.7 to 154.1' SANDY SILT, s(ML): About 70% no to low plasticity, no dry strength, rapid dilatancy, low toughness fines; about 30% fine sand; stiff, greenish gray, moist; no reaction with HCl.
-145, -150, -155	154.1–170	CL	154.1 to 171.4' LEAN CLAY, (CL): About 90% low plasticity, low dry strength, slow dilatancy, low toughness fines; about 10% fine sand; very stiff, light greenish gray, moist; no reaction with HCl. From 162.5' slightly indurated. From 165.0' medium plasticity, low dry strength fines; dark greenish gray, non-indurated.

Depth, feet	Drilling Method	Sampled Interval	Recovery %	Blows per 6 in.	SPT N Value	N_{60}(ASTM)	PP or TV, tsf	Retained Sample	Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
145.0–146.5	Rotary	SPT	73	12 19 25	44	53		Yes						S17A-145.0-146.5
146.5–150.0	Rotary	PCORE	86				>4.5P, >4.5P, 3.5P							
150.0–151.5	Rotary	SPT	87	11 17 20	37	45		Yes						S18A-150.0-151.5
151.5–155.0	Rotary	PCORE	100				2.0P, 3.0P	Yes (153.5–154.0)						P22A-153.5-154.0 Boarderline silt
155.0–156.5	Rotary	SPT	100	5 13 16	29	35	2.0P	Yes						S19A-155.0-156.5
156.5–160.0	Rotary	PCORE	91				4.2P	Yes (159.3–159.7)						P23A-159.3-159.7
160.0–162.5	Rotary	PITCHER	88				4.0P	Yes						T04A-160.0-162.5
162.5–165.0	Rotary	PCORE	100				2.0P							
165.0–166.5	Rotary	SPT	87	13 15 17	32	39		Yes						S20A-165.0-166.5
166.5–170.0	Rotary	PCORE	77				3.75P							

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

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	Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
-160	170–171.4	CL		Rotary	SPT	100	19 31 40	71	86								S21A-170.0-171.5
	171.4–174.5	s(CL)	171.4 to 174.5' SANDY LEAN CLAY, s(CL): About 60% low plasticity, low dry strength, slow dilatancy, low toughness fines; about 40% fine sand; very stiff, greenish gray, moist; no reaction with HCl.	Rotary	PCORE	49				3.8P							End Drilling 8/24/2012 Start Drilling 8/25/2012
-165	174.5–177.2	(CL)s	174.5 to 177.2' LEAN CLAY with Sand, (CL)s: About 75% low plasticity, low dry strength, slow dilatancy, low toughness fines; about 25% fine sand; very stiff, greenish gray, moist; no reaction with HCl.	Rotary	SPT	87	15 22 25	47	57	3.8P							S22A-175.0-176.5
	177.2–185.0	SC	177.2 to 185.0' CLAYEY SAND, (SC): About 60% fine sand; about 40% low plasticity fines; very dense, dark greenish gray, moist; no reaction with HCl.	Rotary	PCORE	100											P27A-179.0-179.5
-170	180	SC		Rotary	SPT	60	13 20 23	43	52								S23A-180.0-181.5
	182	SC	From 182.0' small voids that appear to be rootlets that decomposed or air pockets.	Rotary	PCORE	100											P28A-184.5-185.0
-175	185		Total depth 185.0' Backfilled within 15' of mudline with 95% cement/5% bentonite grout mix (% by wt.) using Tremie method														
-180	190																
	195																

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

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

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**
[X] VERTICAL [ ] 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)

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	Water Content % (LABORATORY DATA)	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
10	0		0.0 to 5.0' Top of barge deck to top of water.														
5	5		5.0 to 26.5' Top of water to mudline.														
0	10																
-5	15																
	20																

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	Drilling Method	Sampled Interval	Recovery %	Blows per 6 in.	SPT N Value	N_{60}(ASTM)	PP or TV, tsf	Retained Sample	LABORATORY DATA: Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
-10	20		5.0 to 26.5' Top of water to mudline. *(Continued)*														
-15	25																
	26.5		26.5 to 36.0' Mud.		NSD												
-20	30																
-25	35																
	36	SP-SC	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	SPT	100	3 5 5	10	12		X				10		S01A-036.0-037.5
	37.5				NSD												Cleaned out run to 43 feet
-30	40																
	43		From 43.0' medium dense, trace fine gravel.		SPT	53	6 9 11	20	24		X						S02A-043.0-043.8
	44.5					20											
	45																

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 3 of 7

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	Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
-35	45–47.5	SP-SC	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. *(Continued)*	Rotary	PCORE	20											gravel slough at top of punch core sample likely from 38-43 feet.
	47.5–49.5	s(CL)	47.5 to 54.5' SANDY LEAN CLAY, s(CL): About 60% low plasticity, slow dilatancy fines; about 40% fine sand; soft, gray, moist; no reaction with HCl.	Rotary	SPT	100	1 1 1	2	2	1.25P	✓	32	28	13	57		S03A-048.0-049.5 Lab. Classification: SANDY LEAN CLAY (CL)
-40	49.5–53		From 49.5' very soft.	Rotary	PCORE	74				0.2P, 0.1T	✓						P02A-051.6-052.1
	53–55			Rotary	SHELBY	95					✓						T01A-053.0-054.9 Shelby Tube
-45	54.5–60	SM	54.5 to 62.8' SILTY SAND, (SM): About 65% fine sand; about 35% nonplastic fines; loose, brown, moist; no reaction with HCl.	Rotary	PCORE	26					✓						Less than 50 psi down pressure. No pocket penetrometer performed at bottom of shelby, too sandy P03A-055.8-056.3
-50	60–61.5			Rotary	SPT	100	1 3 4	7	8		✓						S04A-060.0-061.5
	61.5–63			Rotary	PCORE	100											
	63–64.5	(SP)g	62.8 to 69.0' Poorly Graded SAND with Gravel, (SP)g: About 60% fine to medium sand; about 35% fine, subrounded gravel; about 5% nonplastic fines; medium dense, moist; no reaction with HCl; trace subangular coarse sand.	Rotary	SPT	53	8 8 12	20	24		✓						S05A-063.0-063.8
-55	64.5–68			Rotary	PCORE	0											
	68–69.5			Rotary	SPT	47	16 10 8	18	22		✓				6		S06A-068.0-068.7
	69–70	(SW)g	*Description on next page.*	Rotary	PCORE	37											

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

State of California
California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES

Elevation, feet	Depth, feet	Graphic Log	FIELD CLASSIFICATION AND DESCRIPTION
-60	70	(SW)g	69.0 to 72.0' Well-Graded SAND with Gravel, (SW)g: About 65% fine to coarse sand; about 30% fine, subangular to subrounded gravel; about 5% nonplastic fines; medium dense, brown, wet; no reaction with HCl. *(Continued)*
	72	SM	72.0 to 75.1' SILTY SAND, (SM): About 60% fine sand; about 40% nonplastic fines; medium dense, brown, moist; no reaction with HCl.
-65	75	CL	75.1 to 80.0' LEAN CLAY, (CL): About 90% low plasticity, no to low dry strength, slow dilatancy, low toughness fines; about 10% fine sand; very stiff, light greenish gray, moist; no reaction with HCl. From 78.0' highly indurated.
-70	80	s(ML)	80.0 to 82.5' SANDY SILT, s(ML): About 80% no to low plasticity, low dry strength, rapid dilatancy fines; about 20% fine sand; soft, brown, moist; no reaction with HCl.
	82.5	SM	82.5 to 85.7' SILTY SAND, (SM): About 70% fine sand; about 30% nonplastic fines; very dense, brown, moist; no reaction with HCl.
-75	85.7	CL	85.7 to 97.3' LEAN CLAY, (CL): About 90% medium plasticity, low dry strength, slow dilatancy, low toughness fines; about 10% fine sand; hard, light greenish gray, moist; no reaction with HCl.
-80	95		

Approx. Depth, feet	Drilling Method	Sampled Interval	Recovery %	Blows per 6 in.	SPT N Value	N_{60}(ASTM)	PP or TV, tsf	Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
70–73	Rotary	PCORE	37										P06A-070.3-070.8
73–74.5	Rotary	SPT	53	7 10 12	22	27							S07A-073.0-073.8
74.5–78	Rotary	PCORE	71				2.0P; 3.0P						P07A-076.5-077.0 Torvane fractures sample
78–80.5	Rotary	PITCHER	52										T02A-078.0-079.3 Pitcher Sample
80.5–83	Rotary	PCORE	32				0.5P						P08A-080.8-081.3
83–84.5	Rotary	SPT	87	9 22 26	48	58							S08A-073.0-084.3
84.5–88	Rotary	PCORE	74				0.2T >4.5P						P09A-086.6-087.1
88–90.5	Rotary	PITCHER	88				>4.5P	35	49	27		CU XR	T03A-088.0-090.2 Pitcher Sampler
90.5–93	Rotary	PCORE	100				3.0T >4.5P						P10A-090.5-091.0
93–94.5	Rotary	SPT	80	7 10 14	24	29							S09A-093.0-094.2
94.5–95	Rotary		100										

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

Elevation, feet	Depth, feet	Graphic Log	FIELD CLASSIFICATION AND DESCRIPTION
-85	95–97.3	CL	85.7 to 97.3' LEAN CLAY, (CL): About 90% medium plasticity, low dry strength, slow dilatancy, low toughness fines; about 10% fine sand; hard, light greenish gray, moist; no reaction with HCl. *(Continued)*
	97.3–100.9	s(ML)	97.3 to 100.9' SANDY SILT, s(ML): About 60% no to low plasticity, low dry strength, rapid dilatancy fines; about 40% fine sand; greenish gray, moist; no reaction with HCl. At 99.6' 0.5' thick Silty Sand (SM) layer.
-90	100.9–107.5	SP-SM	100.9 to 107.5' Poorly Graded SAND with Silt, (SP-SM): About 90% fine to medium sand; about 10% nonplastic fines; dense, greenish gray, moist; no reaction with HCl.
-95	107.5–112.1	(SW)g	107.5 to 112.1' Well-Graded SAND with Gravel, (SW)g: About 70% fine to coarse sand; about 25% fine, subangular to subrounded gravel; about 5% nonplastic fines; dense, greenish gray, wet; no reaction with HCl.
-100	112.1–119.0	SP-SM	112.1 to 119.0' Poorly Graded SAND with Silt, (SP-SM): About 90% fine to medium sand; about 10% nonplastic fines; very dense, dark greenish gray, moist; no reaction with HCl; trace subrounded coarse sand and subrounded fine gravel.
-105	119.0–119.7	ML	119.0 to 119.7' SILT, (ML): About 90% nonplastic fines; about 10% fine sand.
	119.7–120	(GP)s	

Drilling Method: Rotary

Depth, feet	Sampled Interval	Recovery %	Blows per 6 in.	SPT N Value	N_{60}(ASTM)	PP or TV, tsf	Retained Sample	Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
95–98	PCORE	100				3.5P, .25T, 1.5P							
97.5–98.0							P						P11A-097.5-098.0
98–99.5	SPT	73	10, 17, 28	45	54		S						S10A-098.0-099.1
99.5–103	PCORE	66											
101.0–101.5							P						P12A-101.0-101.5
103–104.5	SPT	100	6, 11, 17	28	34		S				12		S11A-103.0-104.5
104.5–108	PCORE	86											
108–109.5	SPT	73	7, 14, 23	37	45		S						S12A-108.0-109.1
109.5–113	PCORE	100											
113–114.5	SPT	73	8, 28, 29	57	69		S				7		S13A-113.0-114.1
114.5–115.0							P						P15A-114.5-115.0
114.5–118	PCORE	83											
118–119.5	SPT	73	11, 30, 32	62	75		S						S14A-118.0-119.1
119.5–120	PCORE	69											

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

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	Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
-110	120	(GP)s	119.7 to 120.7' Poorly Graded GRAVEL with Sand, (GP)s: About 75% fine, subrounded gravel; about 25% fine to medium sand. *(Continued)*	Rotary													
	121–123	(SP)g	120.7 to 125.8' Poorly Graded SAND with Gravel, (SP)g: About 70% fine to medium sand; about 25% fine, subrounded gravel; about 5% nonplastic fines; very dense, dark greenish gray, wet; no reaction with HCl; trace coarse sand.		PCORE	69					☒						P16A-121.0-121.5
	123					78	29 50/5"				☒						S15A-123.0-123.9
	124																SPT bouncing
-115	125–126				PCORE	78				>4.5P	☒						P17A-125.8-126.3
	126	CL	125.8 to 132.8' LEAN CLAY, (CL): About 90% medium plasticity, medium dry strength, no dilatancy, low to medium toughness fines; about 10% fine sand; hard, greenish gray, moist; no reaction with HCl; slightly induraed.														
	128				SPT	67	11 18 20	38	46	3.5P	☒	28	50	29			S16A-128.0-129.0
-120	130		From 130.0' Trace calcium carbonate inclusions with weak reaction to HCl.		PCORE	100				4.25P 0.7T							
	133	CH	132.8 to 142.5' FAT CLAY, (CH): About 95% high plasticity, high dry strength, no dilatancy, high toughness fines; about 5% fine sand; hard, greenish gray, moist; no reaction with HCl.		SPT	60	9 13 15	28	34	4.0P	☒						S17A-133.0-133.9
-125	135				PCORE	40				4.25P 0.4T							
	138				SPT	67	8 12 14	26	31		☒						S18A-138.0-139.0
-130	140					100											
	140.5–142.9				PITCHER	96					▮	26	51	31		CR UU XR	T04A-140.5-142.9
	142.5	(CL)s	142.5 to 150.9' LEAN CLAY with Sand, (CL)s: About 85% low plasticity, low dry strength, slow dilatancy, low toughness fines; about 15% fine sand; very stiff, greenish gray, moist; no reaction with HCl; Trace calcium carbonate inclusions with weak reaction to HCl; slightly indurated.							4.0P							Some of the sand may be indurated clay
	143–145				PCORE	96				3.75P 0.5T							

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

Project: Delta Habitat Conservation and Conveyance Program		**DRILL HOLE LOG**
Feature: , Sacramento River		**DCR5-DH-014**
Coordinates: North 2,316,299.48	East 6,265,705.94	
Survey Method: Ground Survey	Datum: NAD83	**State of California**
GPS: Latitude	Longitude	**California Natural Resources Agency**
County: Sacramento		**DEPARTMENT OF WATER RESOURCES**

Field Classification and Description

Elevation, feet	Depth, feet	Graphic Log	FIELD CLASSIFICATION AND DESCRIPTION
-135	145–150.9	(CL)s	142.5 to 150.9' LEAN CLAY with Sand, (CL)s: About 85% low plasticity, low dry strength, slow dilatancy, low toughness fines; about 15% fine sand; very stiff, greenish gray, moist; no reaction with HCl; Trace calcium carbonate inclusions with weak reaction to HCl; slightly indurated. *(Continued)*
-140	150.9–152.9	SC	150.9 to 152.9' CLAYEY SAND, (SC): About 65% fine sand; about 35% low plasticity fines; dark greenish gray, moist; no reaction with HCl; slightly indurated.
-145	152.9–158.7	s(ML)	152.9 to 158.7' SANDY SILT, s(ML): About 60% nonplastic, rapid dilatancy fines; about 40% fine sand; dark greenish gray, moist; no reaction with HCl. At 156.0' 0.2' thick Silty Sand (SM) layer. At 157.2' 0.2' thick Silty Sand (SM) layer.
-150	158.7–163.0	SM	158.7 to 163.0' SILTY SAND, (SM): About 75% fine sand; about 25% nonplastic fines; dense, dark greenish gray and alternating thin layers of greenish gray, moist; no reaction with HCl.
-155	163.0–168.0	ML	163.0 to 168.0' SILT, (ML): About 95% nonplastic, rapid dilatancy fines; about 5% fine sand; stiff, greenish gray, moist; no reaction with HCl.
	168.0		Total Depth 168.0' from deck of barge. Backfilled within 15' of mudline with 95% cement/5% bentonite grout mix (% by wt.) using Tremie method

Sampling and Testing

Depth, feet	Drilling Method	Sampled Interval	Recovery %	Blows per 6 in.	SPT N Value	N_{60}(ASTM)	PP or TV, tsf	Retained Sample	Water Content %	Liquid Limit	Plasticity Index	Fines% < #200	Other Lab Tests	REMARKS
145–148	Rotary	PCORE	96					Yes						P22A-144.8-145.3
148–149.5	Rotary	SPT	100	6 12 14	26	31		Yes						S19A-148.0-149.5
149.5–153	Rotary	PCORE	86					Yes						P23A-151.0-151.5
153–154.5	Rotary	SPT	87	9 14 20	34	41		Yes						S20A-153.0-154.3
154.5–158	Rotary	PCORE	91											
158–159.5	Rotary	SPT	93	8 13 25	38	46		Yes						S21A-158.0-158.7 S21B-158.7-159.4
159.5–163	Rotary	PCORE	9											
163–164.5	Rotary	SPT	100	5 11 19	30	36	1.5P	Yes						S22A-163.0-164.5
164.5–168	Rotary	PCORE	100				2.5P .25T	Yes						P26A-166.5-167.0

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

Attachment B
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

Attachment C
GRLWEAP Output Reports

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

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.

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 DRIVABLITY\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   0.000
    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
  FFatique        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
```

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	0.35	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
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_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		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

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_Intake3_014_HPile 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            (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
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) 37.7

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	0.447	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 04/14/2020
CH2M HILL GRLWEAP Version 2010

Rut	Bl Ct	Stroke (ft) down	Stroke (ft) up	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 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:
 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
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) 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	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
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	Stroke	Pressure	Efficy
ft	ft	Ratio	
12.00	6.80	1.00	0.800

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

Rut	Bl Ct	Stroke (ft) down	up	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft			ksi			ksi			kip-ft	b/min
77.7	1.1	6.80	6.77	0.00	1	0	22.74	1	5	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 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
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) 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	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
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	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.71	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	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt 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 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	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 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 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	Efficy
19.69	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	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt 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 (in2) 450.400 Pile Type H Pile
Pile Size (inch) 18.110

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	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) 792.1

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 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
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 Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	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 (ft) 27.4
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 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	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) 858.5

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 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
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

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
858.5	40.6	6.80	6.85	-1.84	15	25	39.64	20	6	66.5	44.7

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	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 04/14/2020
CH2M HILL GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth	Temp. Length	Wait Time	Equivalent Stroke	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
ft	ft	hr	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	Shaft Quake	Toe Quake	Shaft Damping	Toe Damping	Soil Setup	Limit Distance	Setup Time
ft	k/ft2	kips	inch	inch	s/ft	s/ft	Normlzd	ft	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

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.

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 DRIVABLITY\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   0.000
   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
  FFatique        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
```

```
     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

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_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             (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
    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)       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     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
 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    Stroke  Pressure    Efficy
       ft        ft     Ratio
     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   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   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                 (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
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) 17.4

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	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	Stroke	Pressure	Efficy
ft	ft	Ratio	
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	Bl Ct	Stroke (ft) down	up	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft			ksi			ksi			kip-ft	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 (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
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) 26.4

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	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)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
15.71	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
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 (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	in2	ksi	lb/ft3	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

Pile and Soil Model Total Capacity Rut (kips) 91.6

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	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
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	Stroke	Pressure	Efficy
ft	ft	Ratio	
19.69	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
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 (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.	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) 152.5

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 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
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 ft	Stroke ft	Pressure Ratio	Efficy
25.69	6.80	1.00	0.800

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

Rut kips	Bl Ct b/ft	Stroke (ft) down	Stroke (ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt 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 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

Pile and Soil Model — Total Capacity Rut (kips) 171.7

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 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
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)

Depth	Stroke	Pressure	Efficy
ft	ft	Ratio	
27.37	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
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	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	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	Temp. Length	Wait Time	Equivalent Stroke	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
ft	ft	hr	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	Shaft Quake	Toe Quake	Shaft Damping	Toe Damping	Soil Setup	Limit Distance	Setup Time
ft	k/ft2	kips	inch	inch	s/ft	s/ft	Normlzd	ft	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)

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.

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 DRIVABLITY\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   0.000
    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
  FFatique        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
```

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
11.5000	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	0.35	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
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
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

```
 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_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             (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

       Pile and Soil Model            Total Capacity Rut  (kips)      37.7
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  0.457    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              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             (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

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	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
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) down	Stroke (ft) up	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft			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 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

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	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
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

↑

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	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

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
	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
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	Stroke	Pressure	Efficy
ft	ft	Ratio	
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
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

Pile and Soil Model Total Capacity Rut (kips) 177.8

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	0.457	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	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

Pile and Soil Model Total Capacity Rut (kips) 225.6

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	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
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

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

Pile and Soil Model Total Capacity Rut (kips) 275.7

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	0.457	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

Wave Travel Time 2L/c (ms) 7.177

Pile and Soil Model — Total Capacity Rut (kips) 285.4

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	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	0.1	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	Stroke	Pressure	Efficy
ft	ft	Ratio	
38.81	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) down	Stroke (ft) up	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft			ksi			ksi			kip-ft	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

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	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	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	Temp. Length	Wait Time	Equivalent Stroke	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
ft	ft	hr	ft				
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/ft2	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
36.30	0.67	220.71	0.100	0.354	0.050	0.150	1.000	6.560	1.000
36.30	0.67	220.71	0.100	0.354	0.050	0.150	1.000	6.560	1.000
38.81	0.71	235.97	0.100	0.354	0.050	0.150	1.000	6.560	1.000
60.31	0.71	235.97	0.100	0.354	0.050	0.150	1.000	6.560	1.000

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.

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 DRIVABLITY\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          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     0.000       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
  FFatique        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
```

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
11.5000	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
36.30	0.67	25.90	0.10	0.12	0.05	0.15	1.20	6.56	1.0
36.30	0.67	25.90	0.10	0.12	0.05	0.15	1.20	6.56	1.0
38.81	0.71	27.69	0.10	0.12	0.05	0.15	1.20	6.56	1.0
60.31	0.71	27.69	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
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_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

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_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 (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 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	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
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	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

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 Rut (kips) 17.4

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	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	Stroke	Pressure	Efficy
ft	ft	Ratio	
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) down	up	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft			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 Rut (kips) 26.4

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	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			

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	
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	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 Rut (kips) 37.9

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	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
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	Efficy
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	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 Rut (kips) 59.0

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	0.605	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) down	Stroke (ft) up	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 (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 Rut (kips) 84.5

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	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
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)

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

Depth ft	Stroke ft	Pressure Ratio	Efficy
31.69	11.50	1.00	0.800

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

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt 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 (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

Pile and Soil Model Total Capacity Rut (kips) 114.4

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 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
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 ft	Stroke ft	Pressure Ratio	Efficy
37.69	11.50	1.00	0.800

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

Rut kips	Bl Ct b/ft	Stroke (ft) down	up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt 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

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 Rut (kips) 120.5

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	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
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	Stroke	Pressure	Efficy
ft	ft	Ratio	
38.81	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) down	up	Ten Str	i	t	Comp Str	i	t	ENTHRU	Bl Rt
kips	b/ft	down	up	ksi			ksi			kip-ft	b/min
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

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	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	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

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
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/ft2	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
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

DeepEX 2020: Report Output

Project: Delta Conveyance - Intake 3

DELTA CONVEYANCE DESIGN & CONSTRUCTION AUTHORITY

Company: Jacobs
Prepared by engineer: A. Finney
File number: Base Design Rev 1
Time: 11/30/2021 10:11:06 AM

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

Concrete

Name	Strength Fc'	Elastic E	Density g	Tension Strength Ft
	(ksi)	(ksi)	(kcf)	(% 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	Elastic E
	(ksi)	(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

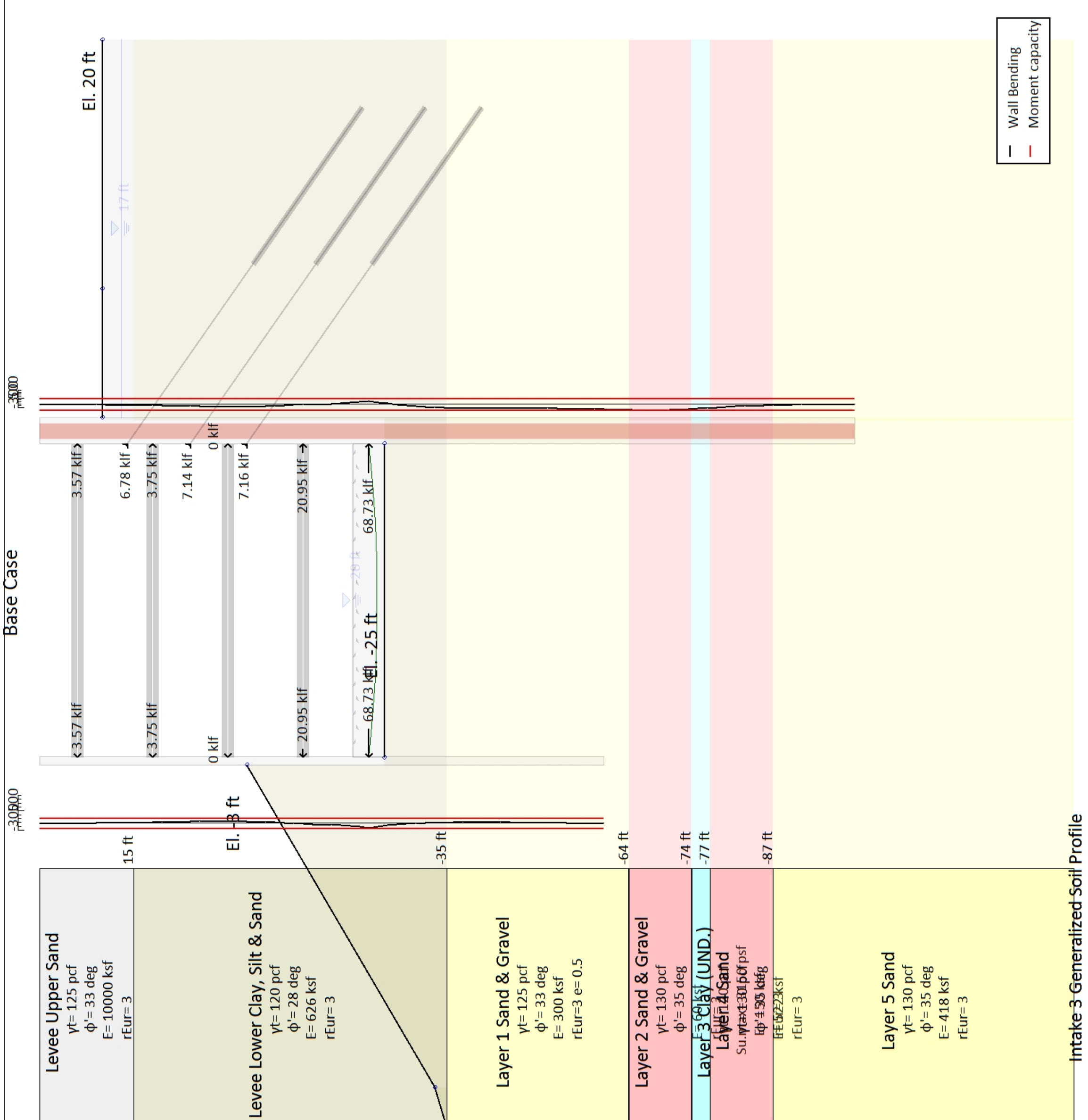
Wood

Name	Ultimate Bending Srtength Fbu	Ultimate Tensile Strength Ftu	Ultimate Shear Strength Fvu	Density g	Elastic E
	(ksi)	(ksi)	(ksi)	(kcf)	(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
fy=fyk= characteristc resistance for steel (for all the codes)
Fu=fuk= ultimate resistence for steel (for all the codes)
Elastic E= Elastic modulus
Density g= specific weight
CONCRETE
Name=material name
f'c=fck= cylindrical resistance for concrete (for all the codes)
Elastic E= Elastic modulus
Density g= specific weight
Tension strength=ft=fctk= characteristic tension resistance for concrete
STEEL REBARS
Name=material name
fy=fyk= characteristic resistance for steel (for all the codes)
Fu=fuk= ultimate resistence for steel (for all the codes)
Elastic E= Elastic modulus
Density g= specific weight
WOOD
Name=material name
Fb=fbk= Ultimate bending strength
Ftu=ftuk= Ultimate tensile strength
Fvu=fvuk= Ultimate shear strength
Density g= specific weight
Elastic E= Elastic modulus

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



Company: Jacobs	Quick summary	Deep Excavation LCC
Engineer: A. Finney		DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021

Summary of Wall Moments and Toe Requirements

Top Wall	Wall	L-Wall	H-Exc.	Max+M/Cap	Max-M/Cap	FS Toe	FS Toe	FS Toe	FS 1 Toe EL.	Slope
(ft)	Section	(ft)	(ft)	(k-ft/ft)	(k-ft/ft)	Pas. mob.	Rotation	Embedment	(ft)	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	Type	Elev. Z	X	Supports	Angle	Space H	Free L	Fixed L
Number		(ft)	(ft)	Wall #	(deg.)	(ft)	(ft)	(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	R.Max	R.Min	R.Max	R.Min	STR
Number	(k)	(k)	(k/ft)	(k/ft)	
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

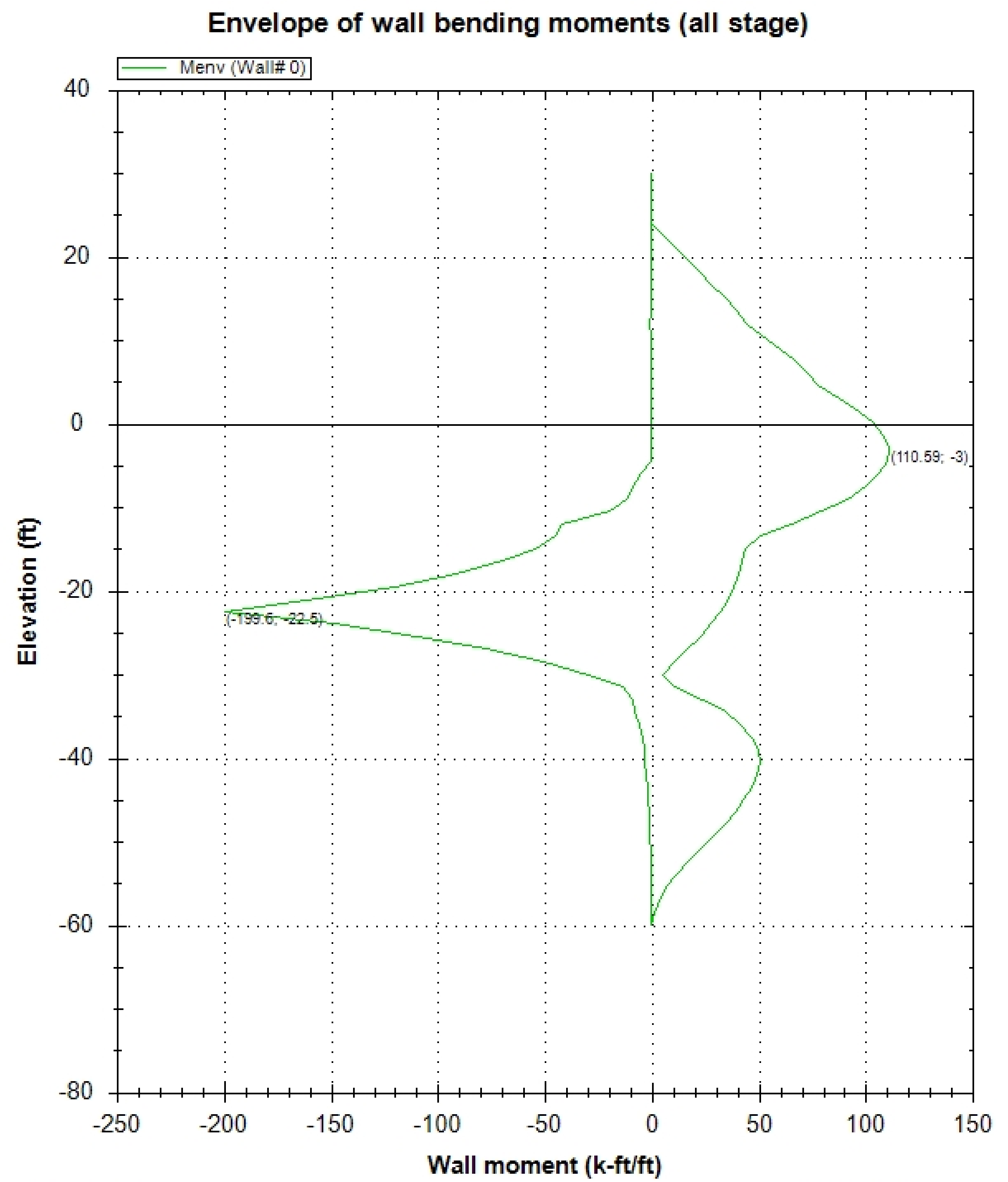
Notes: R.max = Maximum support reaction.
R.min = Minimum support reaction.
STR = Critical support capacity stress check = Load/Design capacity

General assumptions for last stage: Stage 19

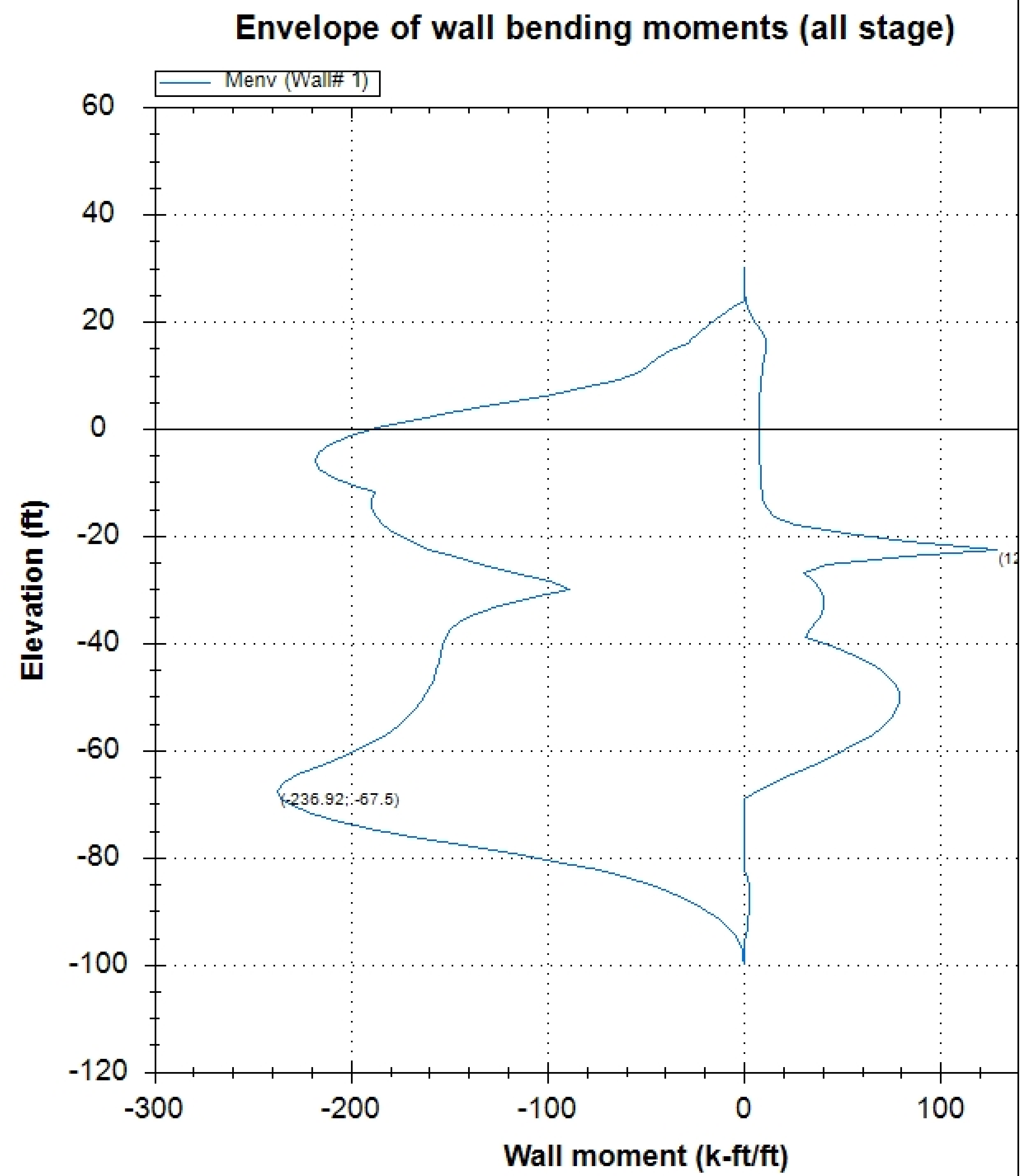
Concrete Code:	
Steel Code:	
Non linear	
Drain State Clays	
Water γ= 62.4 pcf	
Adv. NL surcharge method	
Drive Ka	
Resist Kp	Rankine (Coul. d=0)

Envelope of results

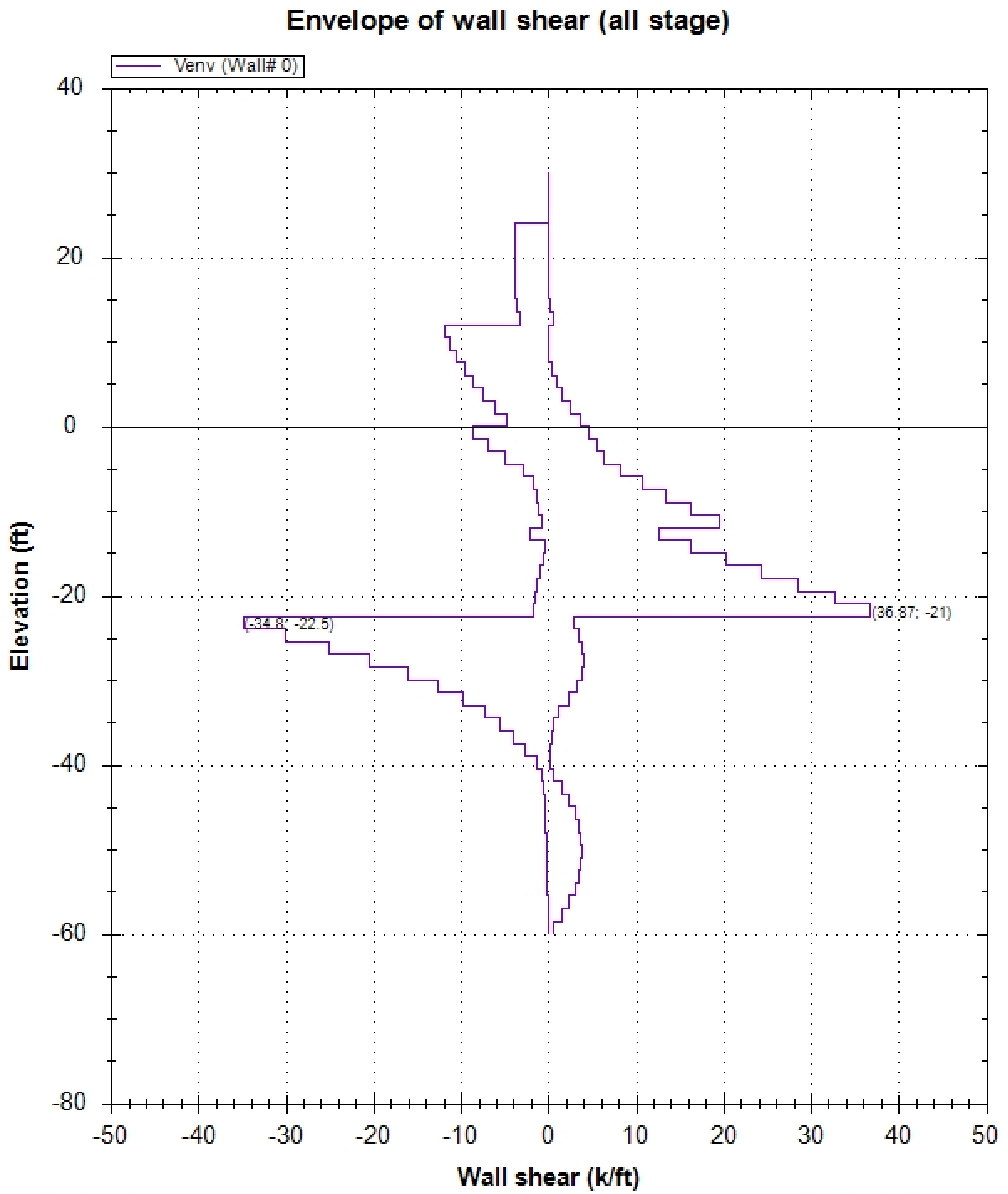
A sequence of result diagrams for each excavation stage is reported



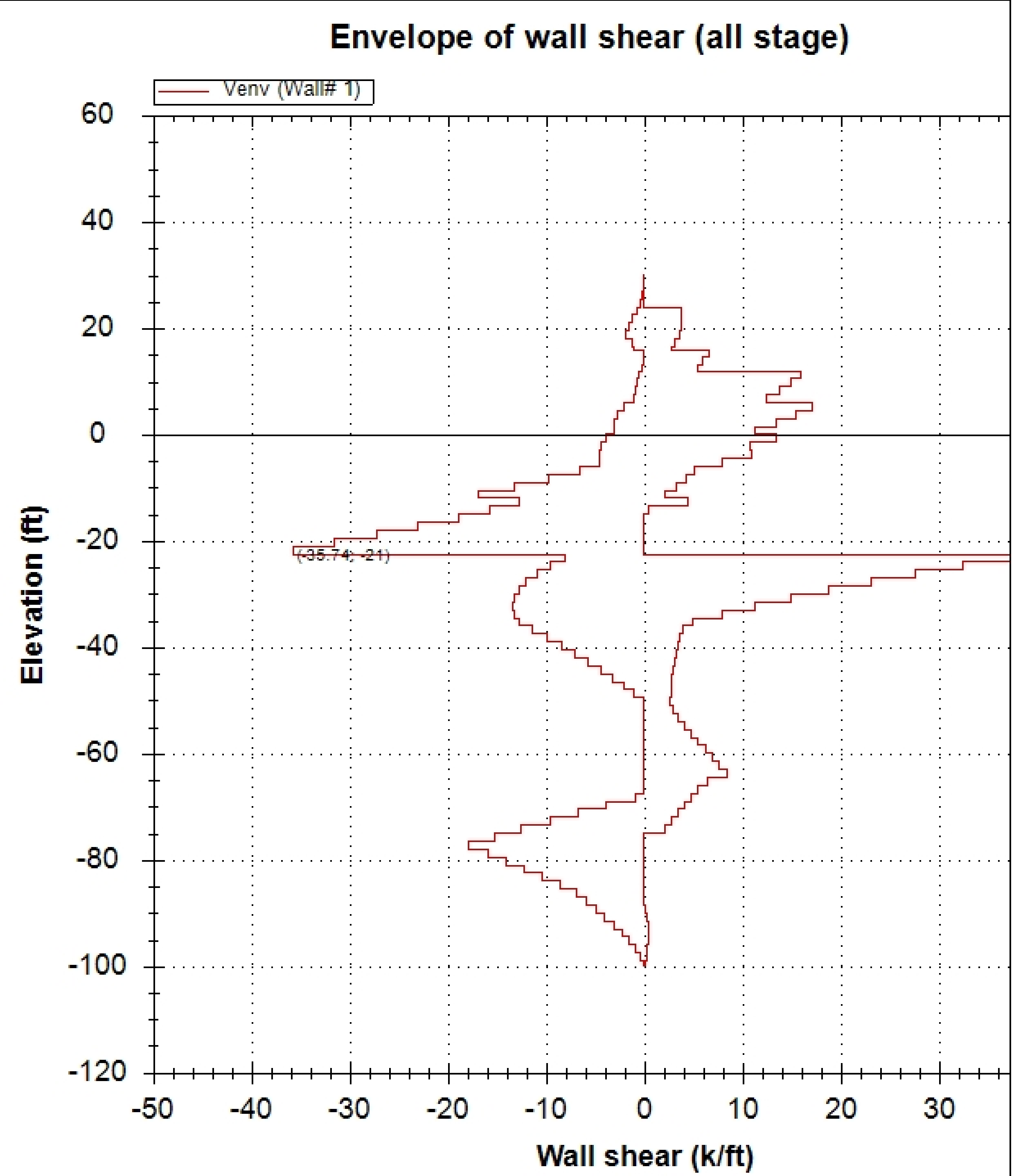
Company: Jacobs Engineer: A. Finney	DS: 0 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



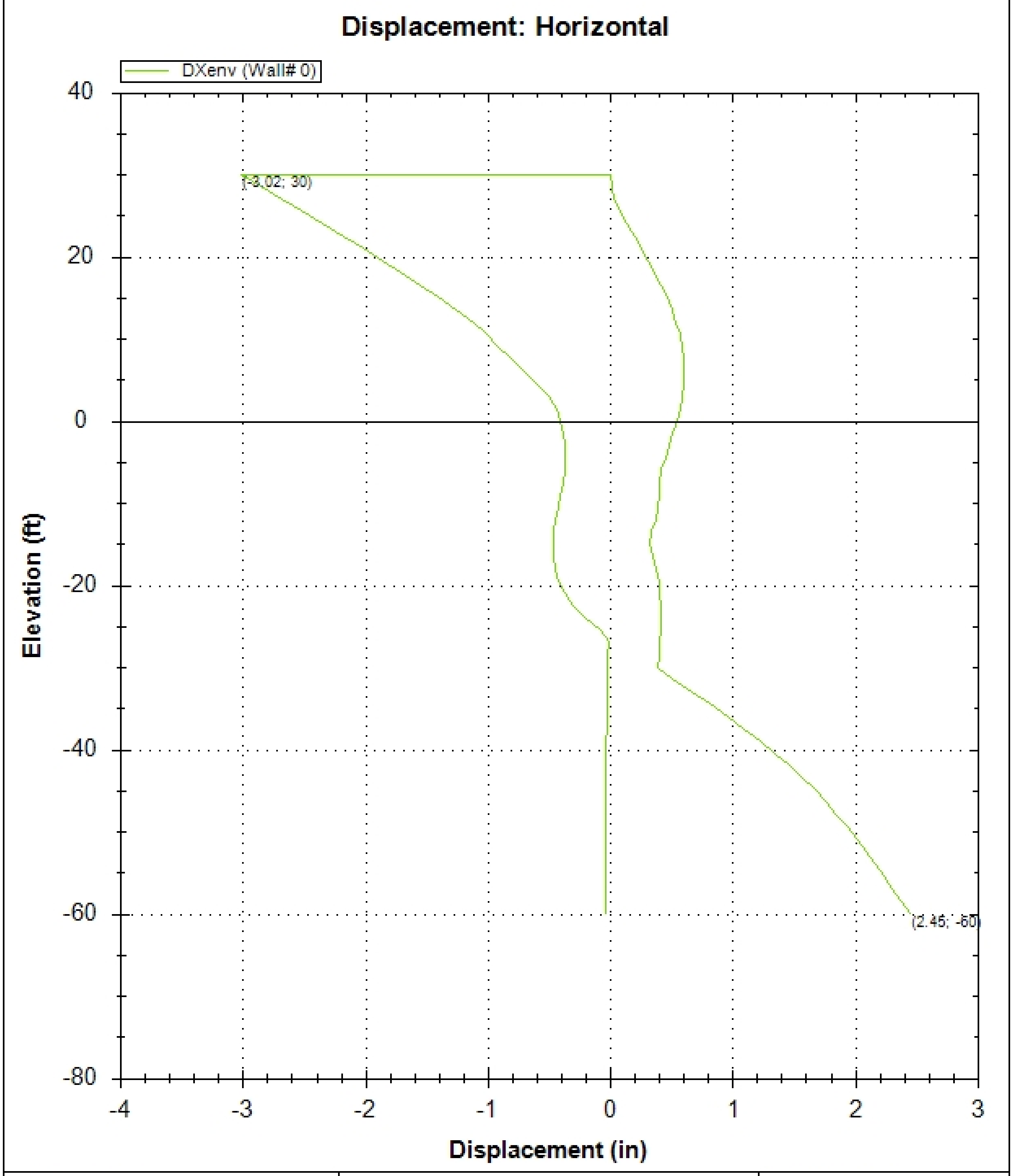
Company: Jacobs Engineer: A. Finney	DS: 0 (wall 1) Envelope of results	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



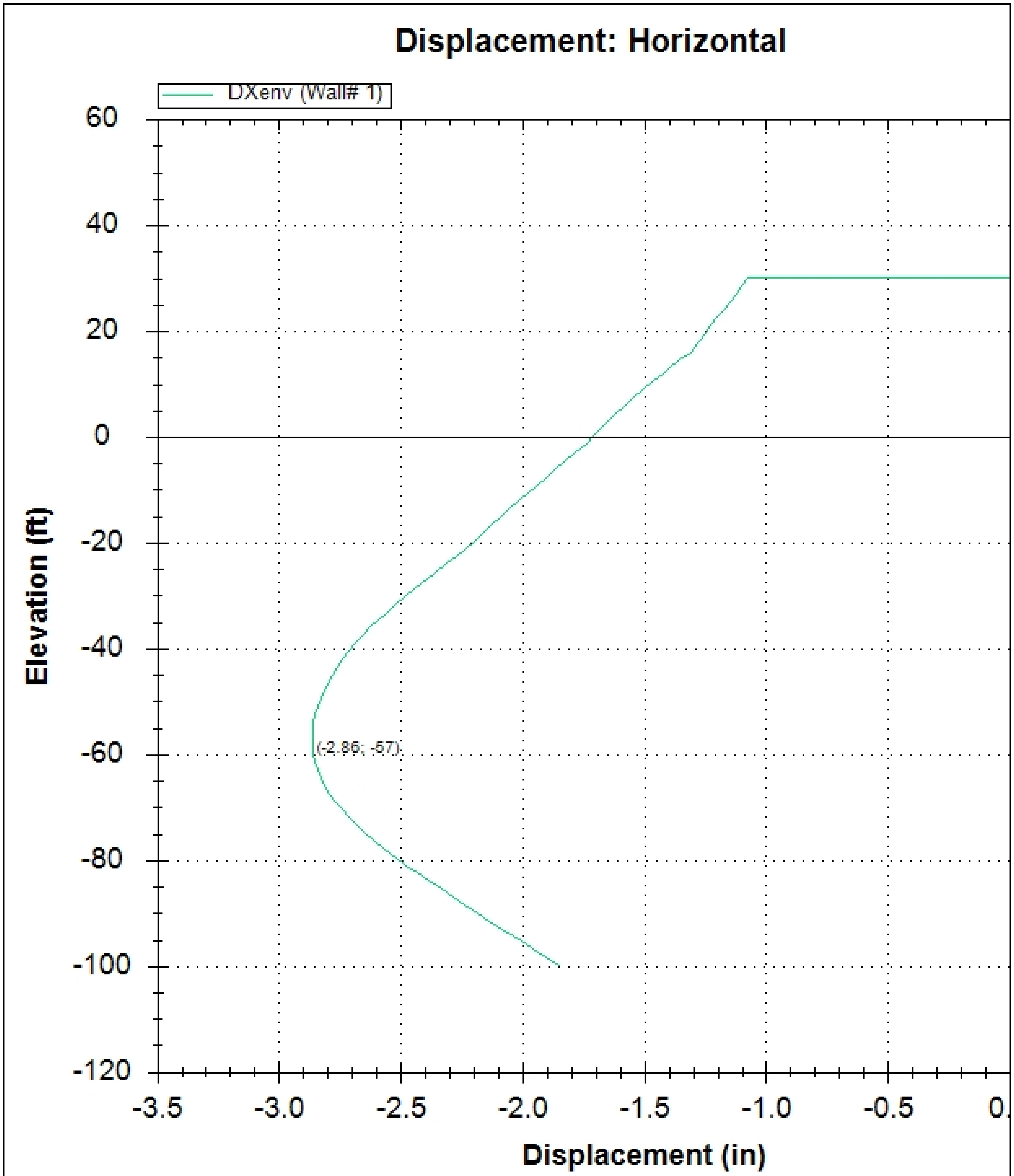
Company: Jacobs Engineer: A. Finney	DS: 0 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



Company: Jacobs Engineer: A. Finney	DS: 0 (wall 1) Envelope of results	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



Company: Jacobs Engineer: A. Finney	DS: 0 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



Company: Jacobs Engineer: A. Finney	DS: 0 (wall 1) Envelope of results	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021

DESIGN APPROACHES AND COMBINATION FACTORS

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

Ftan fr=mult factor for friction angle
F C'= safety factor on effective cohesion (Eurocode 7 methods)
F Su'= safety factof 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	F	F	F	F(perm	F(temp	F(perm	F(temp	F Earth	F Earth	F GWT	F GWT	F HYD	F HYD	F UPL	F UPL
	Name		fr)	(c')	(Su)	(EQ)	load)	load)	sup)	sup)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)
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	g dry	Frict	C'	Su	FRp	FRcv	Eload	rEur	kAp	kPp	kAcv	kPcv	Vary	Spring	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(deg)	(deg)	(ksf)	(-)	NL	NL	NL	NL		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	Min Ka	Min sh	ko.NC	nOCR	aH.EXP	aV.EXP	qSkin	qNails	kS.nails	PL
	v	(clays)	(clays)	-	-	(0 to 1)	(0 to 1)	(psi)	(psi)	(k/ft3)	(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 weigth 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

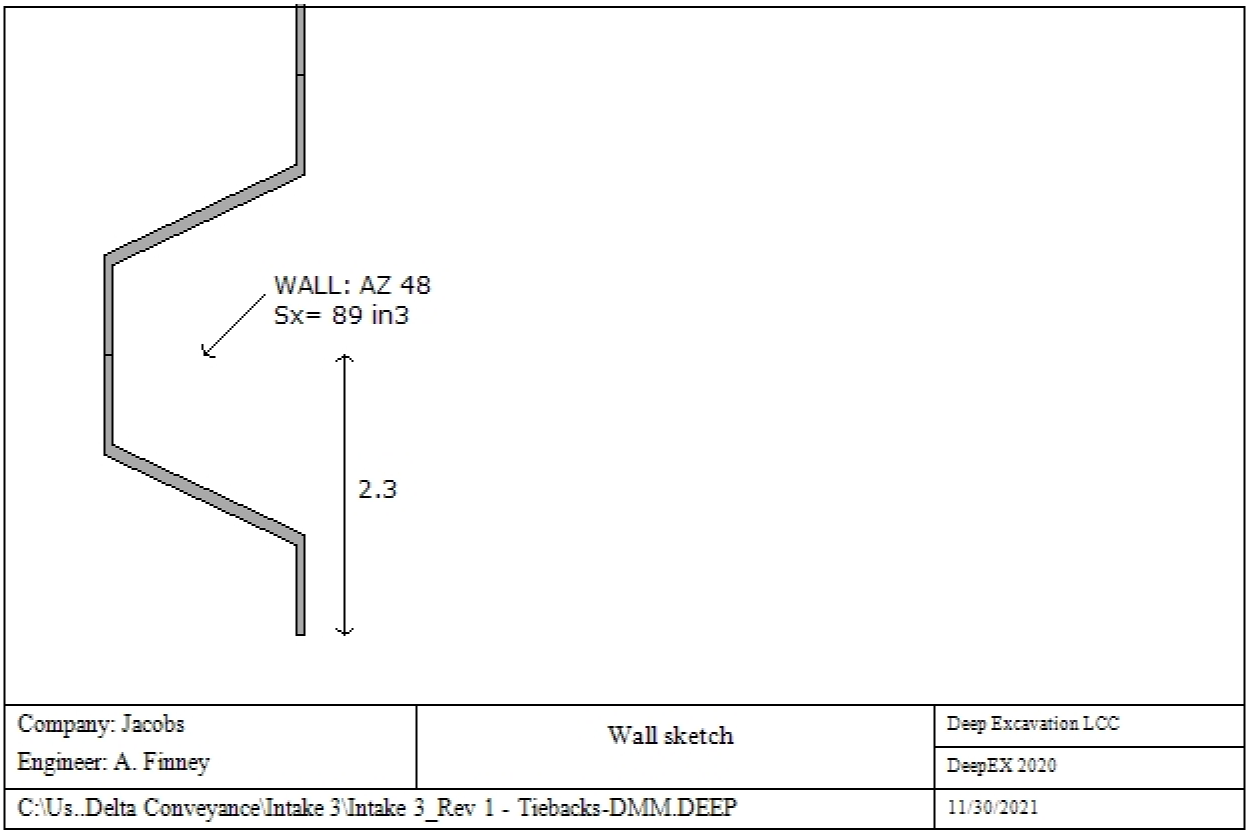
Top Elev= superior SOil level
Soil type= type of the soil (sand , clay , etc)
OCR= overconsolidation ratio
K0= at rest coefficient

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



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 Swater= 1 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.
Steel sheet pile properties

Table: Steel Sheet Pile Cross Sectional Properties

DES	Shape	W	A	h	t	b	s	Ixx	Sxx
		(plf)	(in^2/ft)	(in)	(in)	(in)	(in)	(in^4/ft)	(in^3/ft)
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^4)	(in^3)	(in)	(in^4)	(in^3)	(in)	(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	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-equlibrium 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	
Stage 20	Springs-Up	Peck 1969	N/A	m= 0.3	Kp	N/A	

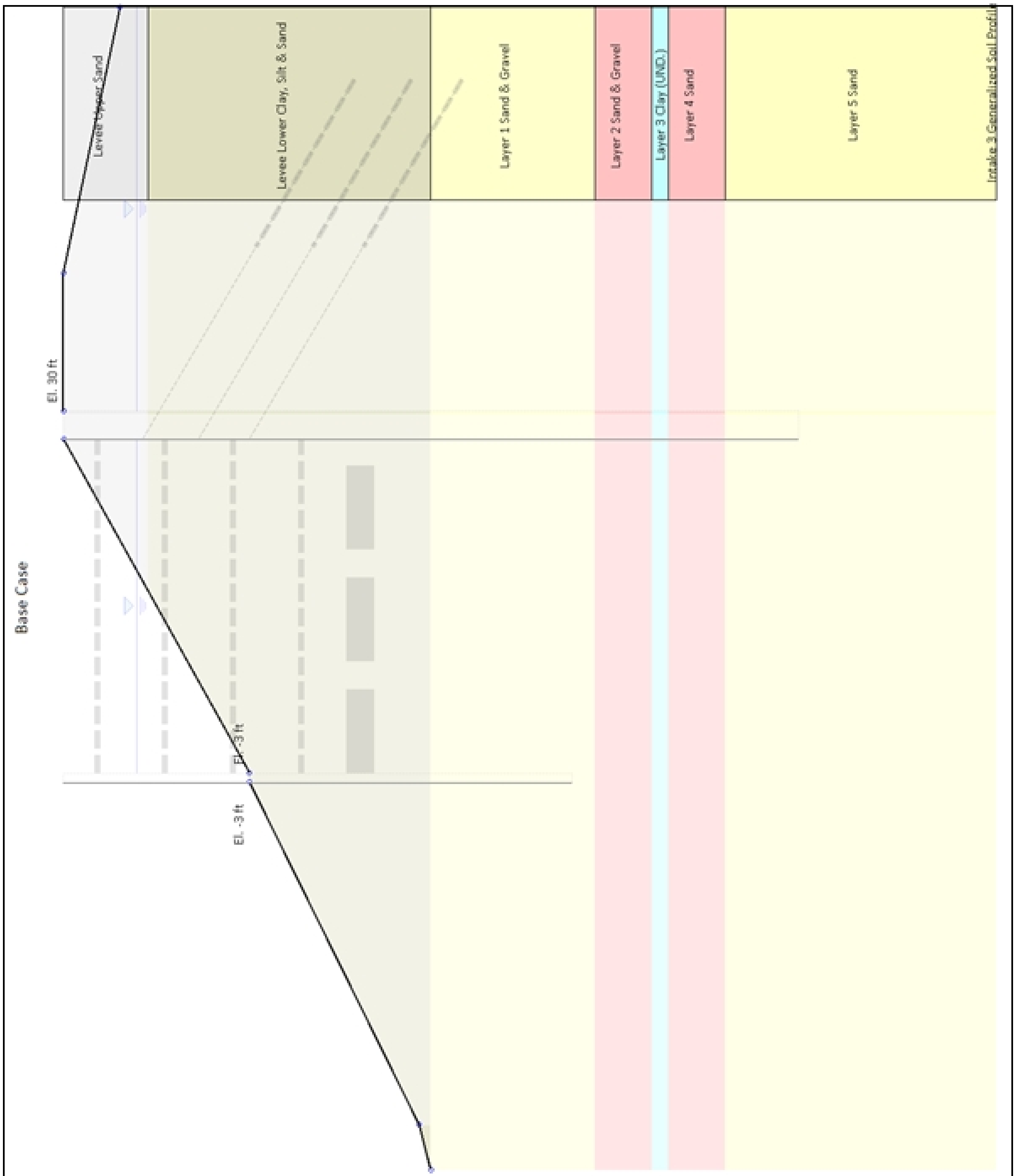
Name	Support	Axial	Used	Min Toe	Toe	Toe
	Model	Incl	FSwall	FDtoe	FSrot	FSpas
Stage 0		N/A	1.5	N/A	N/A	N/A
Stage 1		N/A	1.5	N/A	N/A	N/A
Stage 2		N/A	1.5	N/A	N/A	N/A
Stage 3		N/A	1.5	N/A	N/A	N/A
Stage 4		N/A	1.5	N/A	N/A	N/A
Stage 5		N/A	1.5	N/A	N/A	N/A
Stage 6		N/A	1.5	N/A	N/A	N/A
Stage 7		N/A	1.5	N/A	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-equlibrium 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.

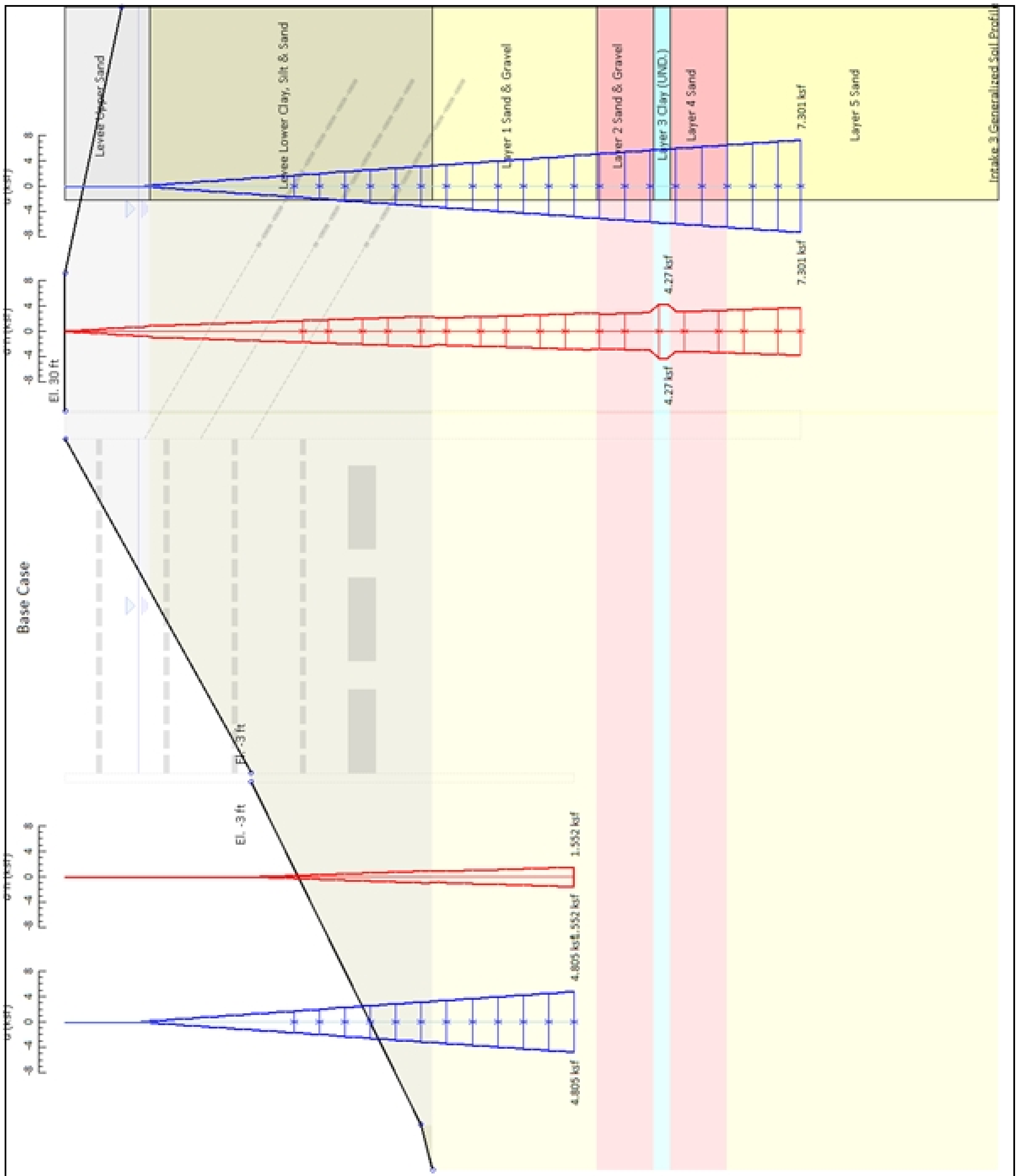
Min FD Toe= embedded minimum safety factor (for limit equilibrium analysis)
Toe FS rot= rotation safety factor (classic for limit equilibrium analysis)
Toe FSpas= driving/resisting pressure safety factor (for limit equilibrium analysis)

EXCAVATION STAGES SKETCHES

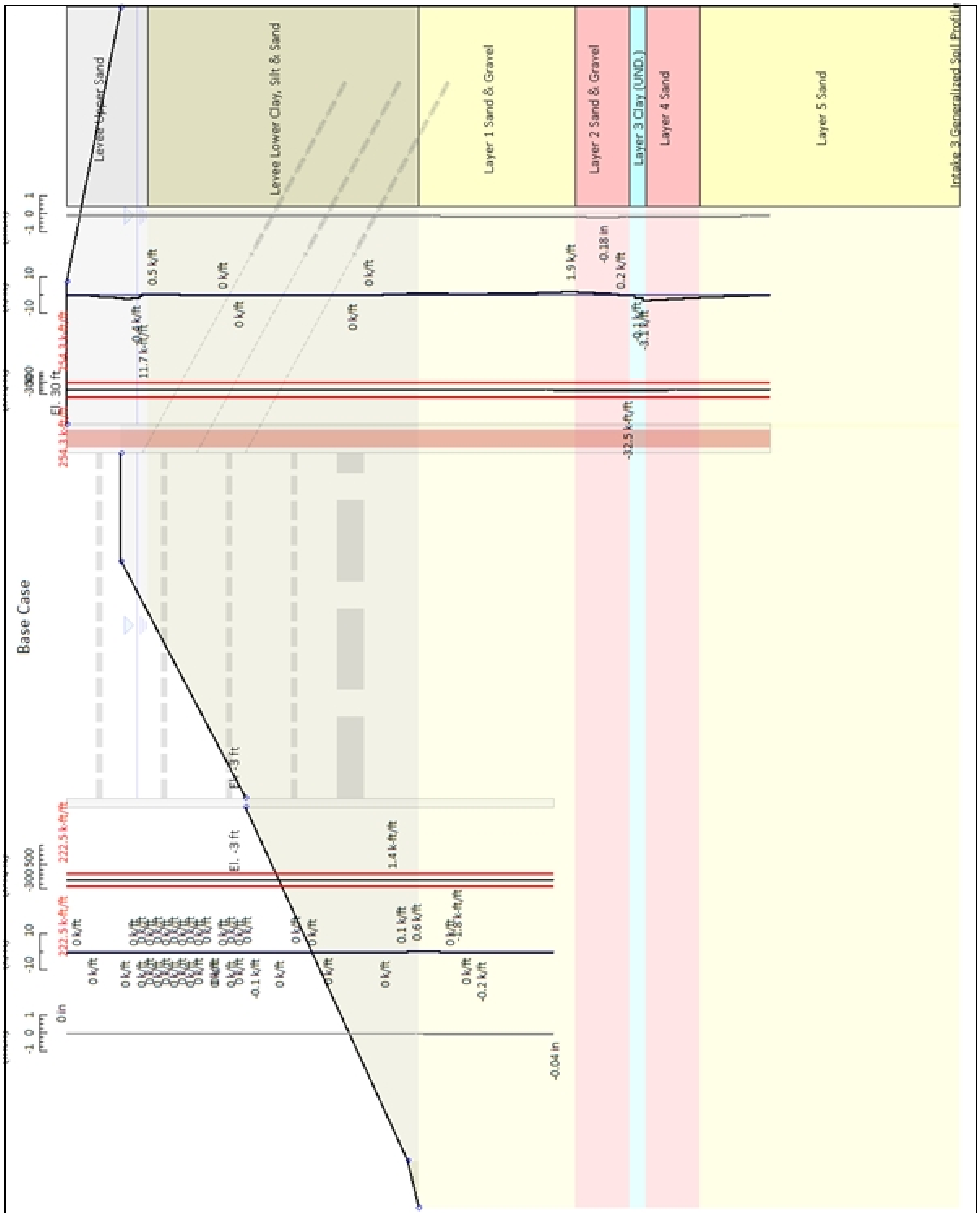
A sequence of figures for each excavation stage is reported



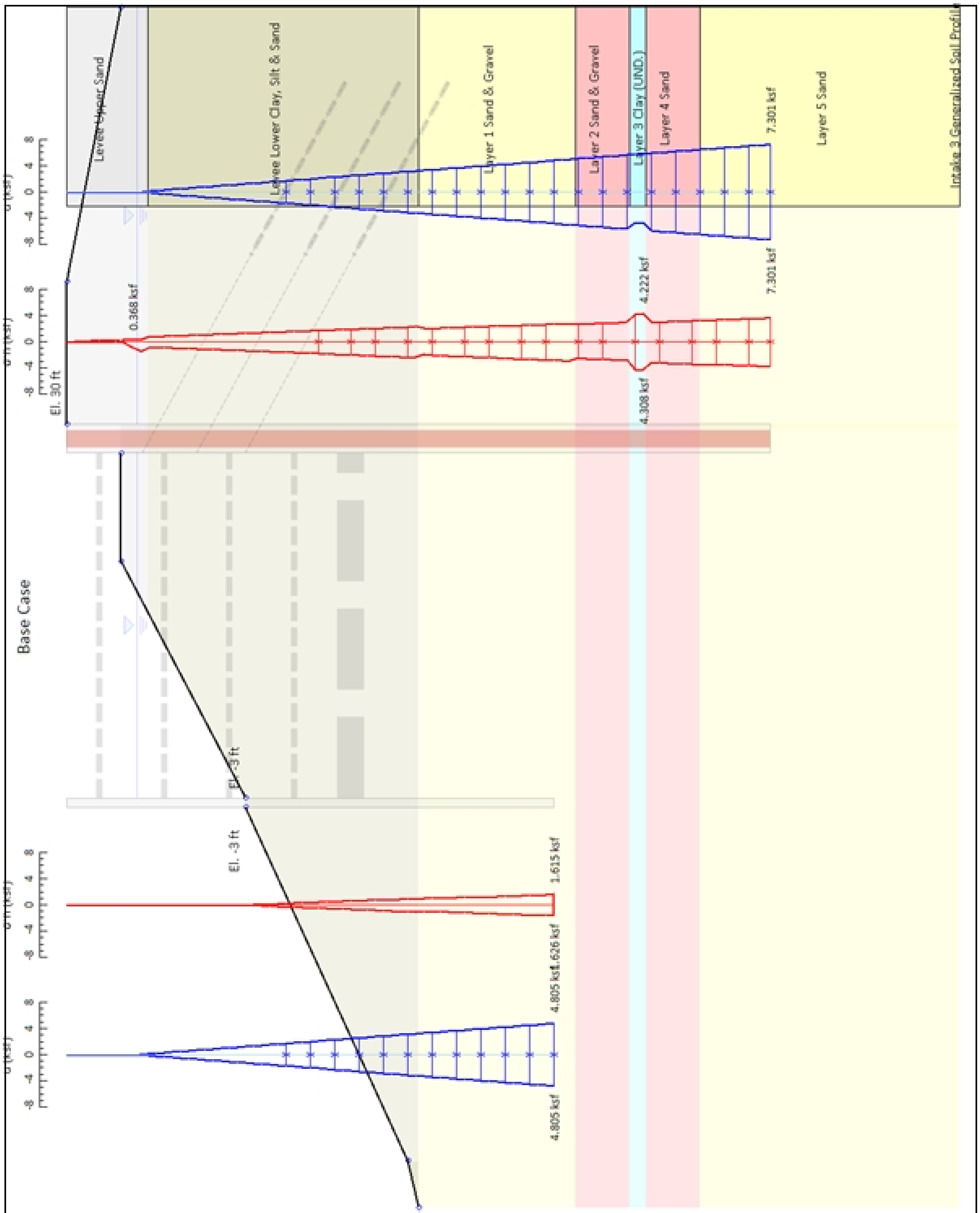
Company: Jacobs Engineer: A. Finney	DS: 0, New stage 0	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



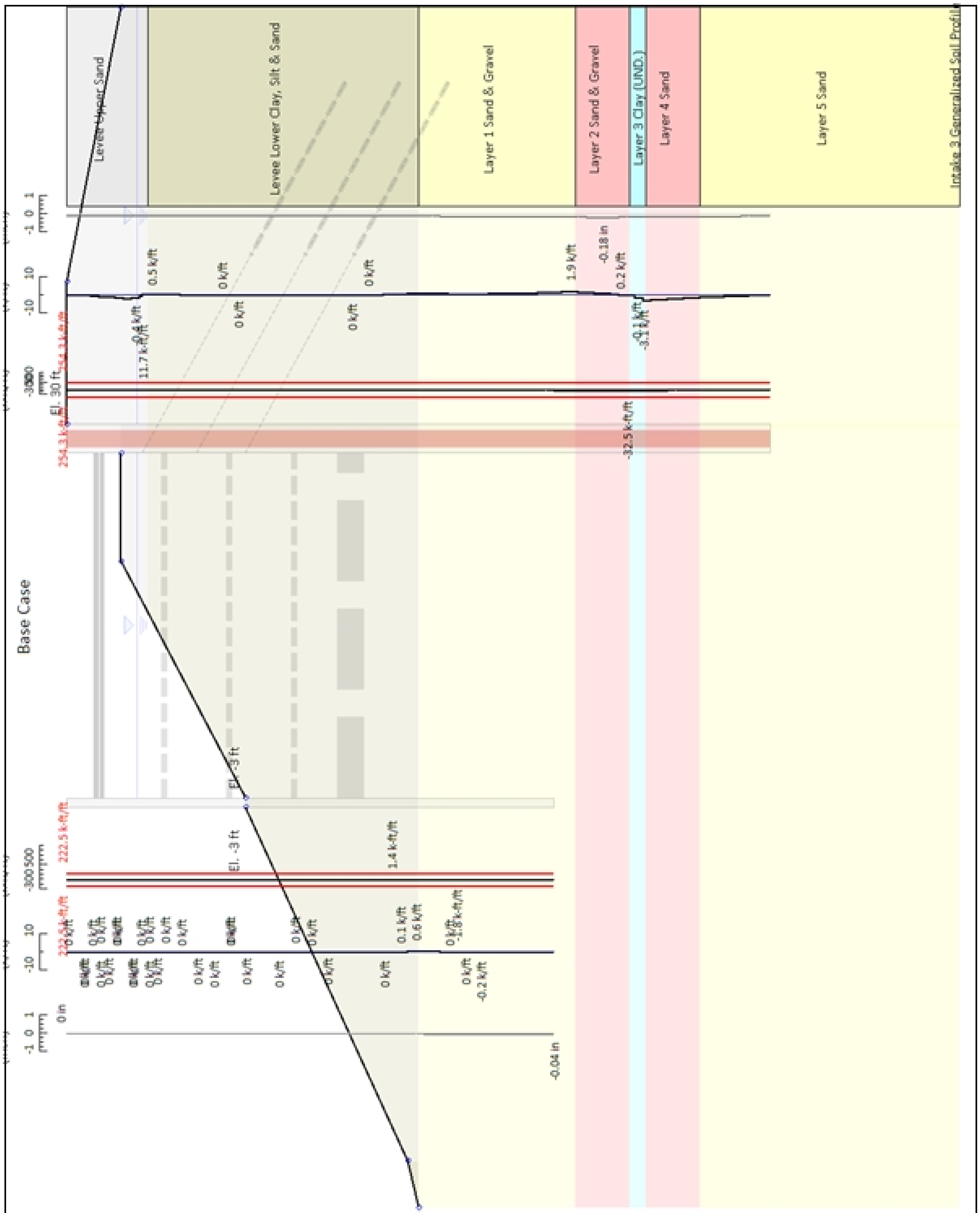
Company: Jacobs Engineer: A. Finney	DS: 0, New stage 0	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



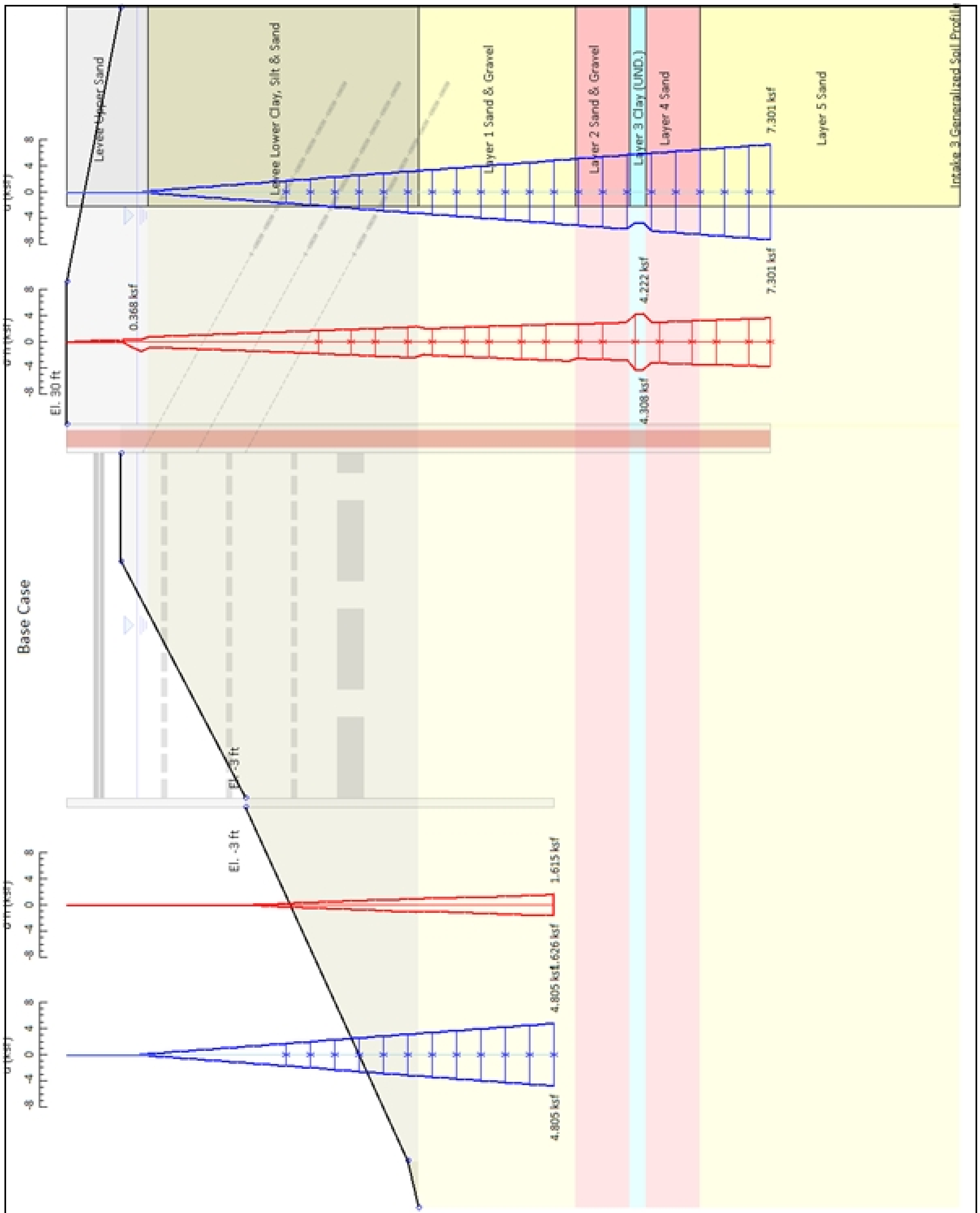
Company: Jacobs Engineer: A. Finney	DS: 0, New stage 1	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



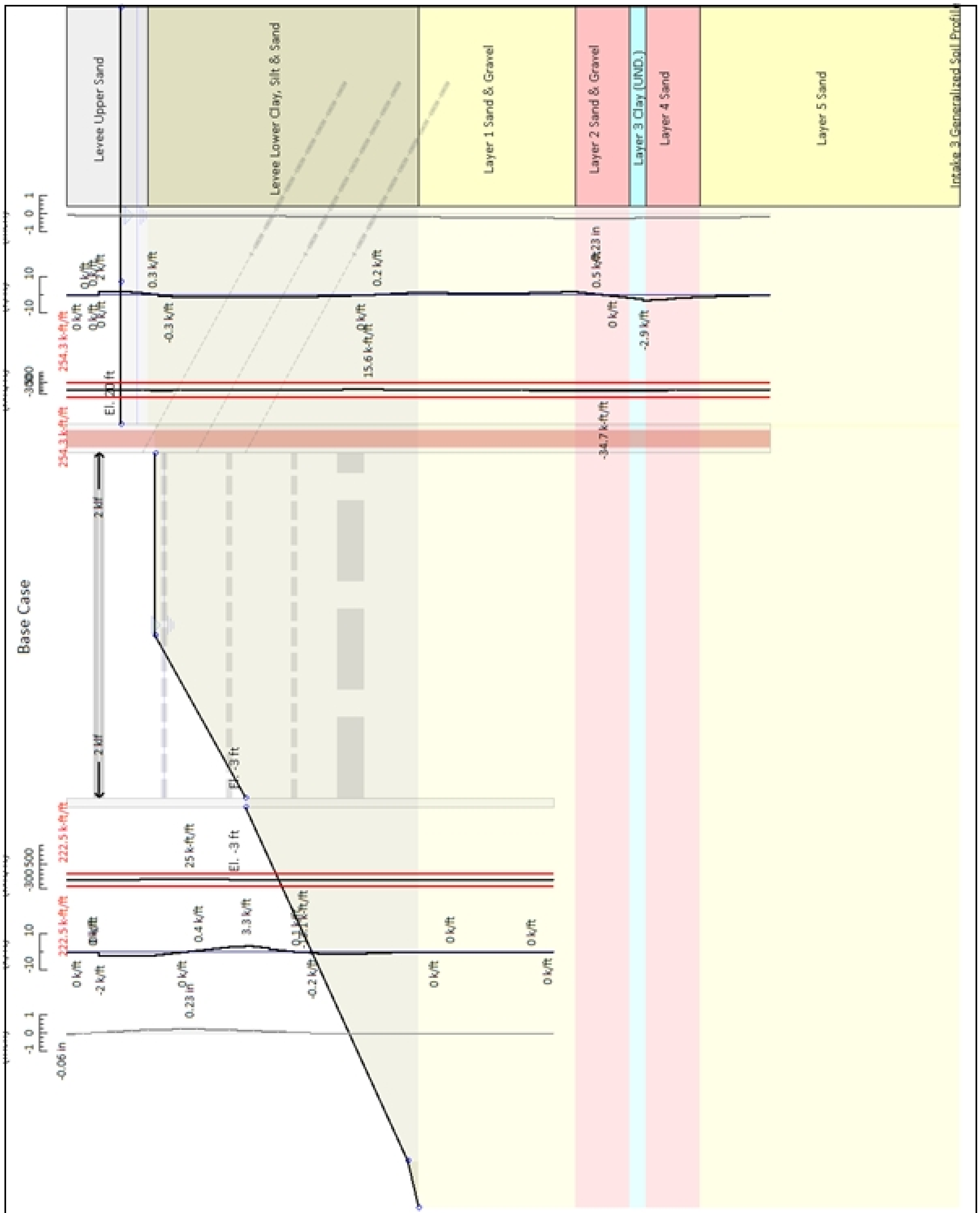
Company: Jacobs Engineer: A. Finney	DS: 0, New stage 1	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



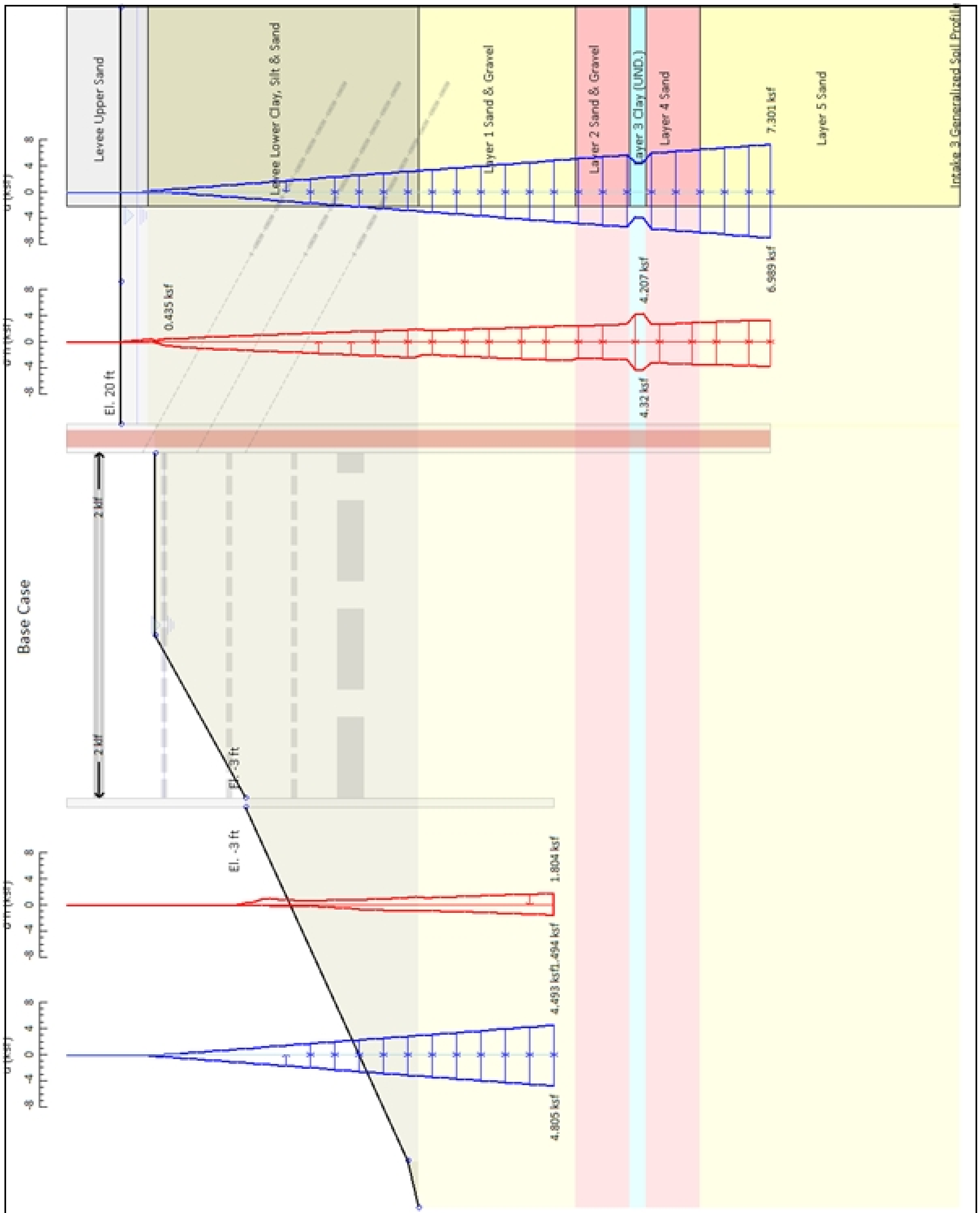
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 1	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



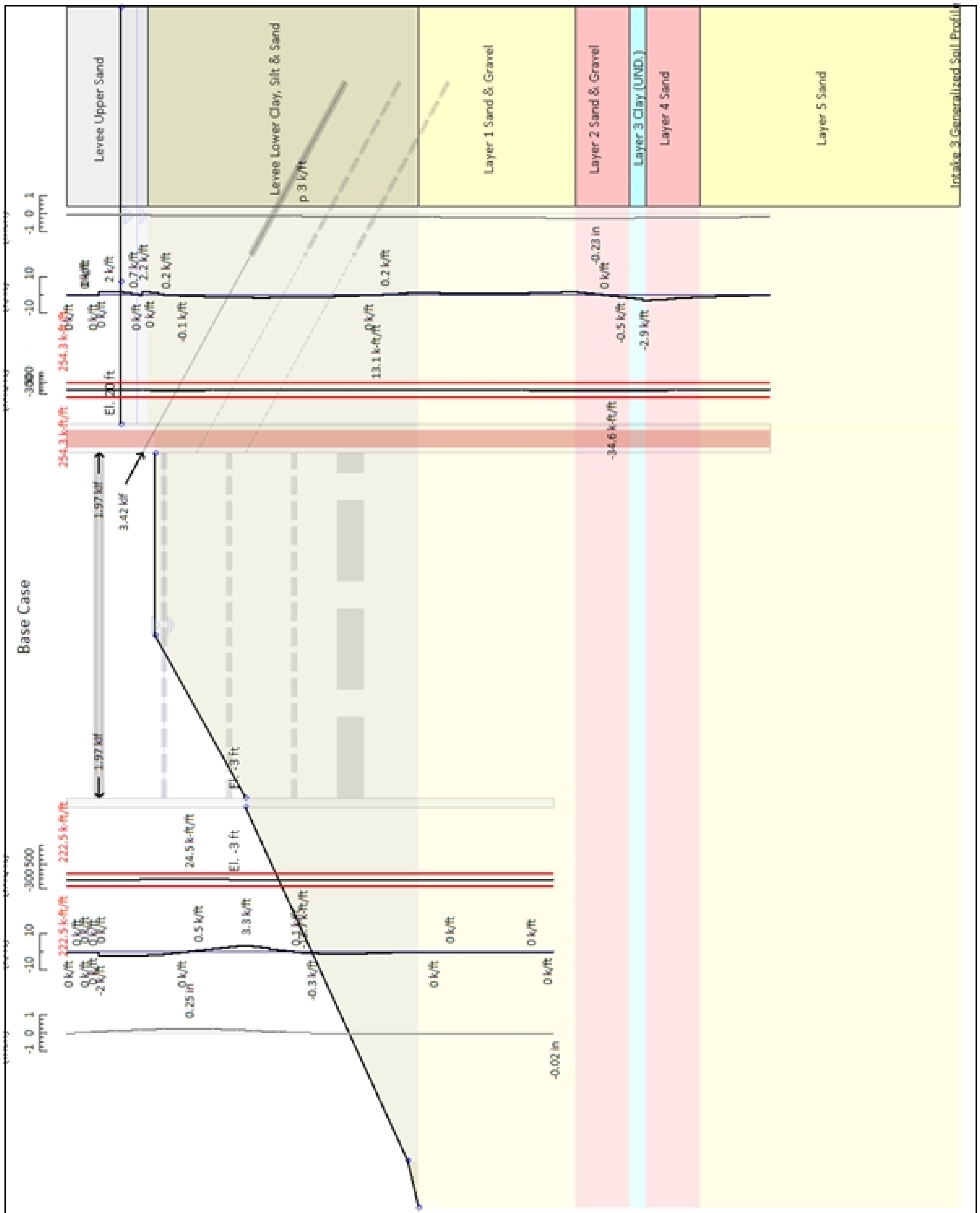
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 1	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



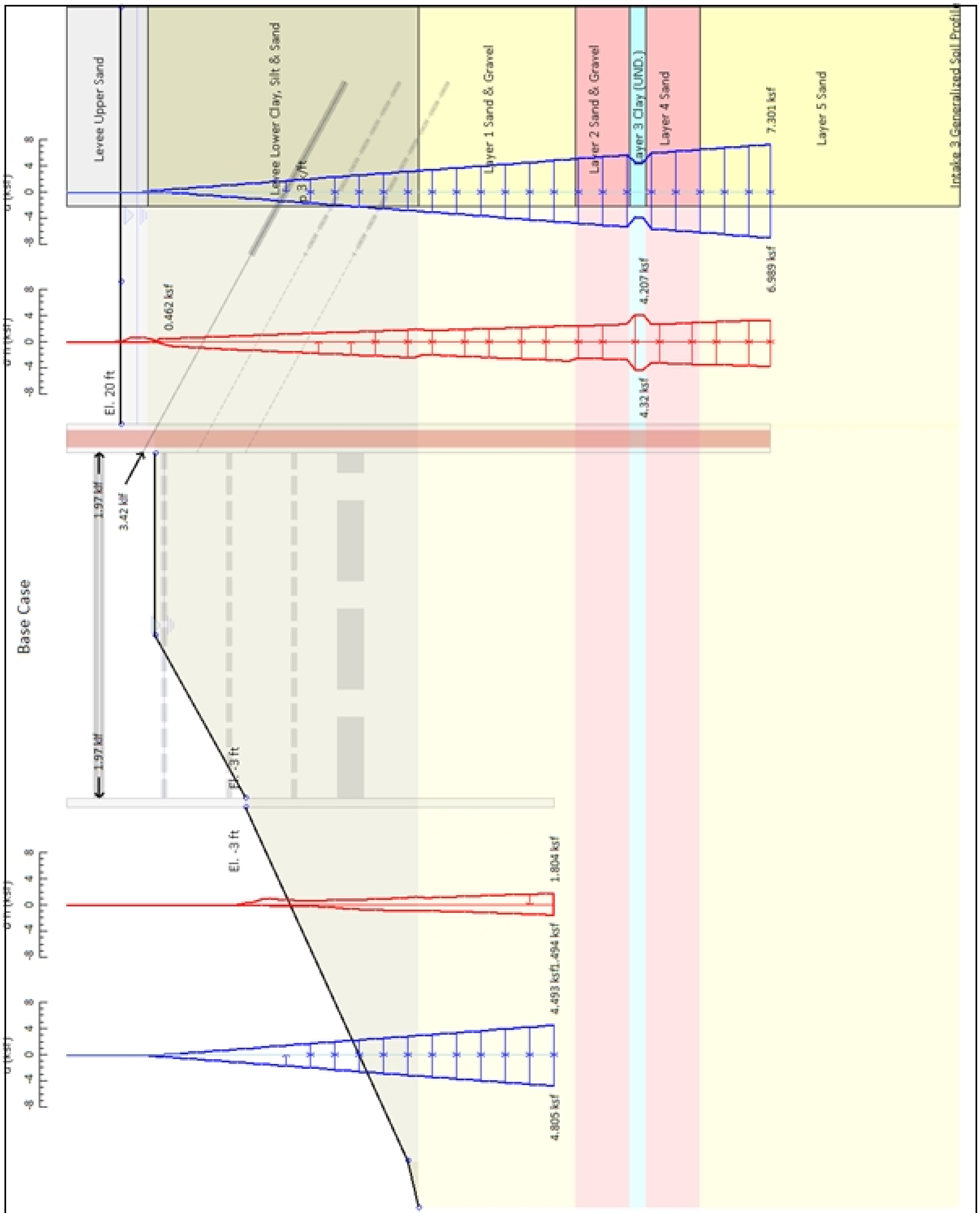
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 2	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



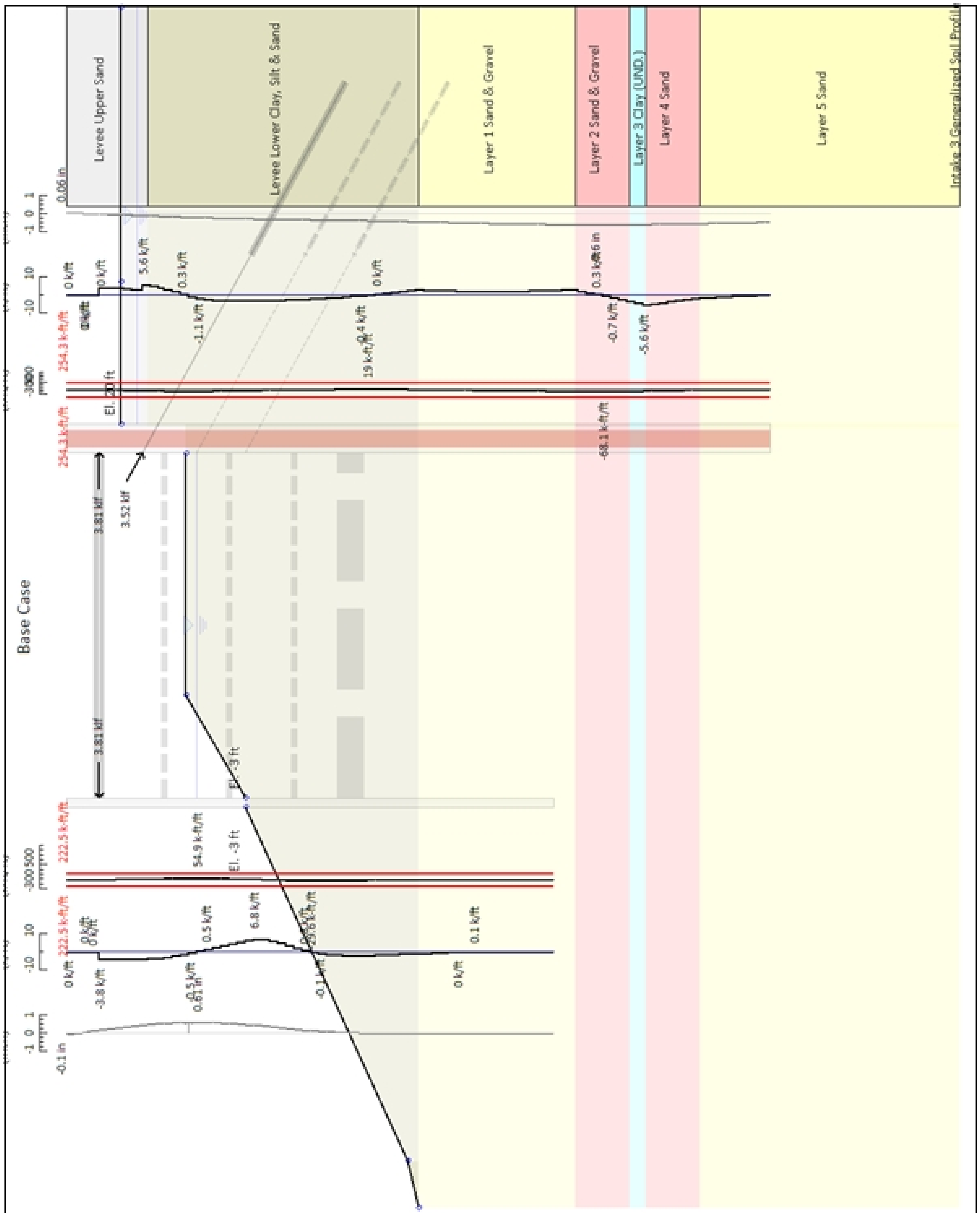
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 2	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



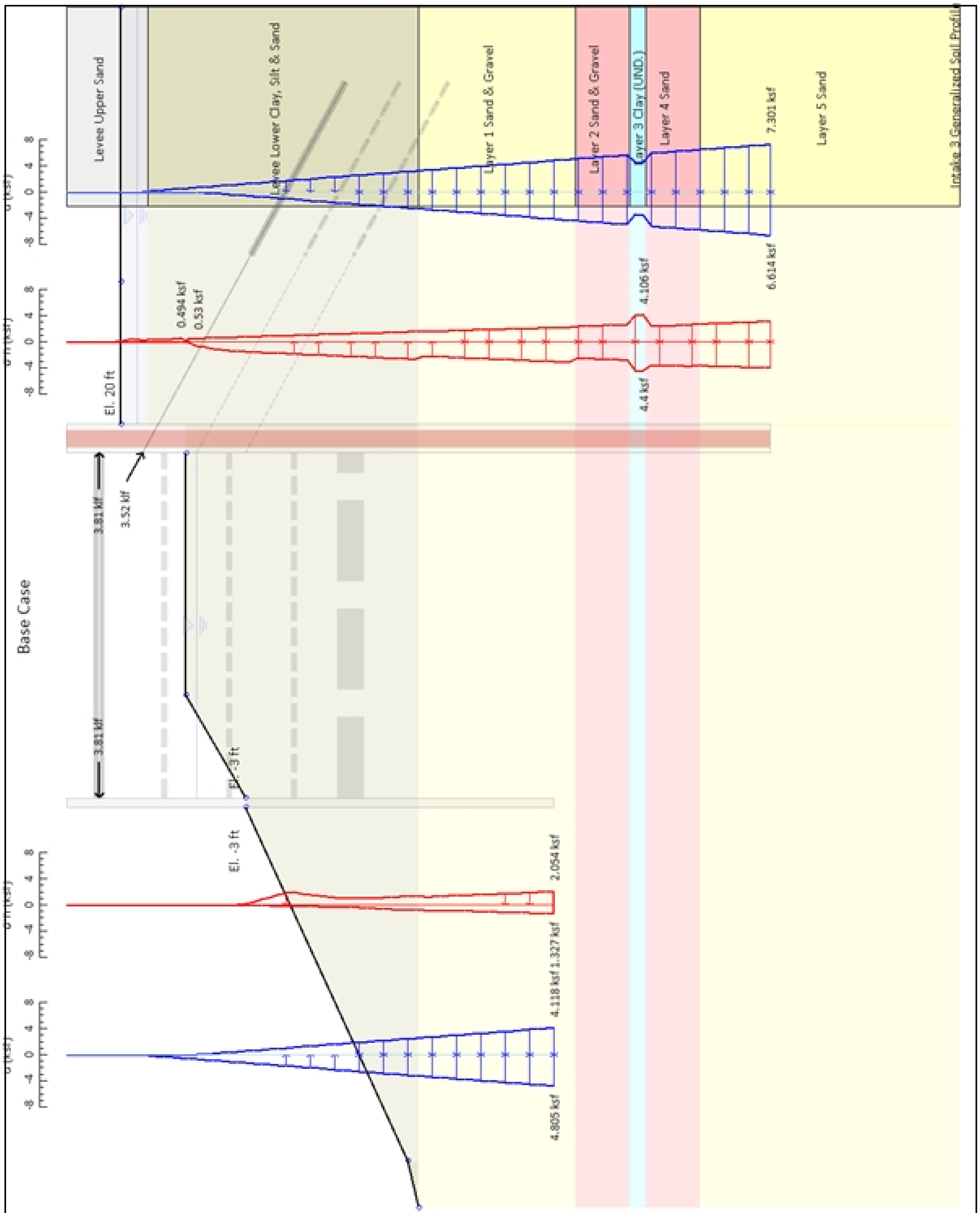
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 3	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



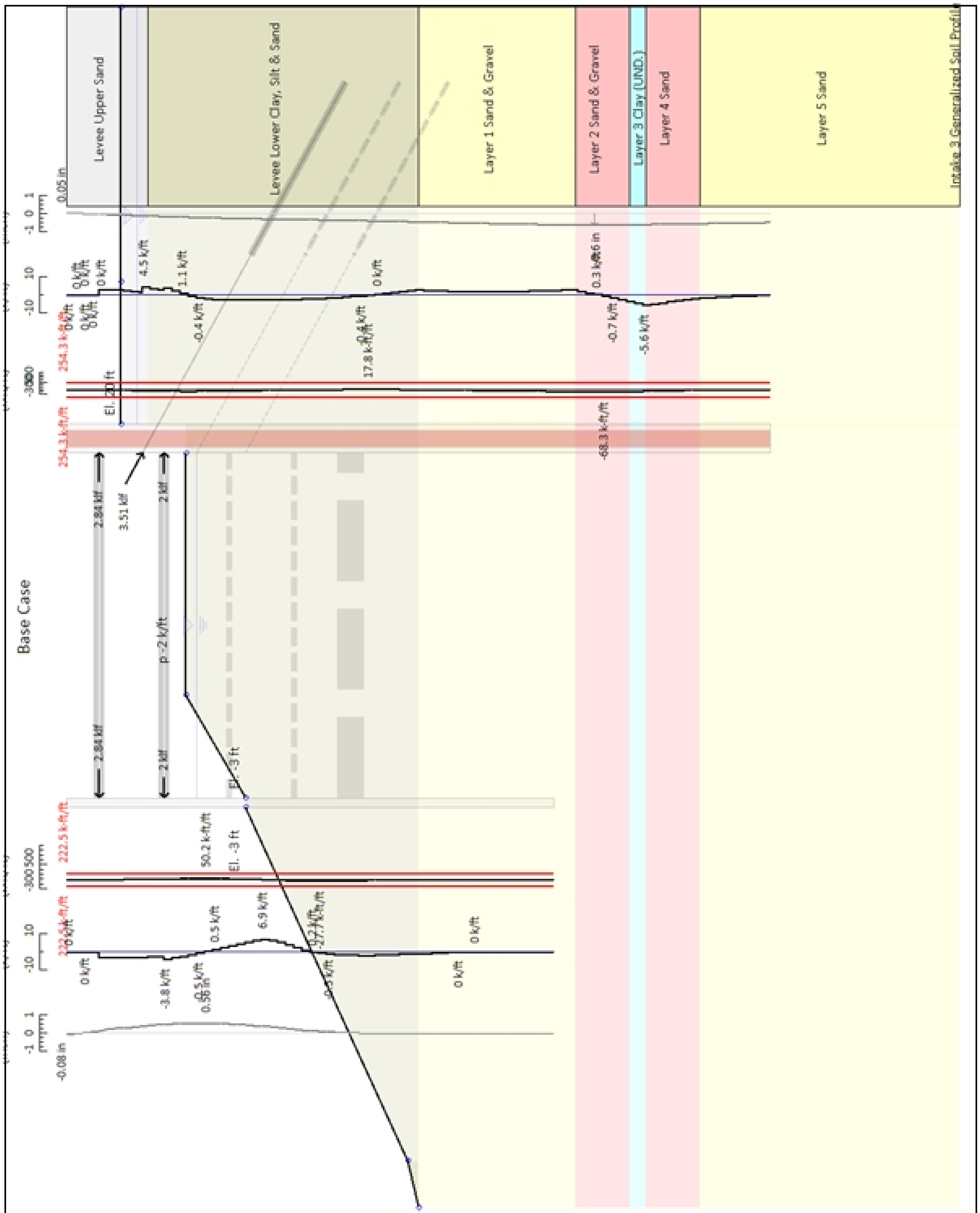
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 3	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



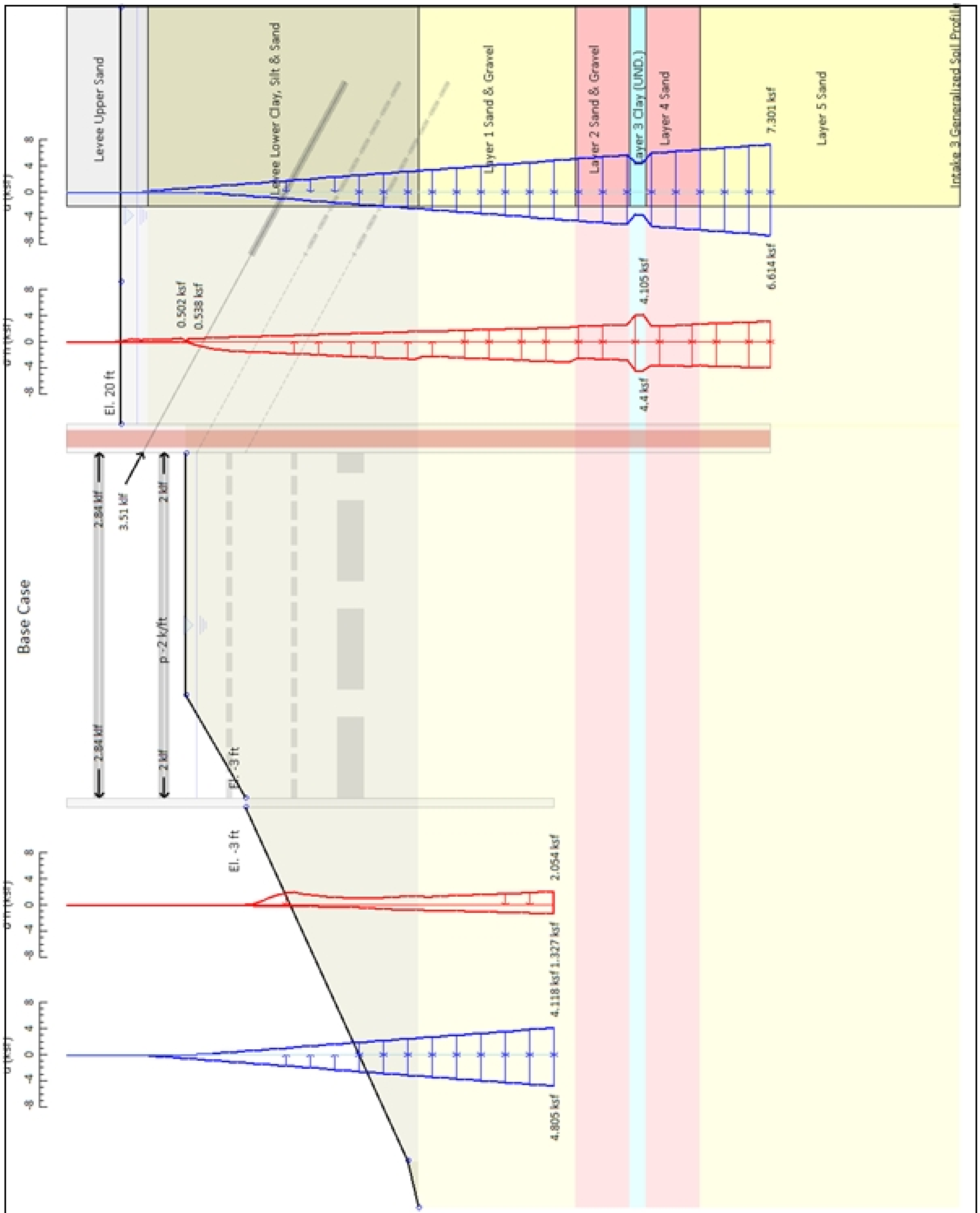
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 4	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



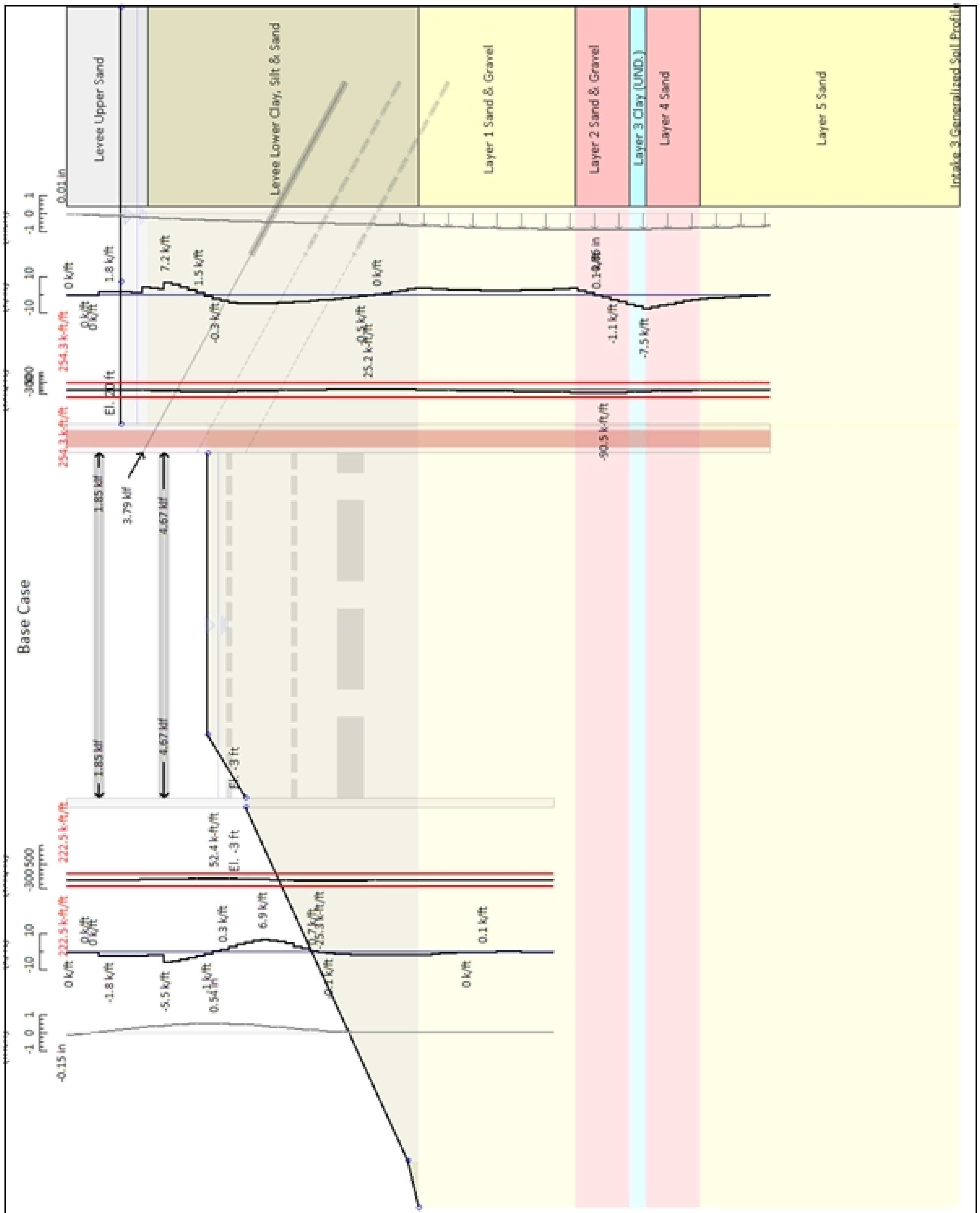
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 4	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



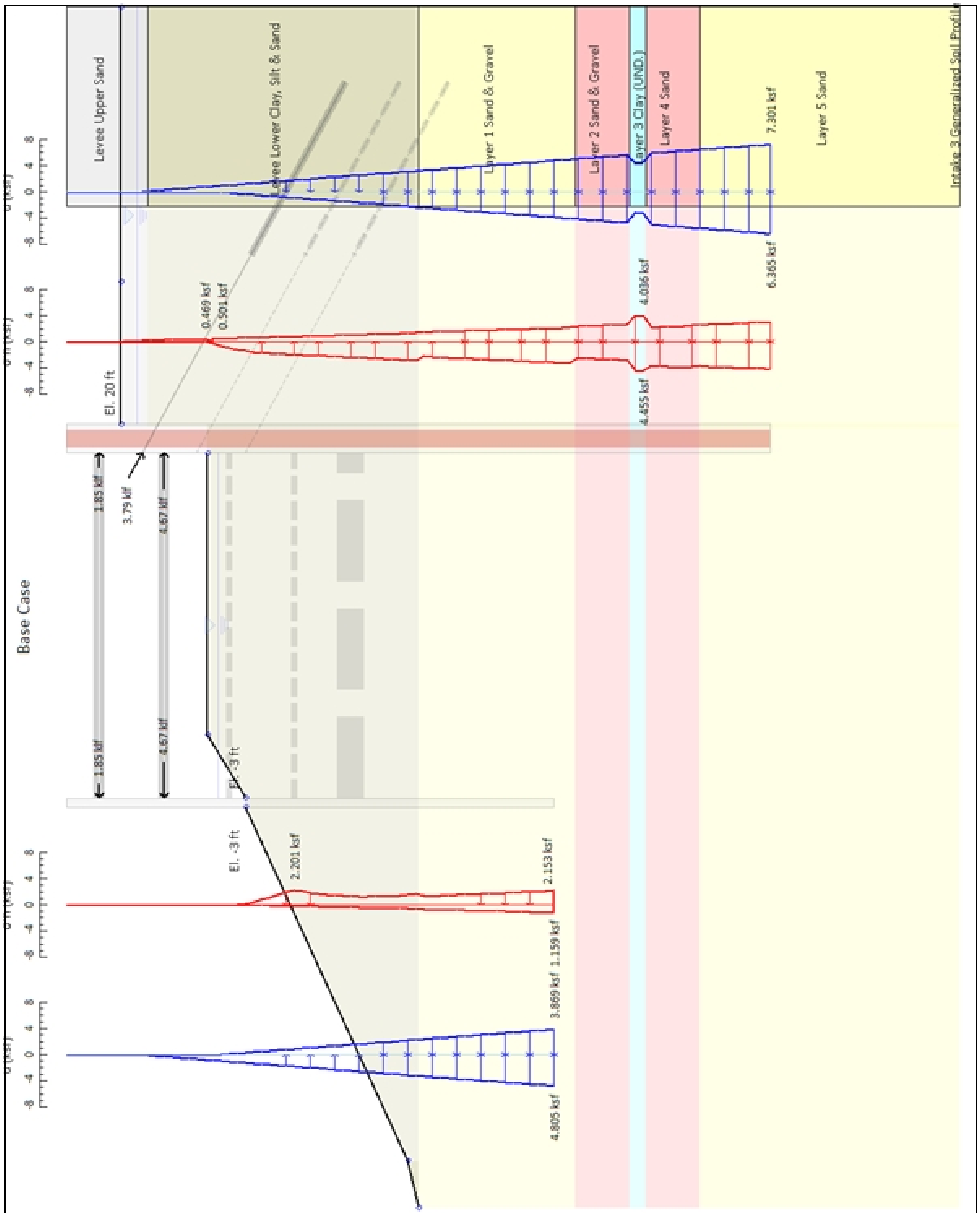
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 5	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



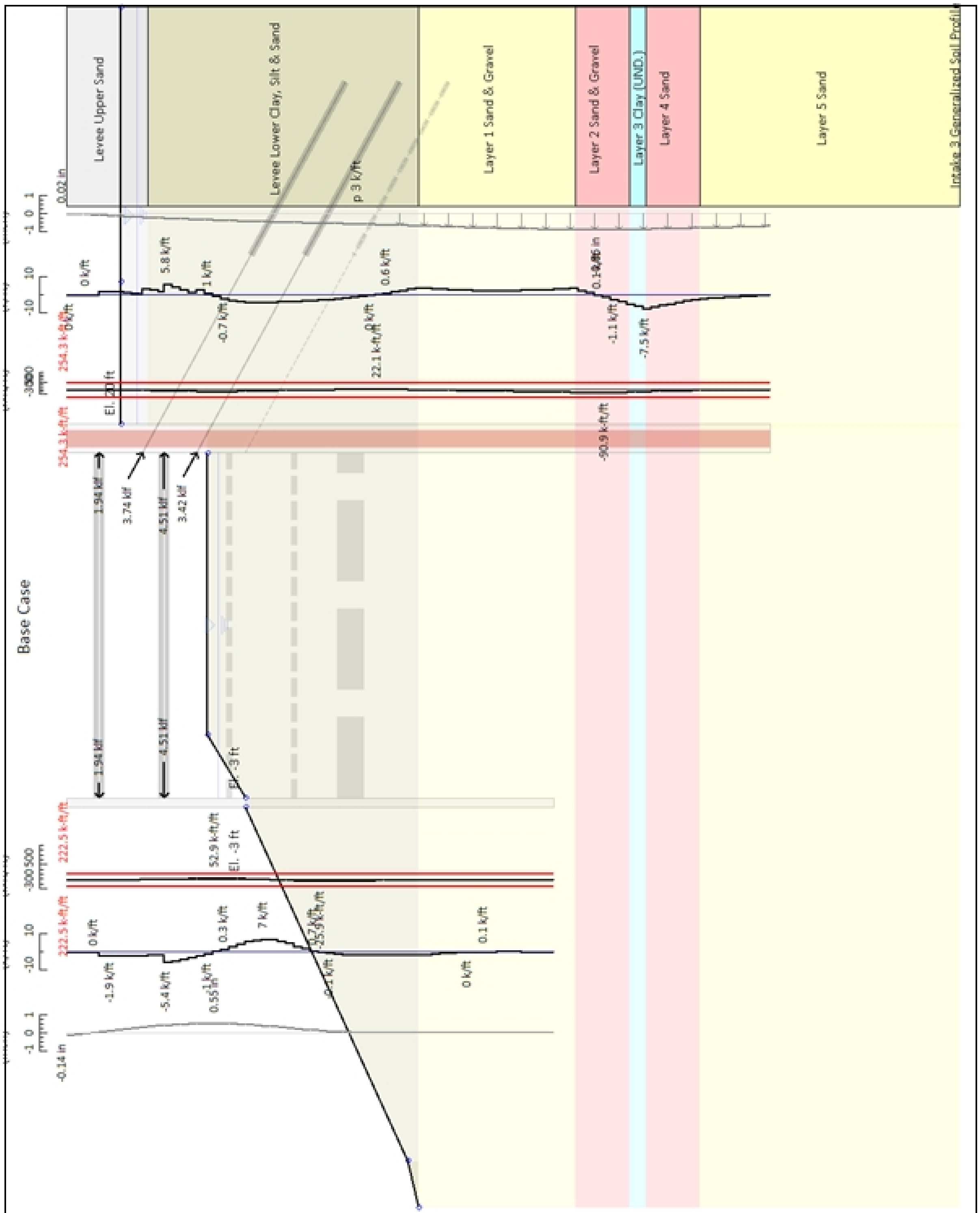
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 5	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



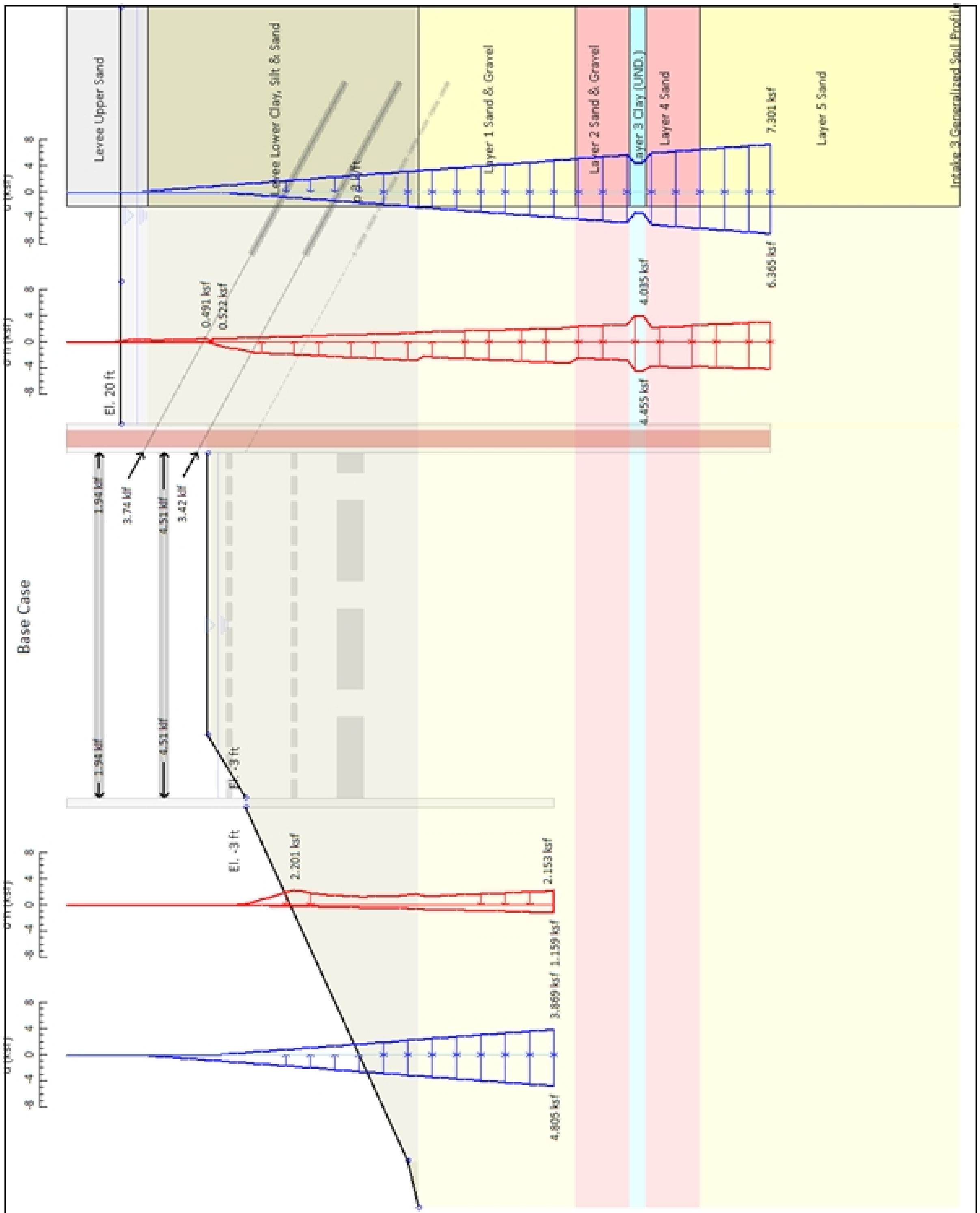
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 6	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



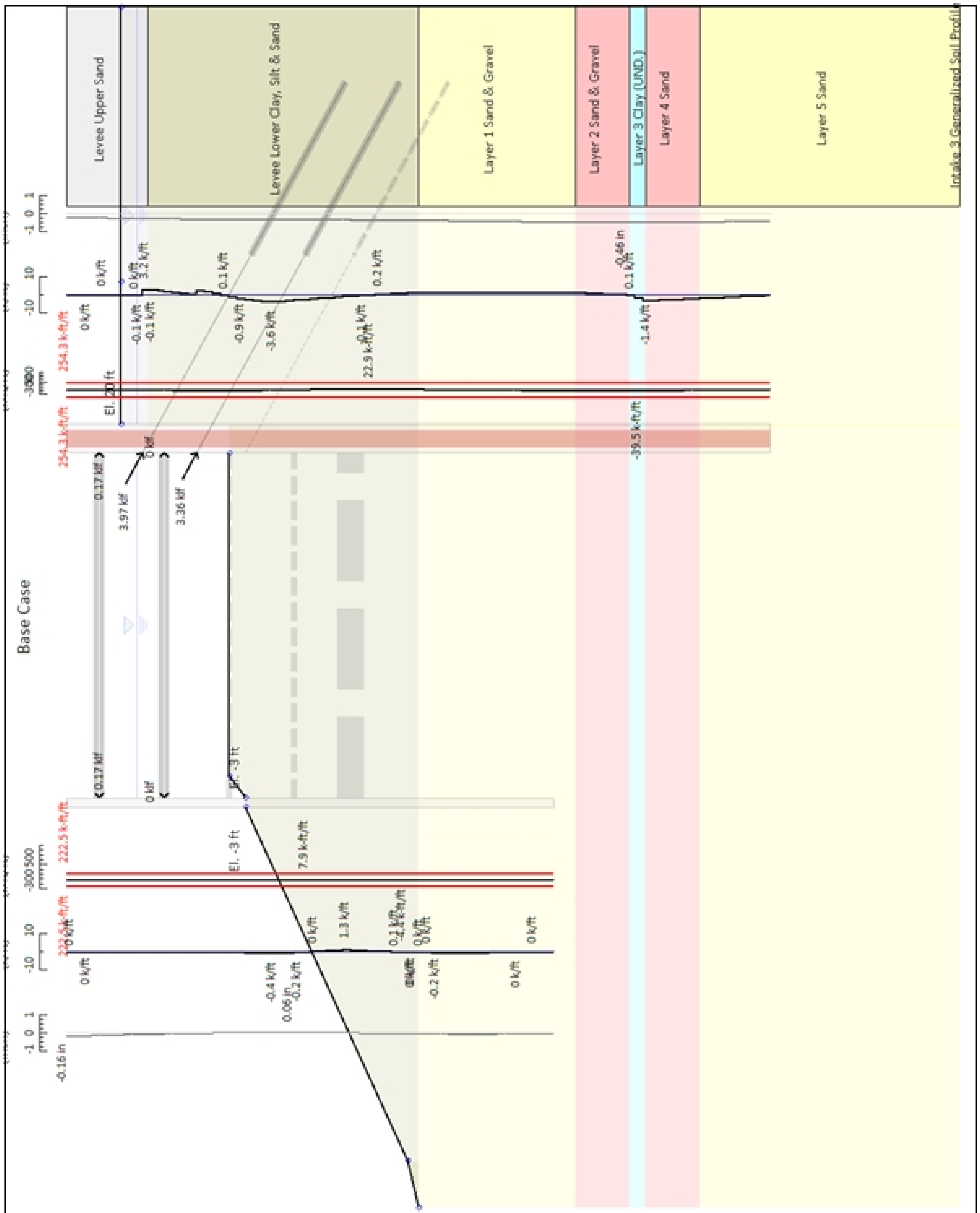
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 6	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



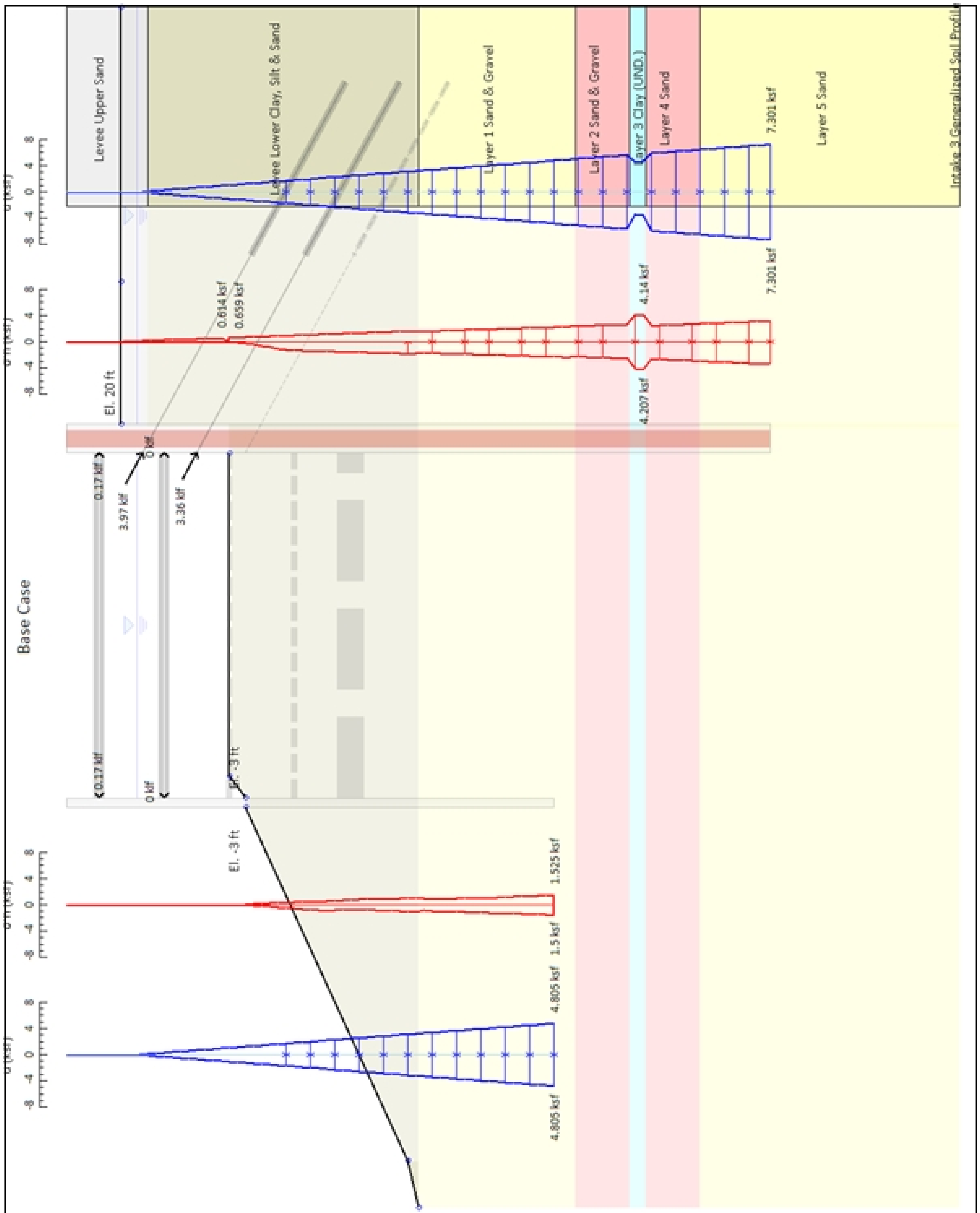
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 7	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



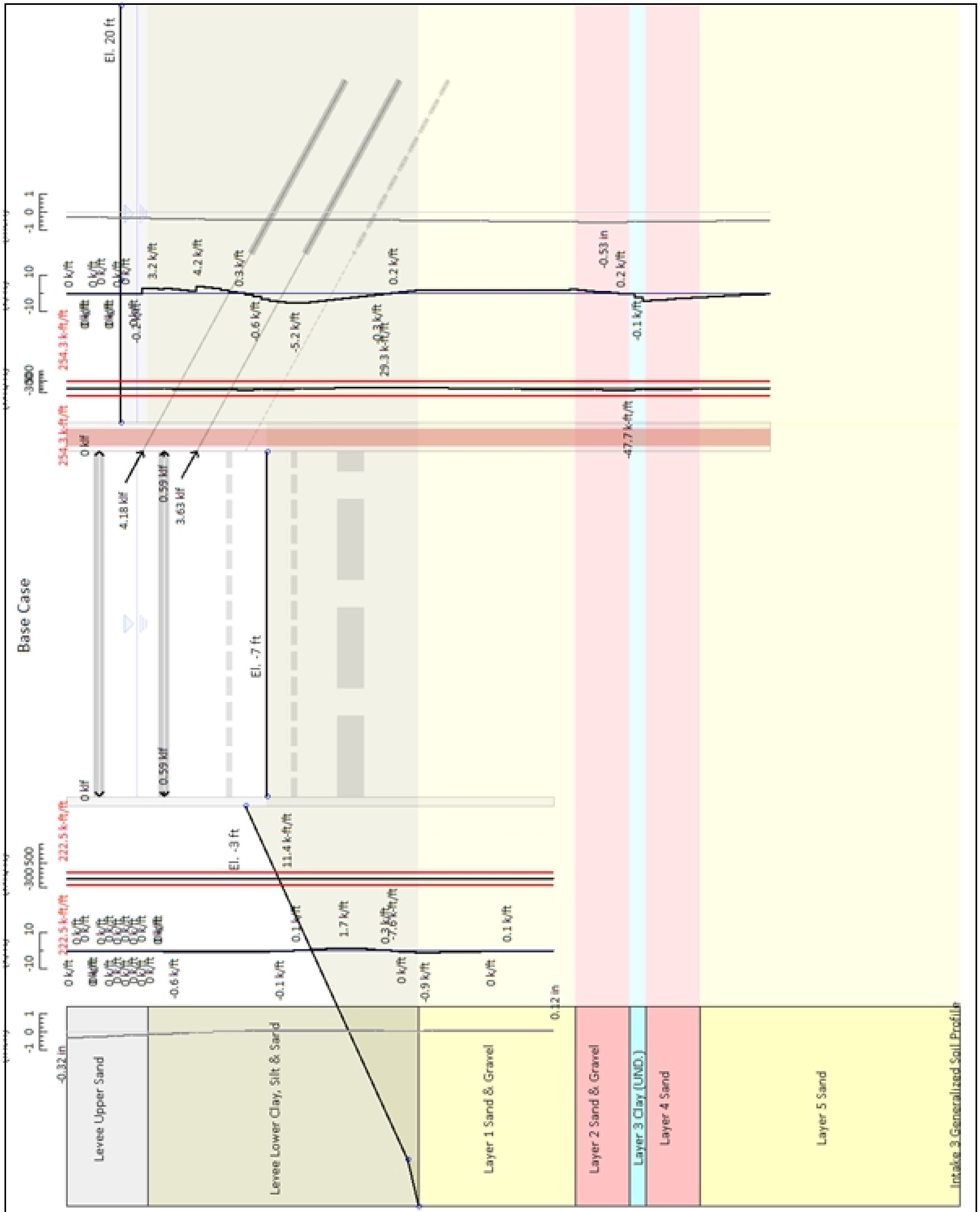
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 7	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



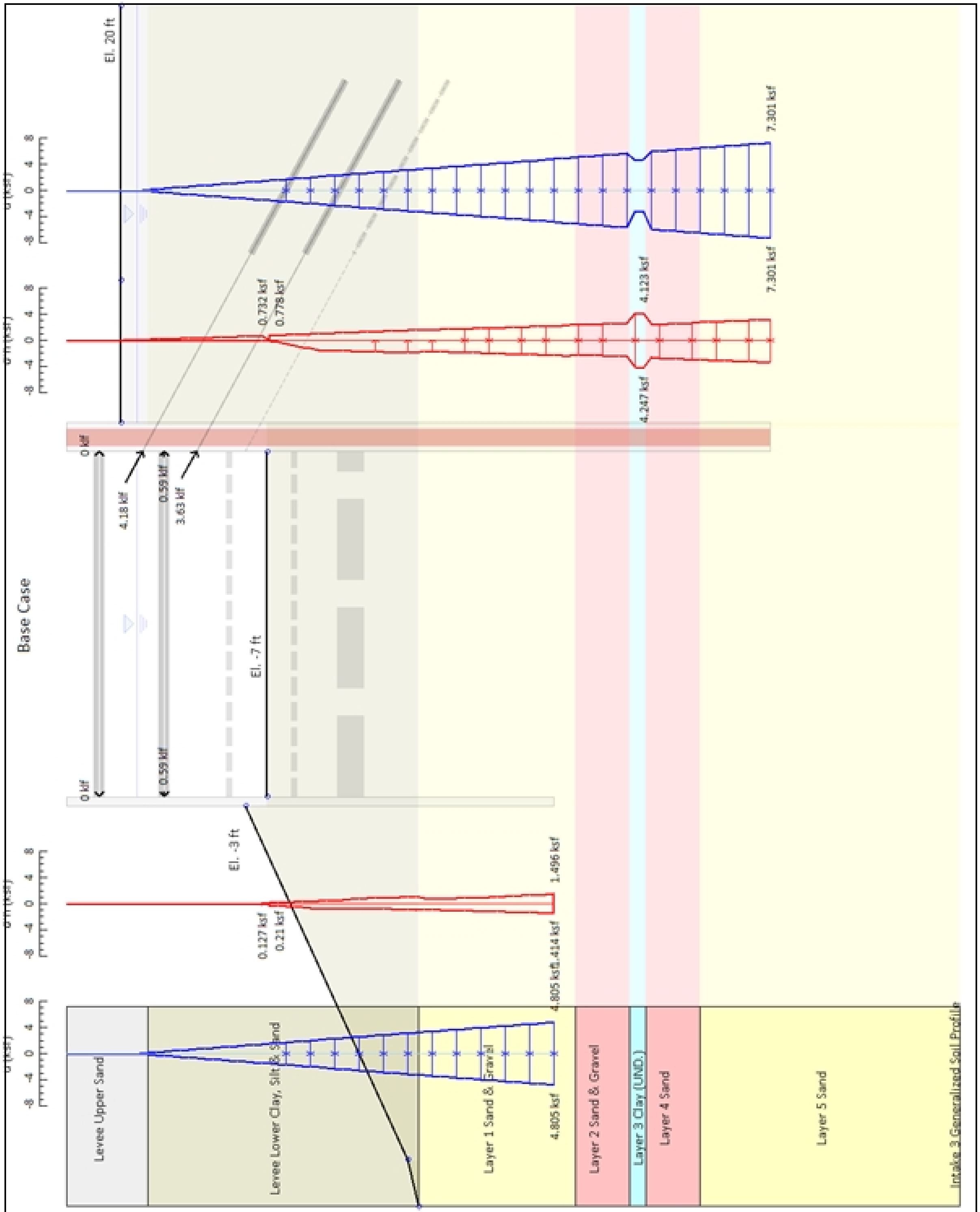
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 8	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



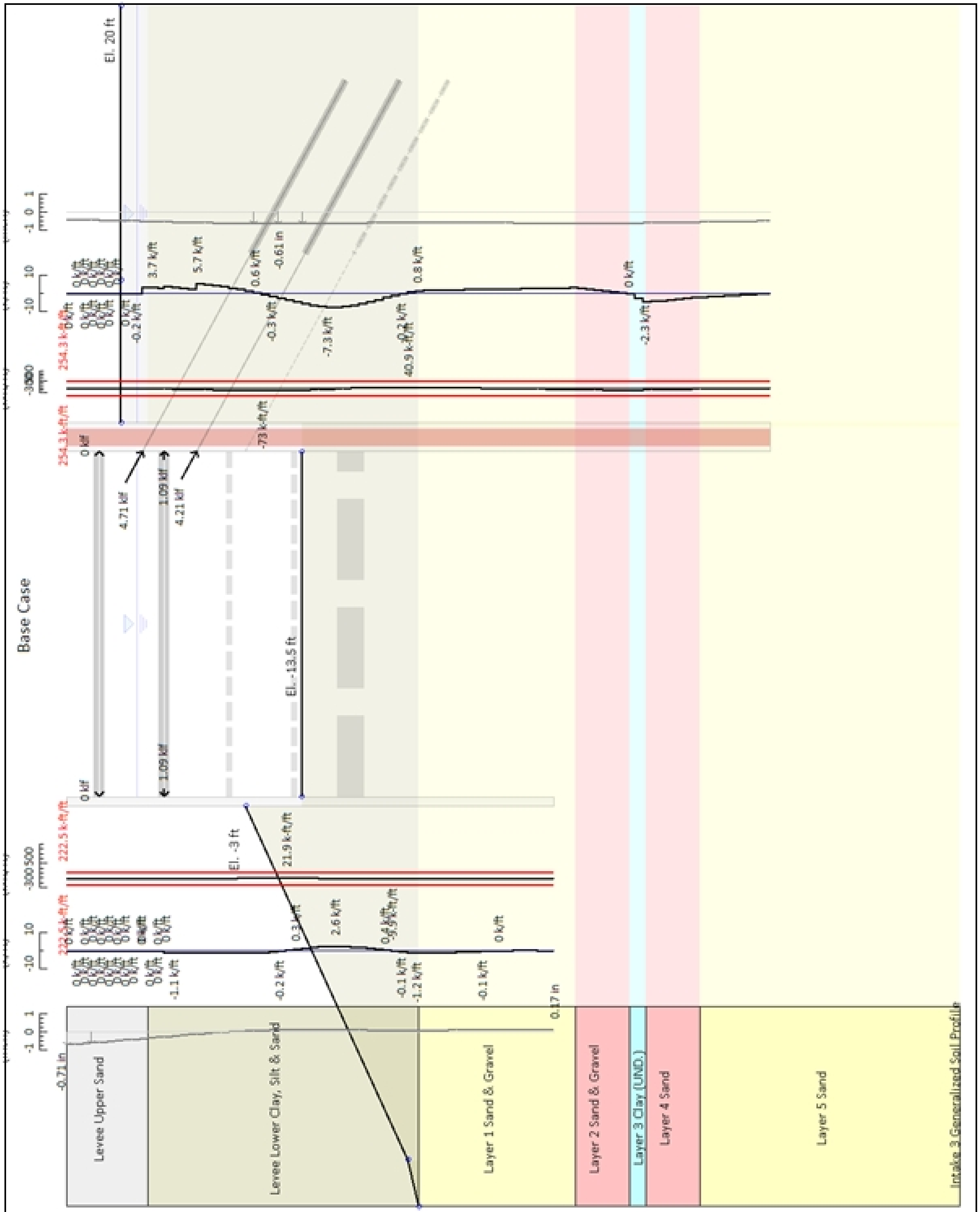
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 8	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



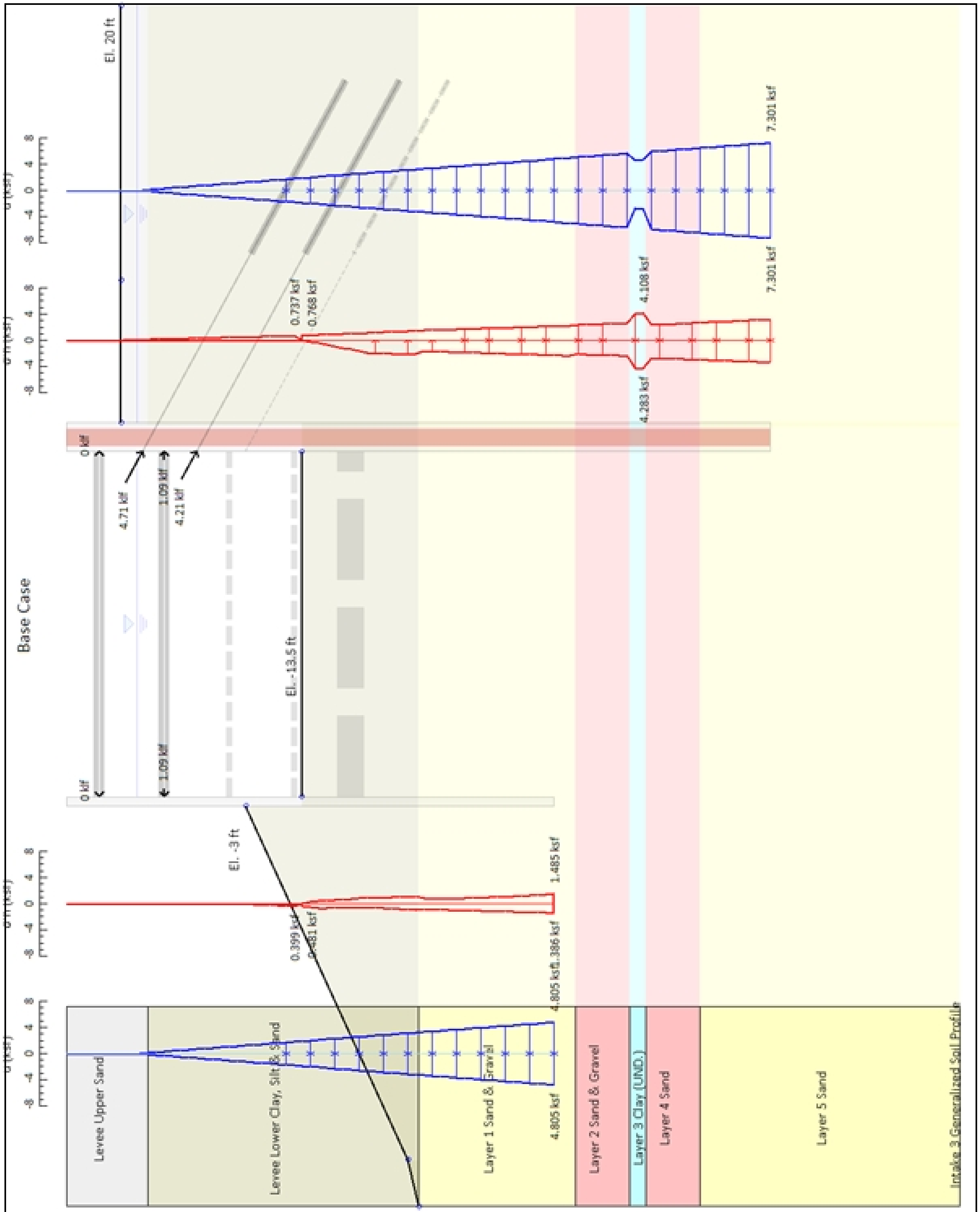
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 9	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



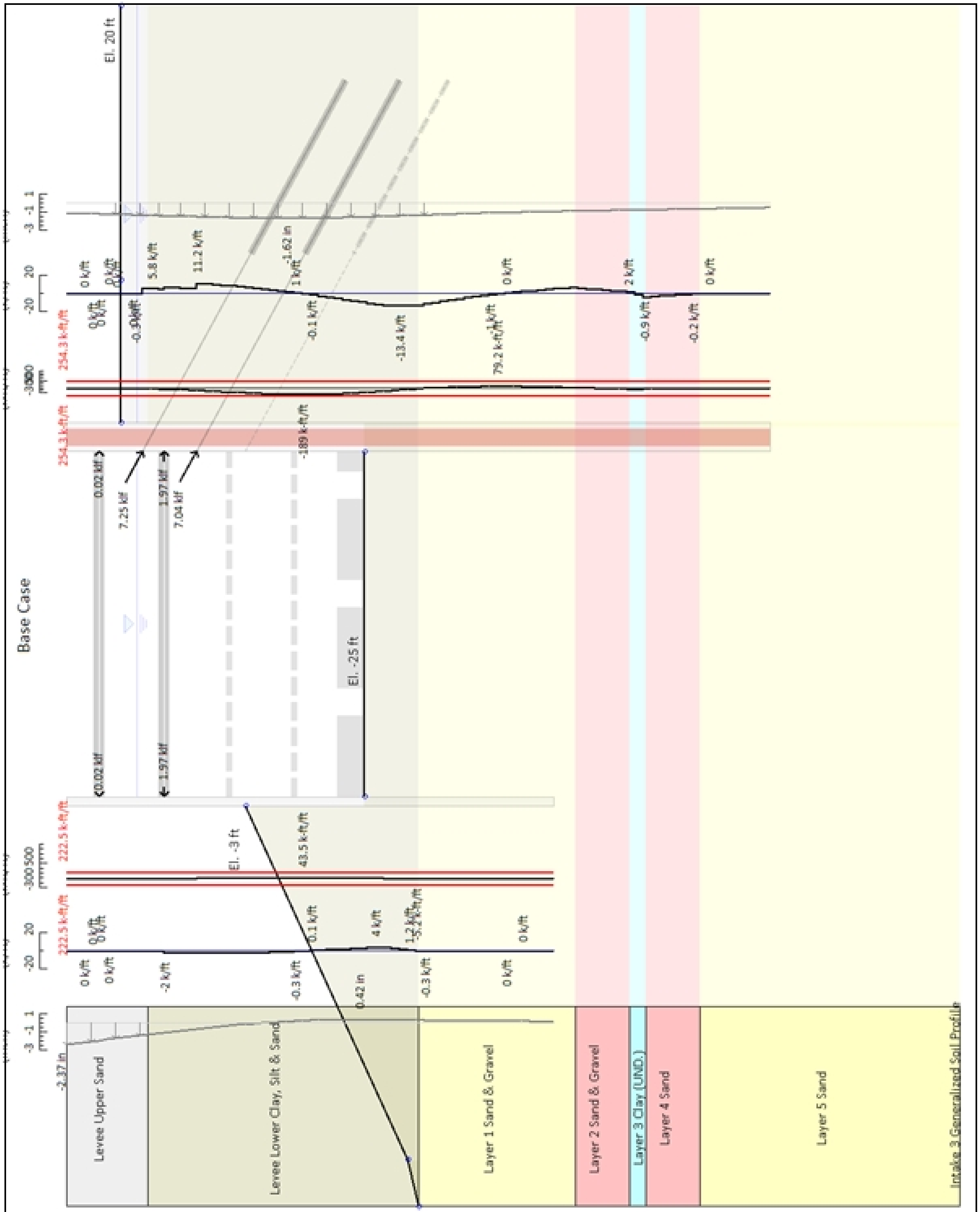
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 9	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



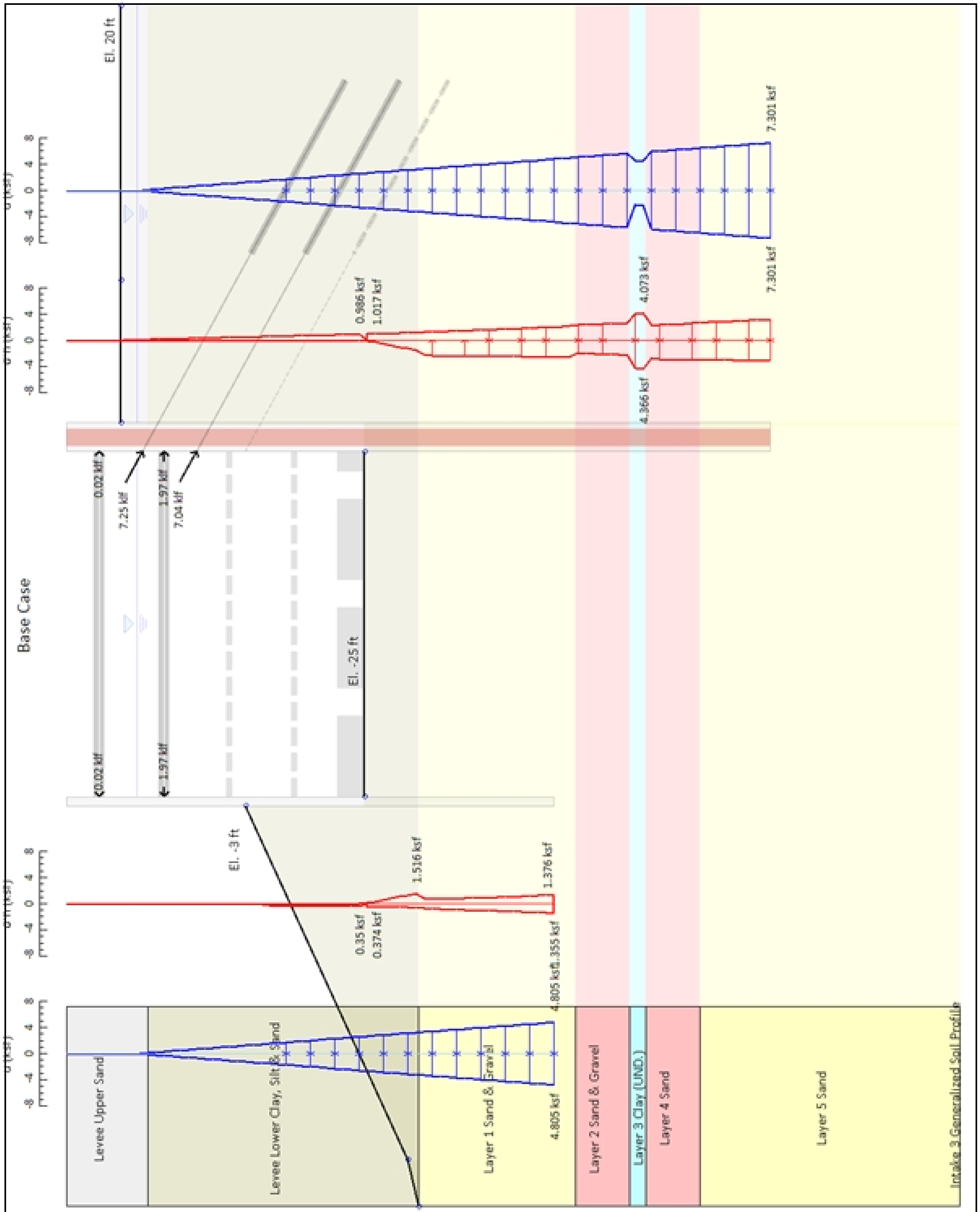
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 10	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



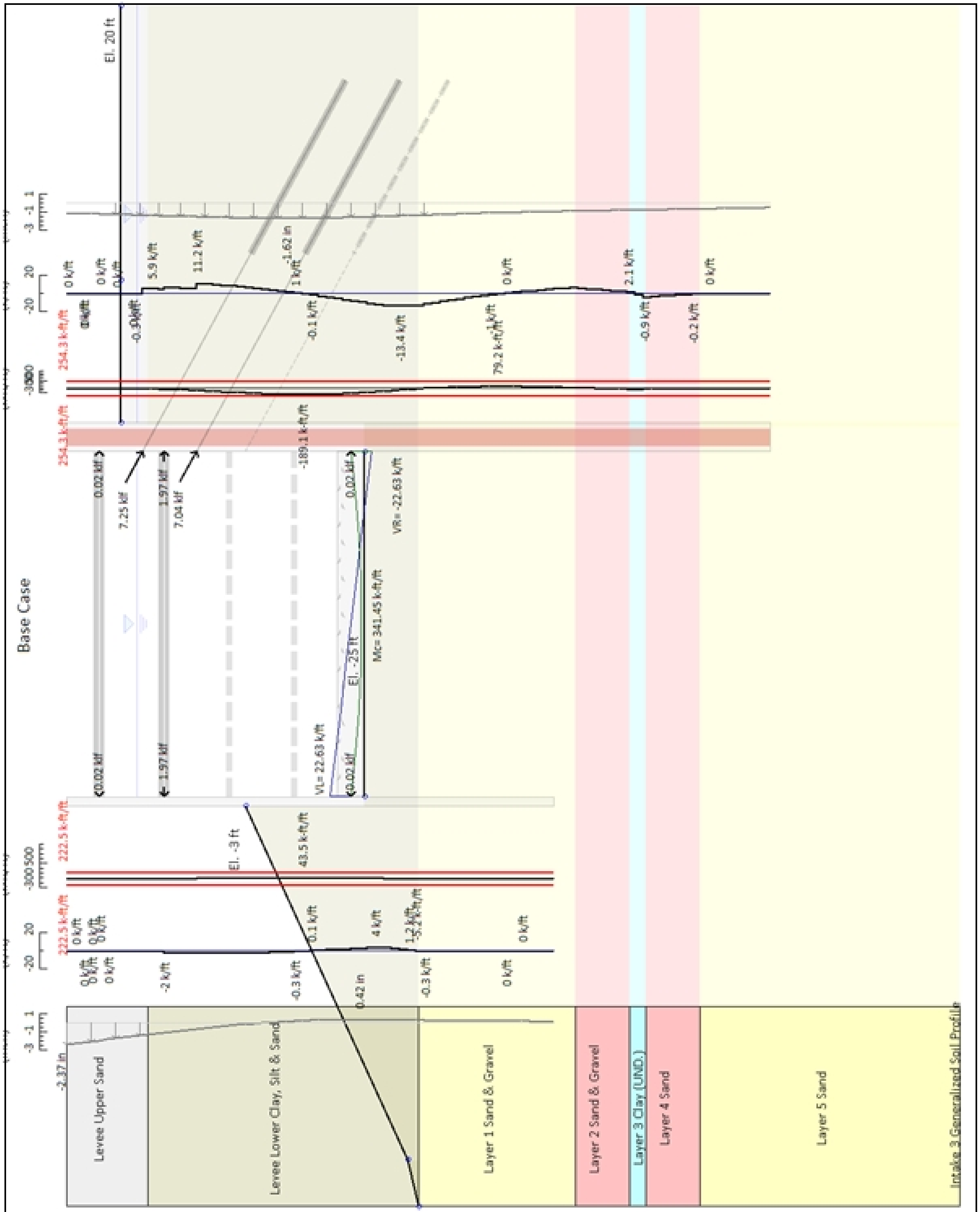
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 10	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



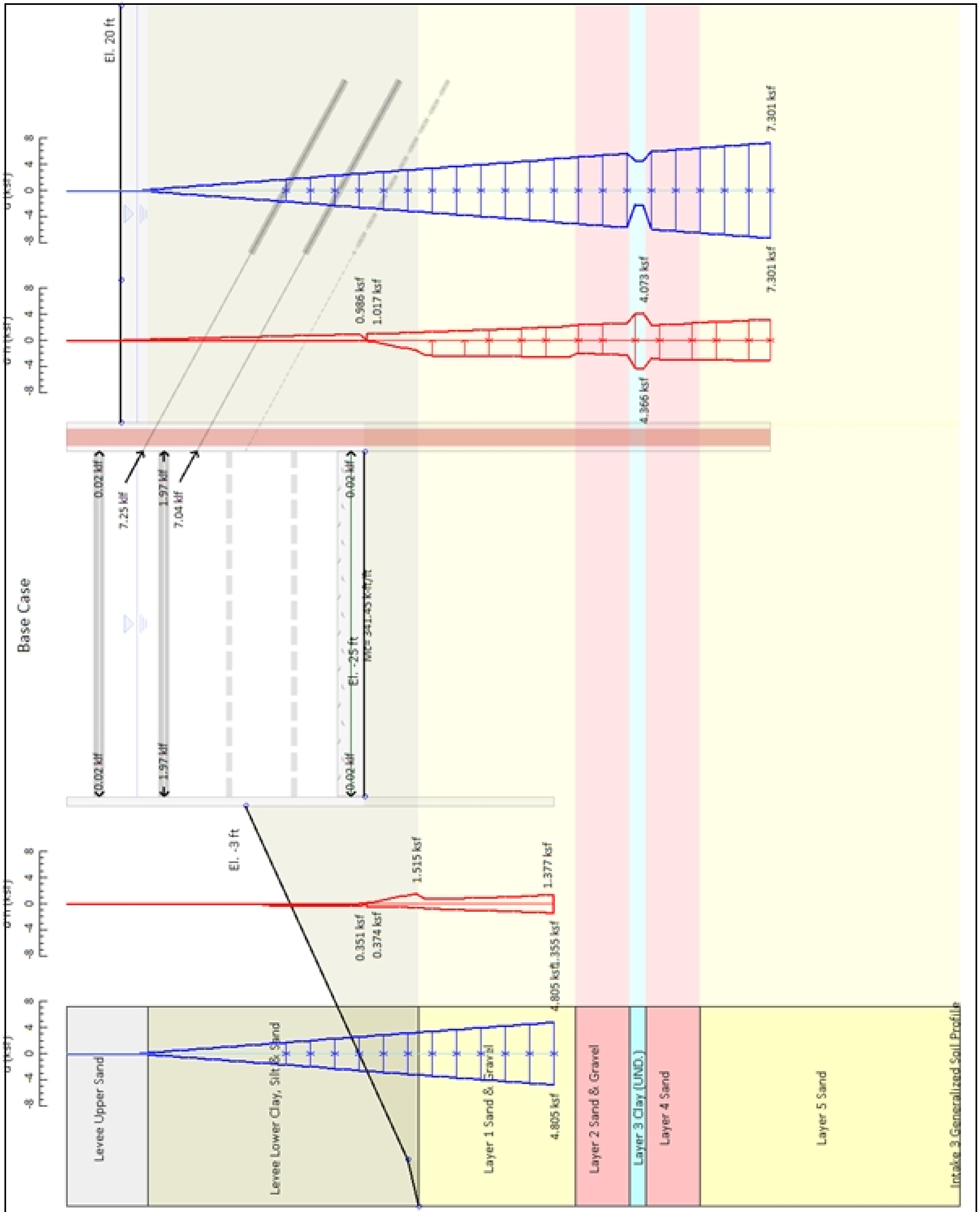
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 11	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



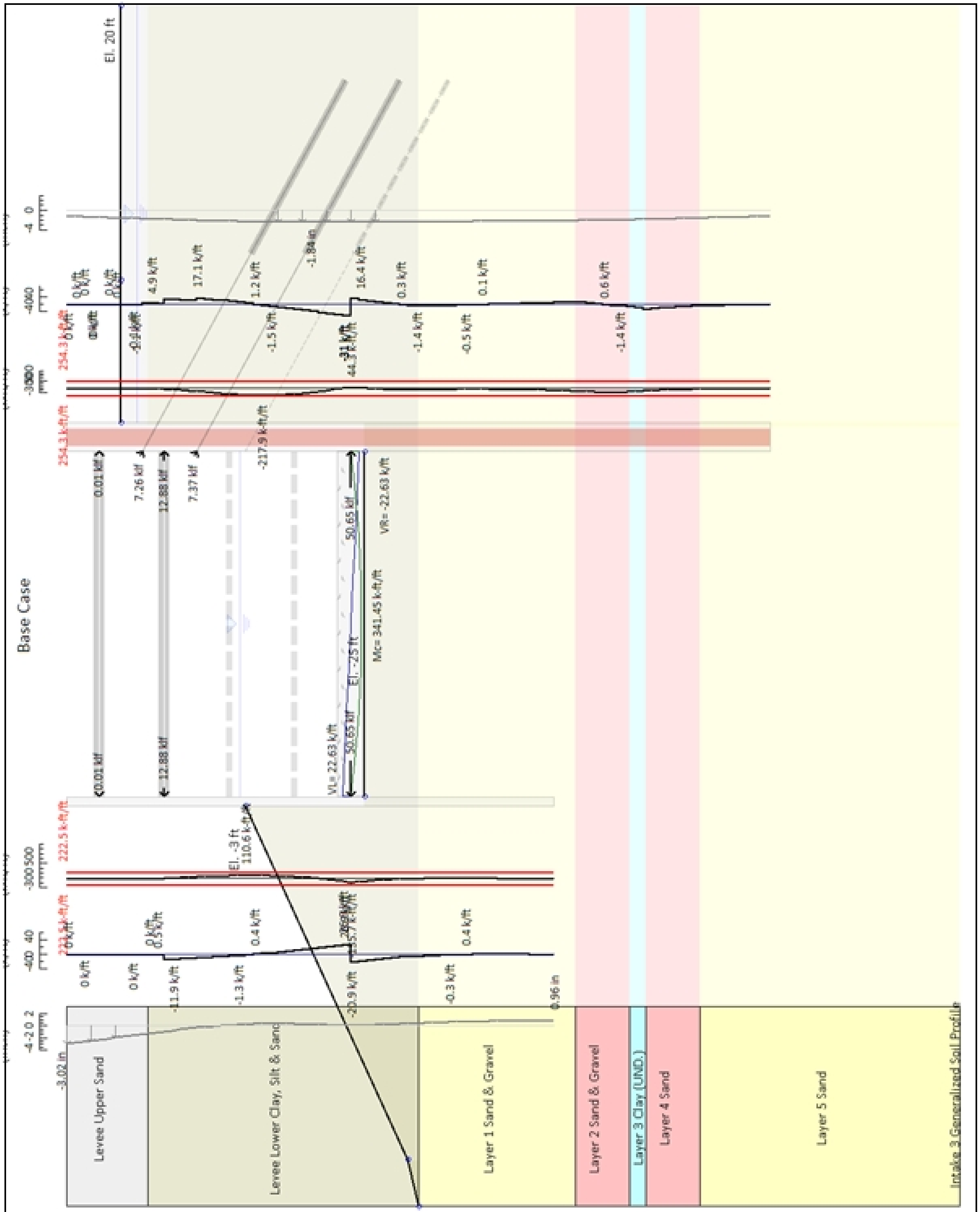
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 11	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



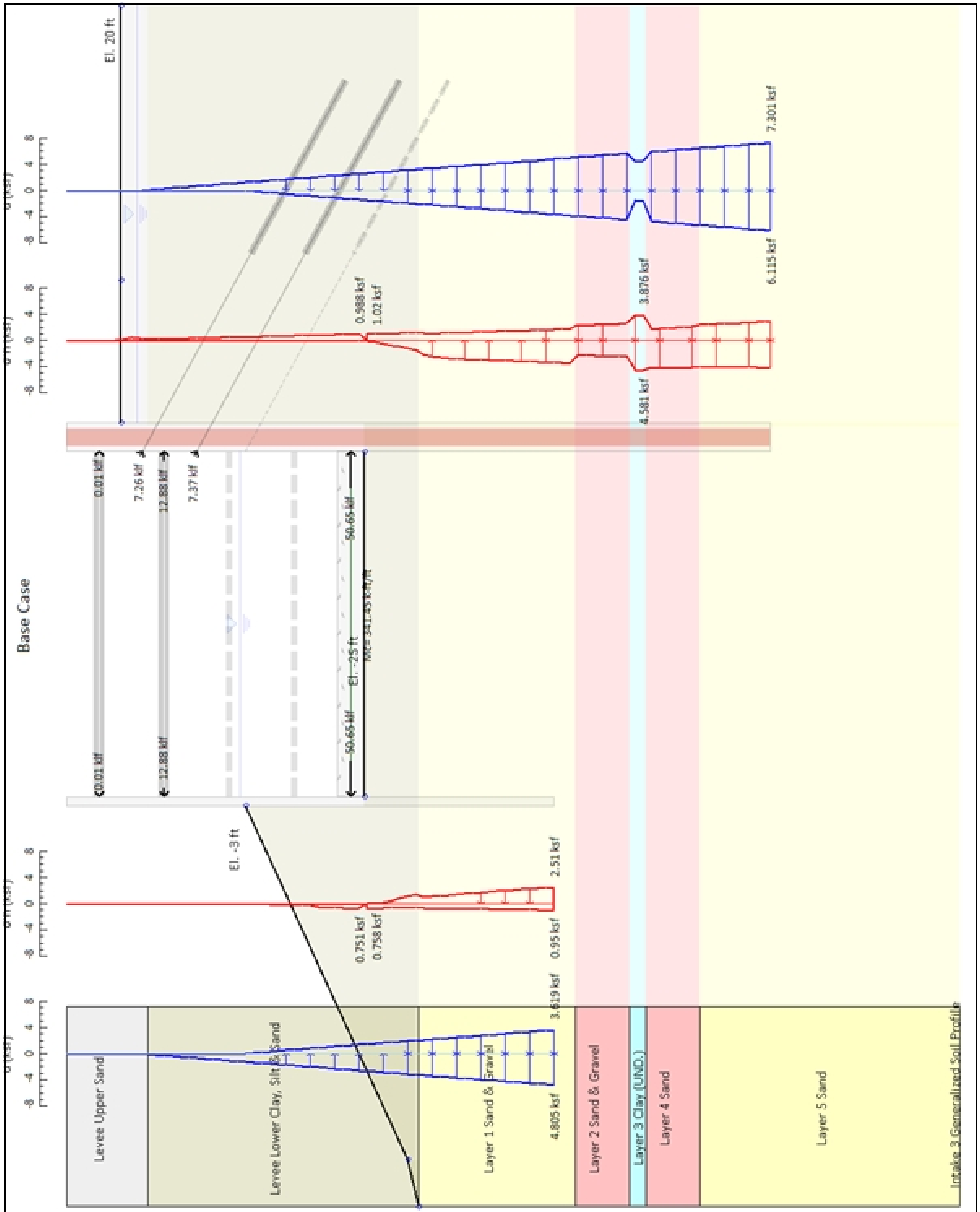
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 12	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



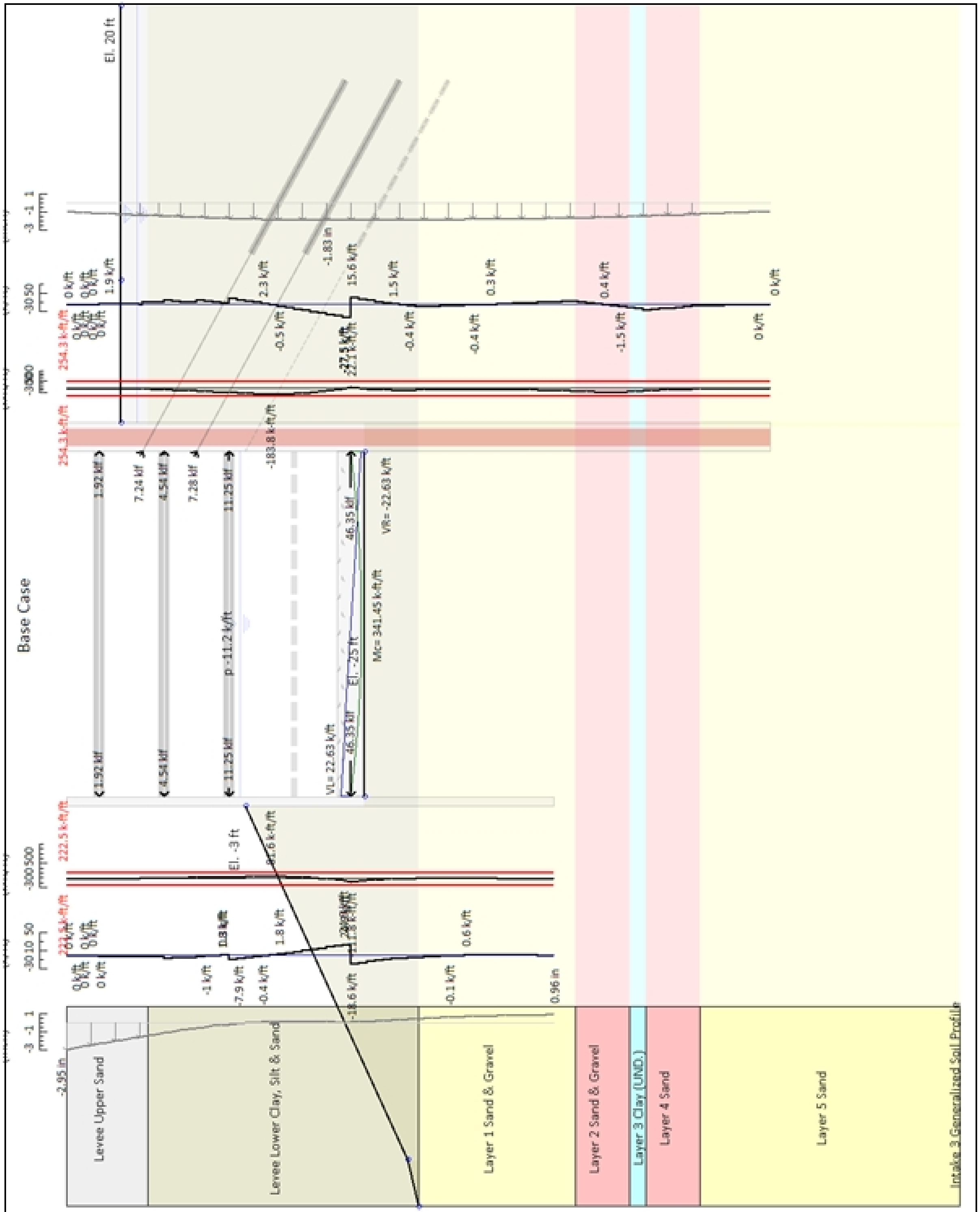
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 12	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



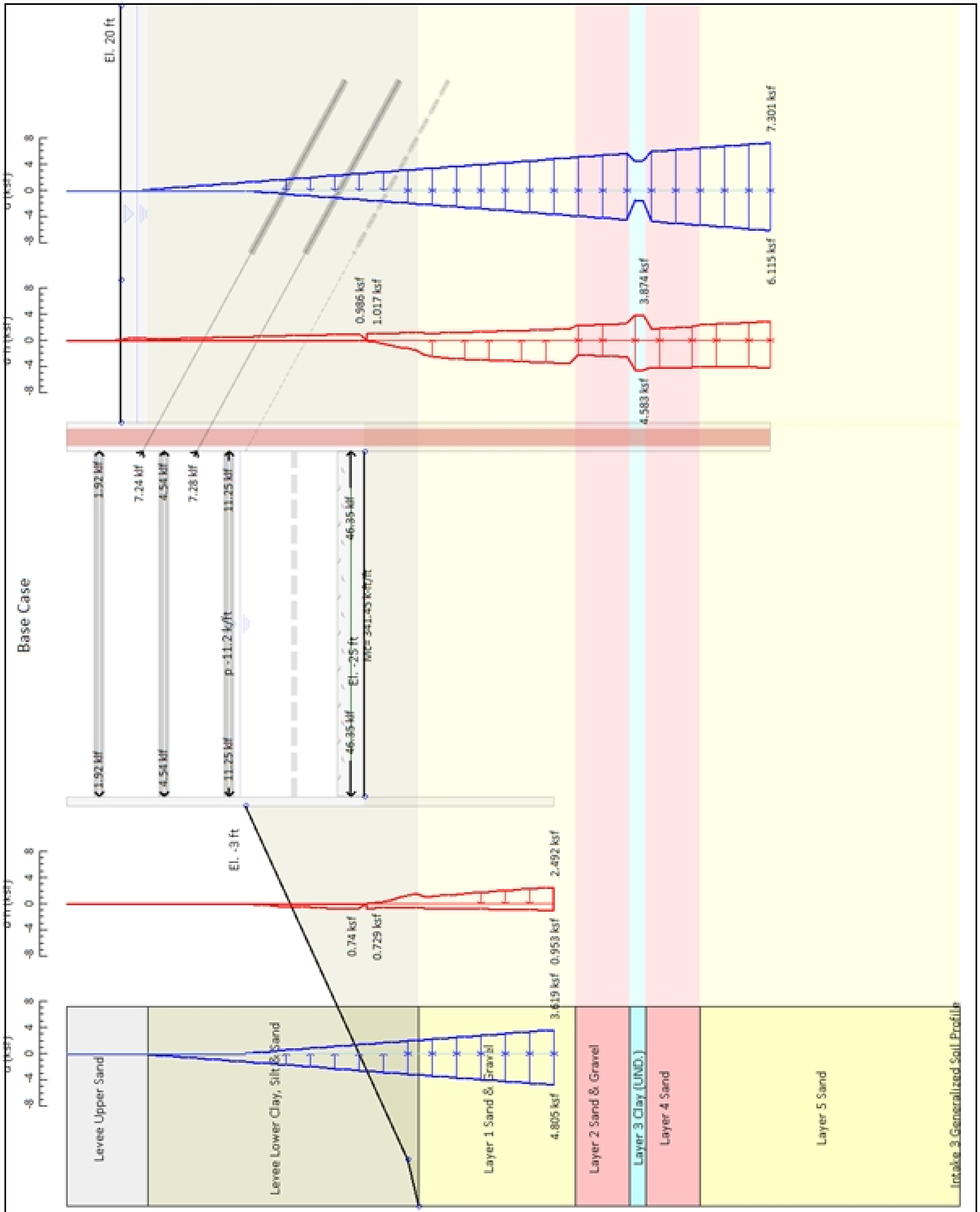
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 13	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



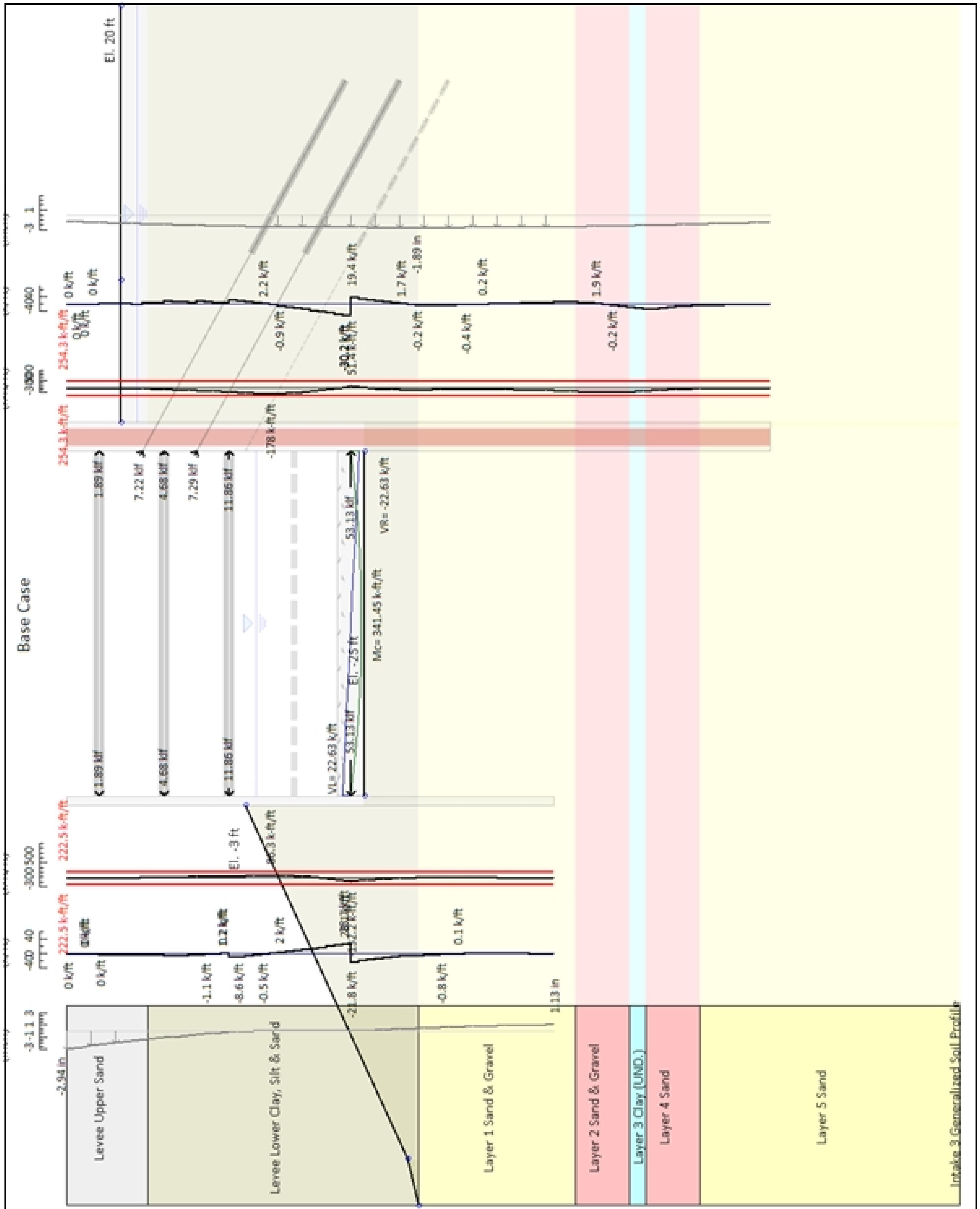
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 13	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



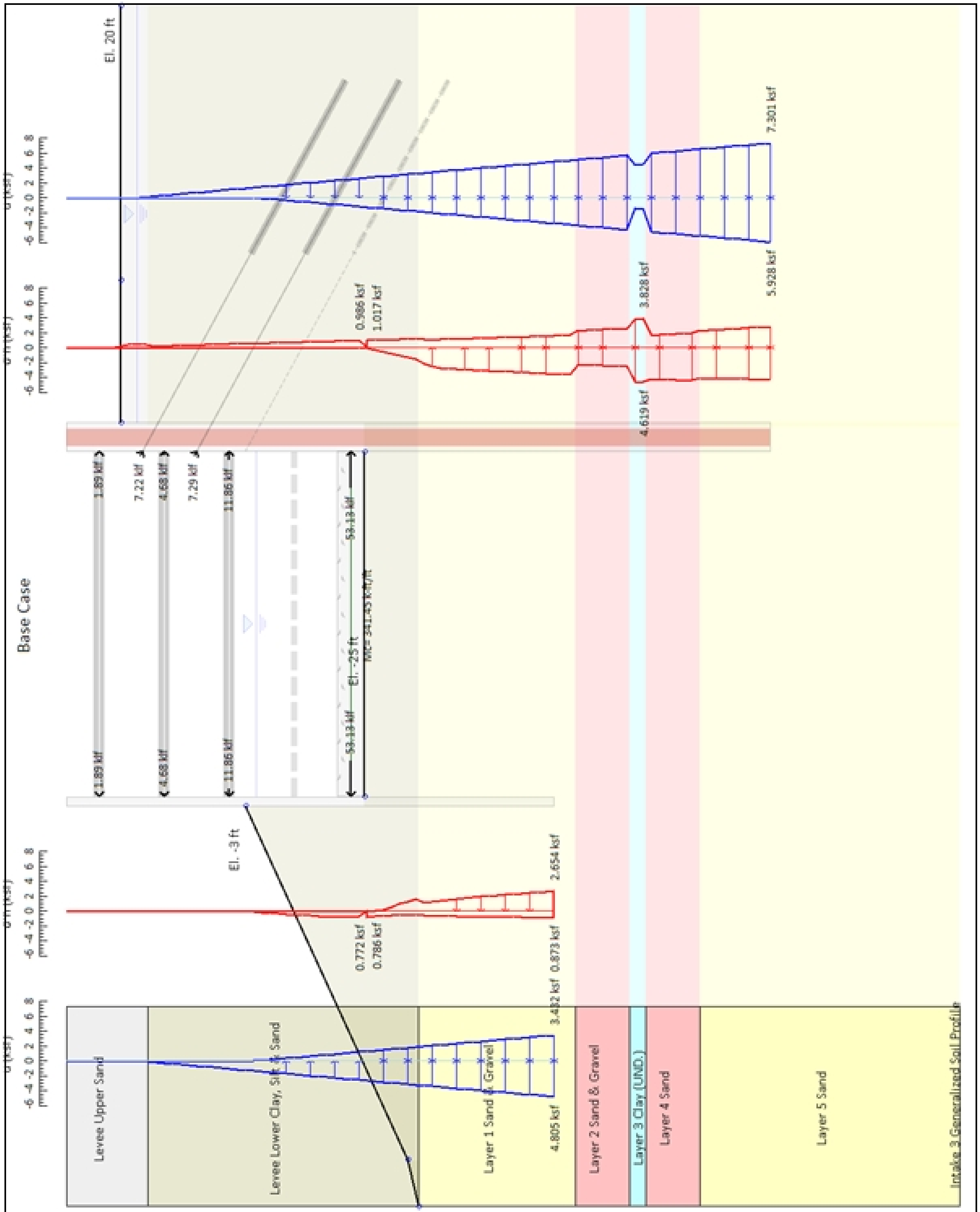
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 14	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



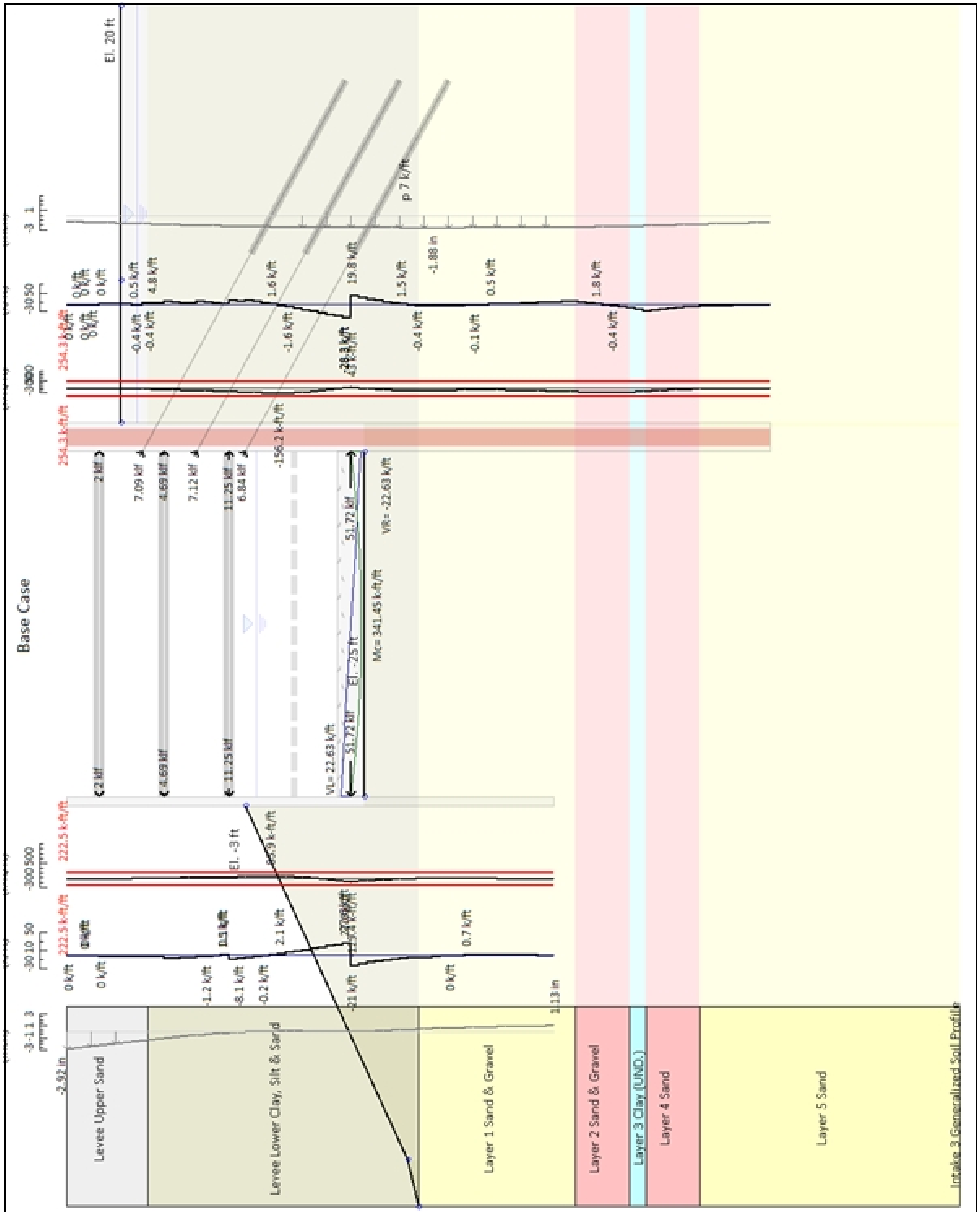
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 14	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



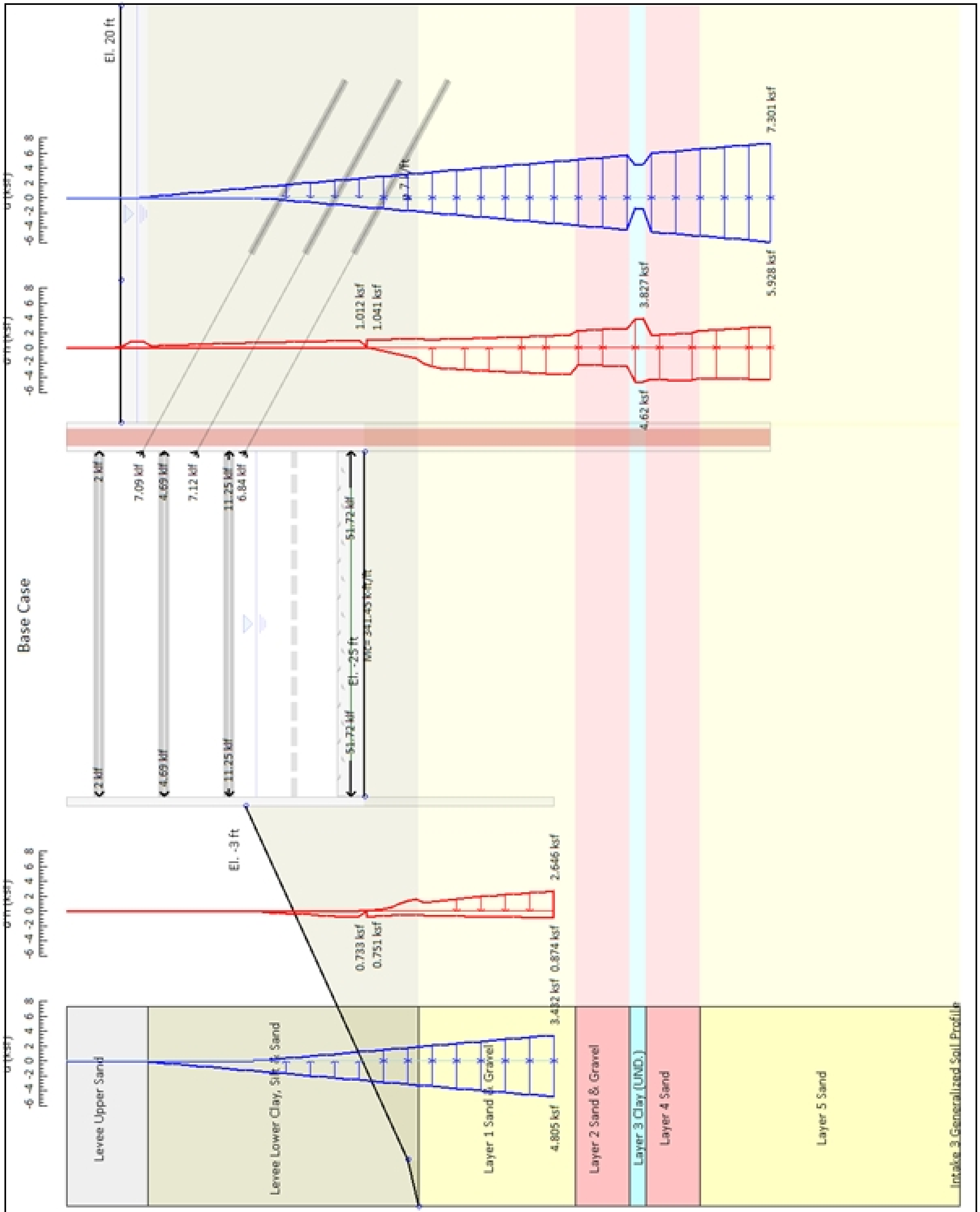
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 15	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



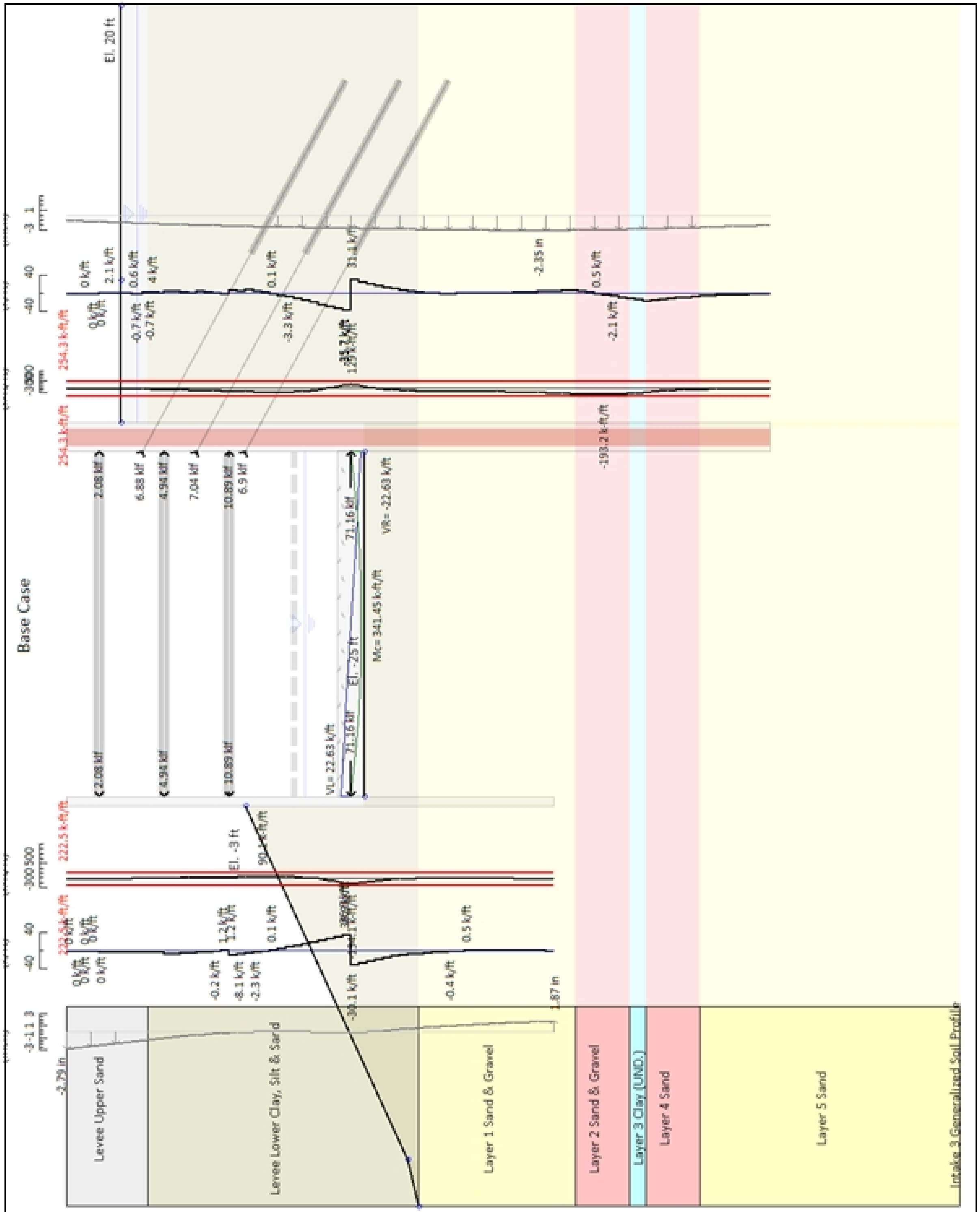
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 15	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



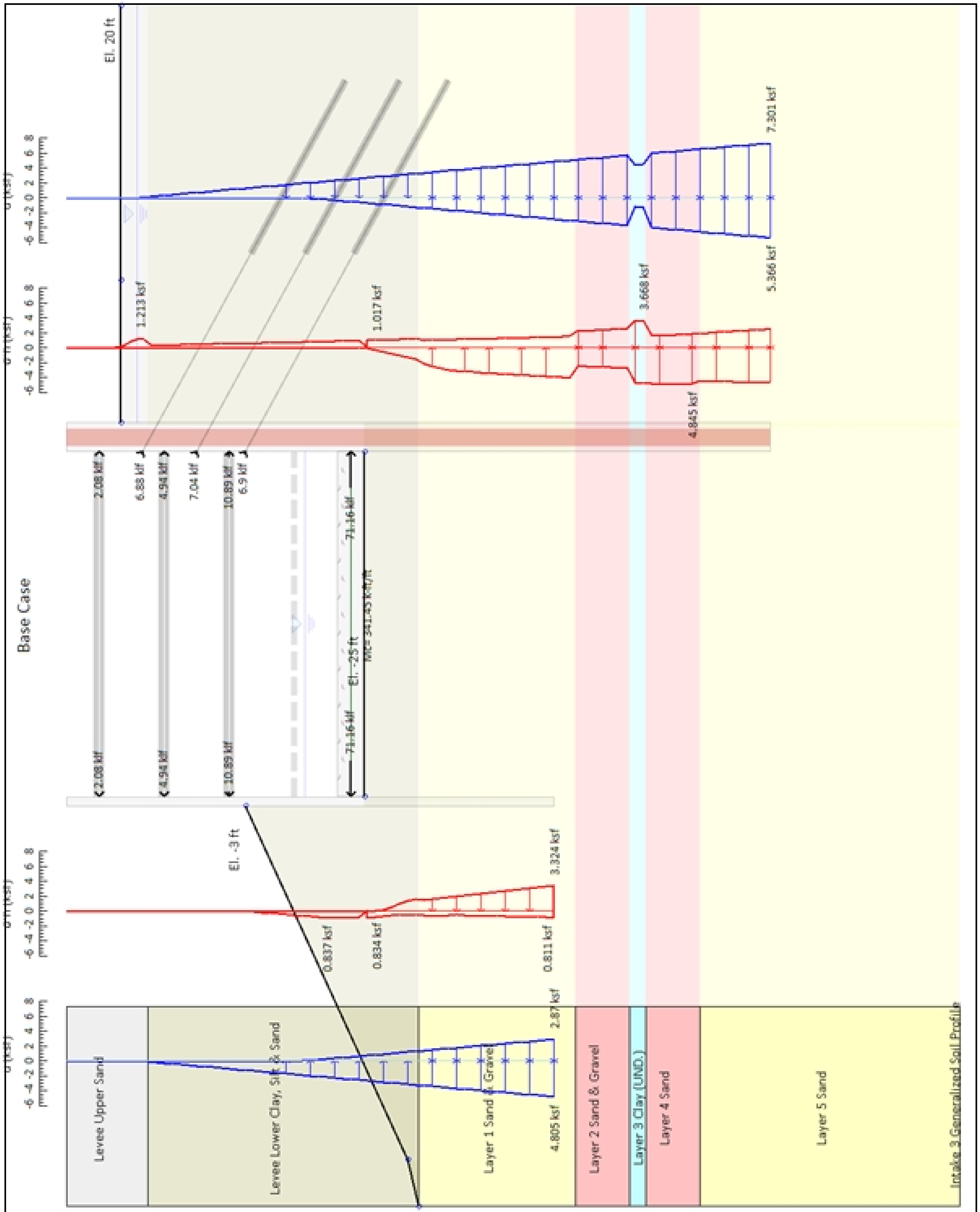
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 16	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



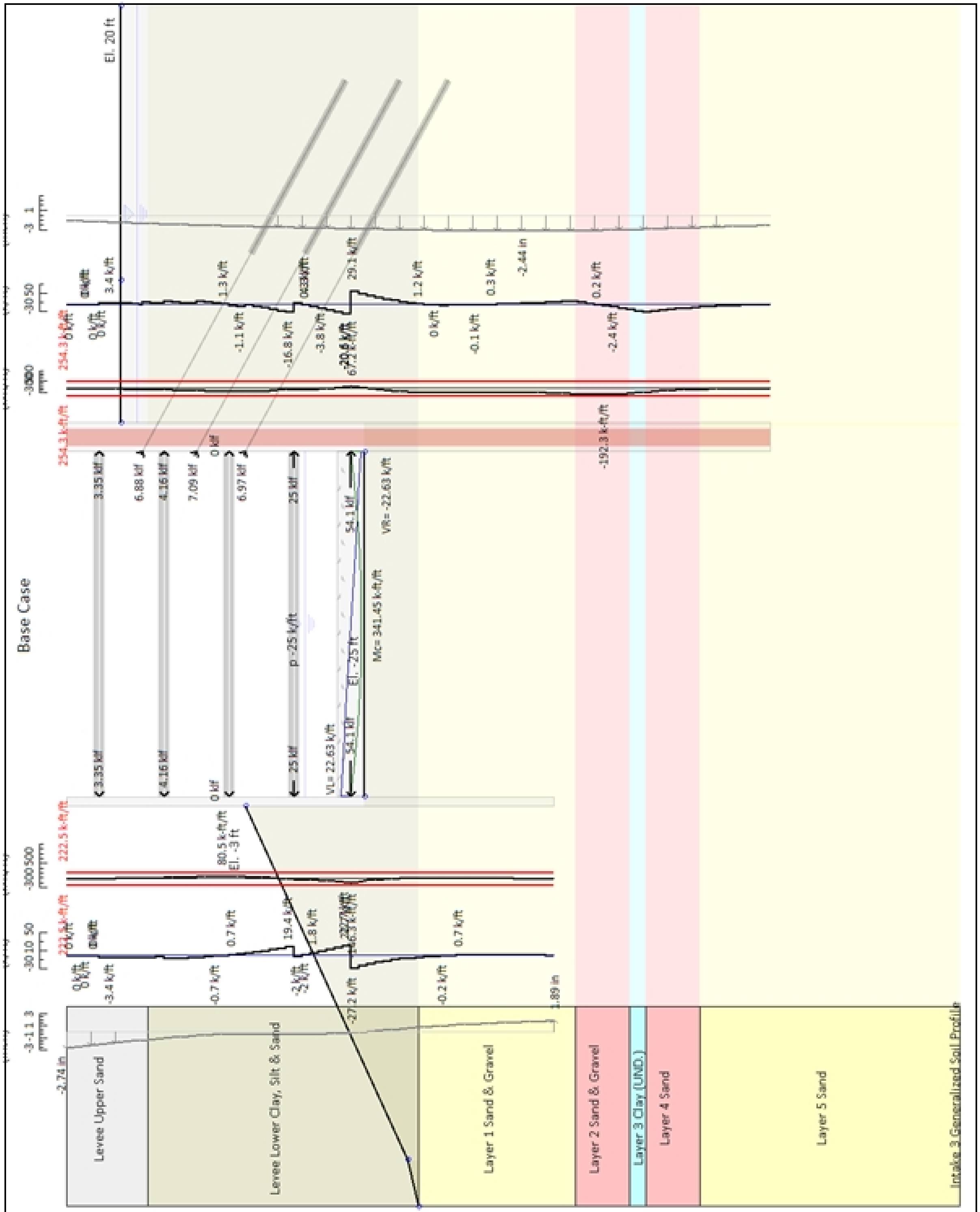
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 16	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



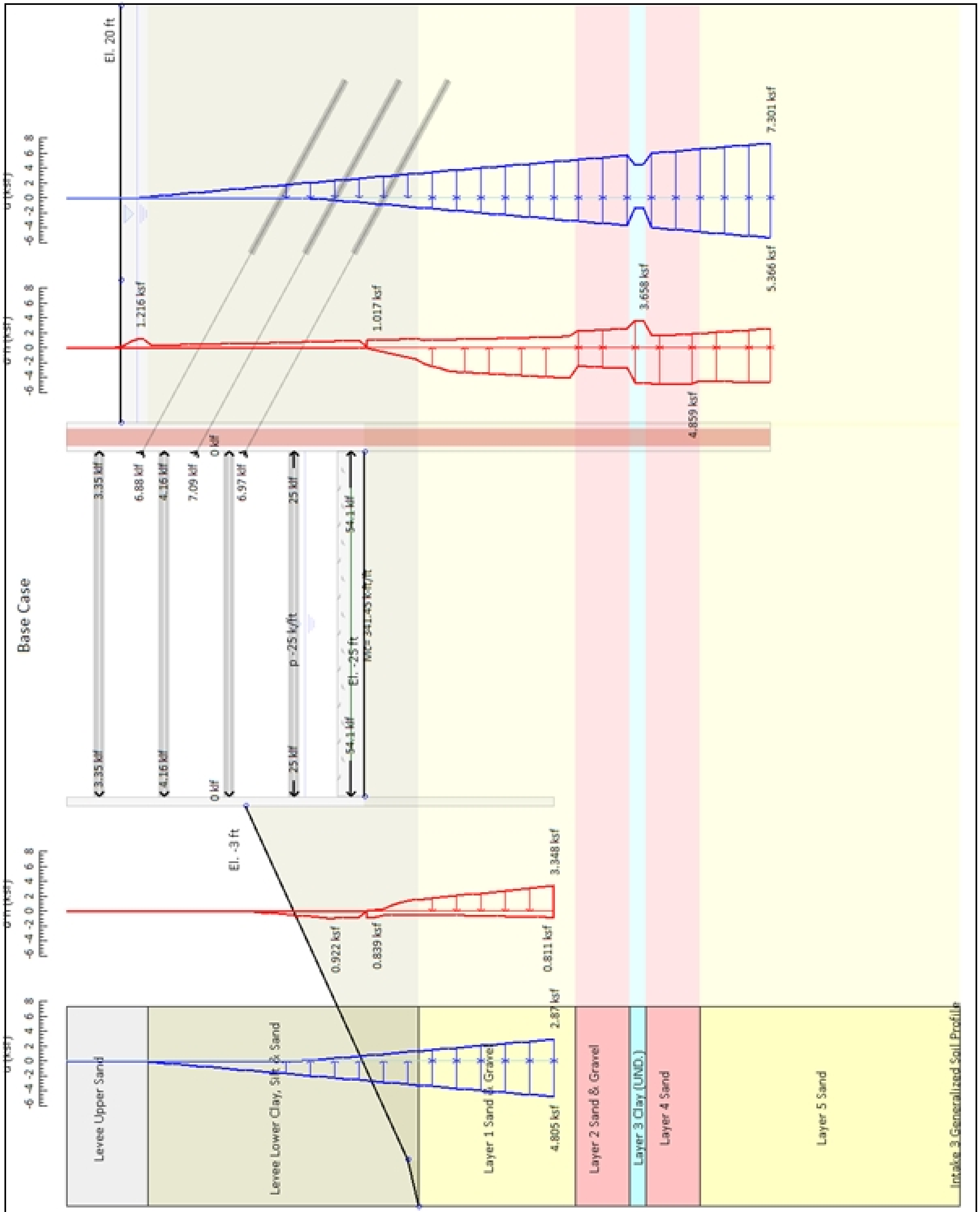
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 17	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



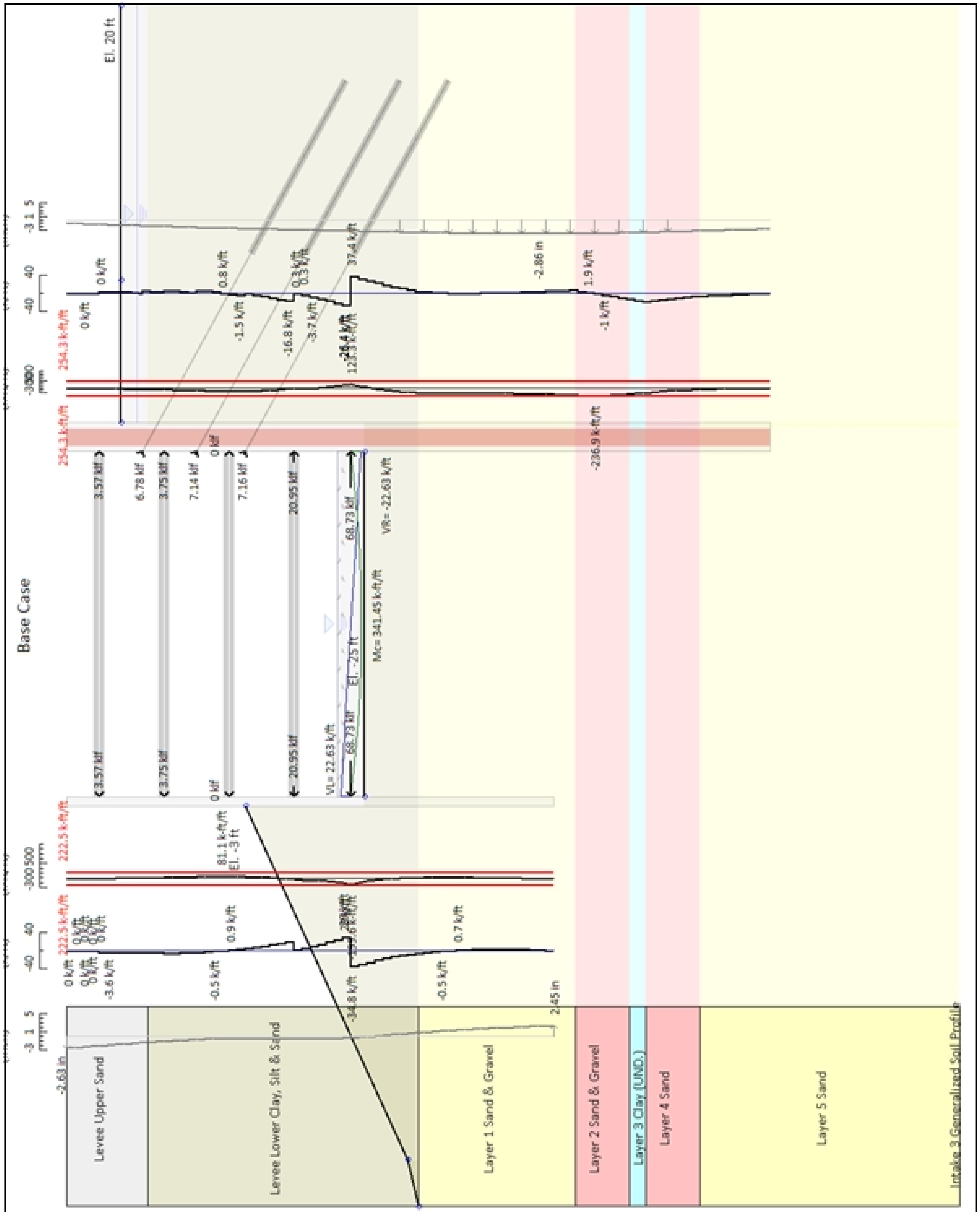
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 17	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



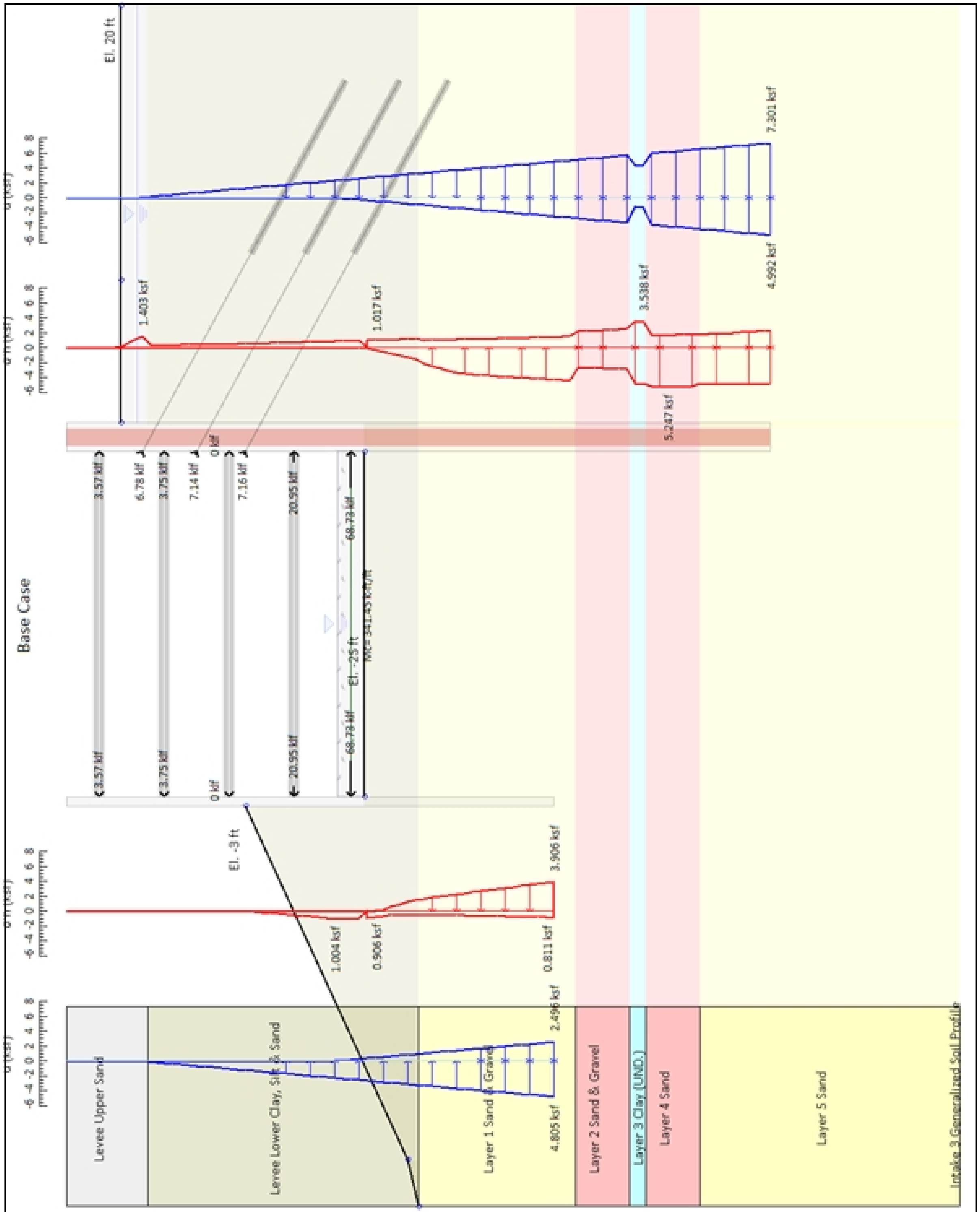
Company: Jacobs Engineer: A. Finney	DS: 0, Stage 18	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



Company: Jacobs Engineer: A. Finney	DS: 0, Stage 18	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



Company: Jacobs Engineer: A. Finney	DS: 0, Stage 19	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021



Company: Jacobs Engineer: A. Finney	DS: 0, Stage 19	Deep Excavation LCC DeepEX 2020
C:\Us..Delta Conveyance\Intake 3\Intake 3_Rev 1 - Tiebacks-DMM.DEEP		11/30/2021

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.