DIRECTIONAL DRILLING
Recommendations

1. General.

Installation of pipelines through the levee embankment using directional drilling technology is prohibited. Installation of pipelines through a flood control project foundation should follow the requirements described in this topic. Levee design for underseepage conditions is based on permeability values and blanket thickness of the respective zones of clay, silt and sand. Any blanket penetrations potentially compromise the integrity of the foundations to resist piping of fines. Voids can exist in the annular spaces between the drill hole and the pipe. Fracturing of the foundation blanket can be caused by excessive pressure heads in and at the base of the blanket. These mechanisms create potential seepage paths in and through the blanket. The seepage path continues below the levee in the foundation sands. Little or no resistance in these void spaces can allow for uncontrolled flow during flood stages, resulting in piping that removes materials from below the levee or blanket and eventually leads to collapse of the levee. If this occurs during flooding conditions catastrophic flooding of the protected area can occur. The following recommendations are based on a study performed at U.S. Army Corps of Engineers, Waterways Experimental Station. The study is presented in the report: CPAR- INSTALLATION OF PIPELINES BENEATH LEVEES USING HORIZONTAL DIRECTIONAL DRILLING, published in April 1998.

2. Design considerations.

2.1. Geotechnical investigations. Detailed subsurface investigations should be performed along the proposed directional drilling site to determine the stratigraphy. Many of the key parameters for a project, including limiting pressures, setback distances, and depth of cover, depend on soil properties and geotechnical data gathered during preconstruction geotechnical investigations or data obtained from the design of the flood protection project by the COE .

2.2. Drilling Fluid Pressures. There are legitimate concerns associated with the fluid pressures used for excavation during the horizontal directional drilling process and the risk of hydraulic fracturing. Reasonable limits must be placed on maximum fluid pressures in the annular space of the bore to prevent inadvertent drilling fluid returns to the ground surface. However, it is equally important that drilling pressures remain sufficiently high to maintain borehole stability, since the ease with which the pipe will be inserted into the borehole is dependent upon borehole stability.

2.2.1 Maximum allowable drilling fluid pressure. Limiting borehole pressures are a function of pore pressure, the pressure required to counterbalance the effective normal stresses acting around the bore (depth), and the undrained shear strength of the soil. It is necessary for the pressure in the annular space of the bore to remain below the maximum allowable pressure throughout the drilling process to minimize the potential for initiating plastic yield and losing drilling mud to the surface. To establish the maximum allowable mud pressure, the internal friction angle, the shear modulus of the soil, the depth of the soil cover, and the initial pore pressure should be used.

2.2.2. Minimum required drilling fluid pressure. Unreasonably low borehole pressures cannot be maintained without severely hindering the drilling process and, in some cases, making the pipe installation impossible. The drilling mud pressure must be maintained above the groundwater pressure to prevent collapse of the borehole.

2.2.3. Monitoring Drilling Fluid Pressures. During the drilling process, the pressure in the borehole must be monitored to ensure that the operational drilling pressures remain within the safe limits, as calculated with the recommended methods. A pressure gauge has to be located at the mud pump to measure mud pressures within the drilling stem. However, there is a significant amount of head loss due to the flow through the drill stem and the rotational movement of the drilling mud caused by the abrupt change in flow direction as it exits the drilling stem into the annular space. Instead of monitoring the pressure in the drill stem and estimating the head losses through the drill stem and nozzles, it is highly recommended that the pressure in the annular space be monitored, since the pressure in the borehole ultimately affects the stability of the bore. It is requested that an external pressure measuring device be installed when drilling beneath flood protection structures. In addition, pressures should be monitored and recorded at the drill stem and in nearby piezometers to monitor the radial effect of the drilling process. Monitoring should include preconstruction and excess pressures resulting from the drilling process dissipate. Plans for monitoring and controlling drilling fluid pressures and for avoiding inadvertent returns should be submitted for review. The limiting pressures should be estimated prior to construction and clearly stated in the contract documents or in the Contractor=s submittals.

2.3. Setback Distances. Determination of appropriate setback distances is very important with respect to damage of the levee toe and seepage and uplift pressures at the point where the top stratum is penetrated by the drill string. Levee toe stability is not the controlling factor under normal circumstances but should be checked in the design as a precaution. However, seepage is a significant concern and must be addressed on a case-by-case basis as seepage is highly dependent on levee geometry, high water level, the material of the top stratum, and the material in the substratum. The setback distance can be established based on seepage analyses, using measured soil properties and engineering characteristics determined from geotechnical investigations. If no seepage analyses are performed, the following recommendations should be considered.

2.3.1. If construction plans and specifications are not supported by borings made at the project site, the pipeline must be at its maximum depth at least 300 feet landside from the center line of the levee on the landside.

2.3.2. If plans are supported by borings at the project site, the drill rig must penetrate the substratum at least 300 feet from the levee center line on the landside and must not exit the substratum or penetrate the top stratum any closer then 300 feet riverside of the levee center line.

2.4. Levee toe stability. External drilling pressures do not pose a serious concern for levee stability if the pipeline is designed at an appropriate depth, proper drilling procedures are employed, and drilling pressures are monitored accordingly. When designing the depth of the pipeline, it is important to consider that the drilling fluid pressures may well exceed the maximum allowable drilling fluid pressure near the entry and exit locations due to the shallow depths, resulting in limited inadvertent returns. Because reasonable fluid pressures must be maintained to initiate and complete the bore, "excessive" pressures are necessary in these shallow zones. Therefore, the entry and exit locations should be located such that these zones do not threaten the safety of the levee.

2.5. Penetration of the top stratum. The permeability of the top stratum and the difference in permeability between the top impervious blanket and the aquifer beneath it area critical factors for the hydraulic gradient beneath a flood control structure. If a larger contrast exists between top stratum and substratum permeabilities, the computed setback distances may be quite high. At a minimum, it is recommended that the pipeline should not penetrate any berm of the levee on either side. In cases where the difference in permeabilities between the top and bottom strata are several orders of magnitude apart, it is important to establish a reasonable distance where seepage and uplift pressures will have negligible effects on levee stability.

2.6. Depth of Cover. The minimum depth of cover should be established by the calculations for maximum borehole pressures and a comparison of those pressures and reasonable drilling pressures. In the case where the reasonable operational drilling pressure exceeds the maximum drilling pressure, the pipeline should be set at a deeper elevation to raise the maximum drilling pressure. Establishing a minimum setback distance at which the maximum depth of the bore is reached prior to the center line of the levee should not be necessary as long as drilling pressures are closely monitored and remain within the established limiting pressures.

Recommended Minimum Depth of Pipe Cover Under Concrete Channel	
Diameter	Depth of Cover
2 inch to 6 inch	5 ft
8 inch to 10 inch	8 ft
15 inch to 24 inch	10 ft
25 inch to 48 inch	15 ft

Source: SPL manual from 1970s

2.7. Speed of Drilling. The speed of drilling should be controlled for several reasons. It may be difficult to maintain the planned line and grade if the advance rate is extremely high. If the drill veers offline due to the advance rate, the driller may decide to pull back a section and redrill for position. Redrilling caused localized pressure bulbs that resulted in increased drilling pressures over longer time periods compared to one-pass drilling. Redrilling for position may be necessary; however, it is recommended advance rates be limited as a preventative measure against pressure buildup. It is extremely important to adjust the flow rate of the drilling mud when changing the speed of the drilling operation. This will limit the possibility of over pressurizing the borehole due to the total volume of mud that is pumped per drill pipe section.

2.8. Groundwater. The groundwater pressures tend to counterbalance drilling fluid pressures and reduce the potential for hydrofracture. When practical, it is recommended that the design depth of the pipeline should remain below the water table when drilling within a lateral distance of 25 feet from the levee toe.

3. Prevention of Seepage and Erosion Along Pipeline. Concerns have been expressed about the potential for development of preferential seepage pathways along the pipeline annulus during flooding or high water stages. The high hydrostatic head and gradients could cause the drilling fluid and soil mixture to be flushed from the annular space. Seepage flows around the pipeline could produce high seepage velocities resulting in soil erosion and development of boils on the landside at the point where the installed pipeline penetrated the ground. The following recommendations for the design and construction measures that minimize or eliminate the potential for unacceptable seepage along the pipeline are provided.. These measures include:

3.1. Grouting of annular space and minimizing annular space. Grouting of the annular space with a cement or bentonite-cement grout mixture will expel the semifluid mixture of bentonite, soil, and water with a grout material that will set and provide a solid barrier against seepage flow along the annulus.

3.1.1 Grouting during pullback. One possibility is that a grout mixture with a delayed set time be pumped into the hole during the final reaming and pullback of the pipe to more effectively displace the bentonite based drilling mud mixture. Grouting during pullback reduces the risks of future development of seepage pathways. While filling the annular space with a low-permeability material is a desirable goal, the process of grouting during pullback is not recommended. Research and testing of grout materials with controlled delayed set times and grouting procedures should be required prior to such a recommendation due to the risks of failure to complete the pipeline installation. If for any reason the pullback was delayed beyond the initial set time, the partially installed pipeline could become grouted in place..

3.1.2. Grouting of the annular space upon completion of the bore. The grouting pressures required to expel the drilling fluid must exceed hydrostatic pressures because the drilling fluid pressure in the annulus must equal or exceed hydrostatic pressure. The grouting pressures must be lower than the overburden pressure or critical pressure required to initiate hydraulic fracturing. To increase the likelihood of uniform grout distribution around the pipe annulus, the use of perforated grout tubes attached to the pipeline has been suggested. After the grout is pumped through the tubes, they would be abandoned in place. This process would increase the difficulty and risk of failure of the pullback operation and could adversely impact corrosion resistance of the pipeline.

3.1.3. A grouting procedure is to insert grouting tubes as far as possible into the borehole after the pipe is pulled back. The grout mixture would be pumped into the annulus through these tubes until grout returned to the surface at the entry or exit of the pipeline. Grouting pressures must be carefully controlled to minimize risks of hydrofracture. This procedure is recommended as an added insurance measure at both ends of the pipeline.

3.1.4. The composition and hydraulic conductivity of the soil drilling fluid mixture should be tested prior to construction to determine the in-place resistance to seepage provided by the mixture. It may be determined that the hydraulic conductivity of the soil-bentonite-water mixture is sufficiently low (lower than the surrounding natural soil) to minimize potential for seepage along this pathway. These tests should be performed using the actual drilling fluid mixture(s) planned for use on the project, with varying percentages of bentonite and natural soils to bracket the planned or expected field conditions. This approach would also necessitate field quality control tests to ensure that the drilling fluid mixtures used for construction were the same as those tested.

3.2. Seepage blankets or berms (antiseepage devices). Seepage blankets and berms may be used to increase the factor of safety against piping and erosion along the landside toe of levees. Some form of these features could be used on the landside entry and exit points of pipeline crossings for the same purpose, i.e., to reduce the risk of piping and erosion along the pipeline that could undermine the levee or its foundation. It is recommended that a seepage analysis be performed during design of the crossing. If the hydraulic gradient at the landside entry/exit points exceeds the maximum allowable gradient, a landside seepage blanket should be evaluated. To achieve its design function, the blanket would not have to extend great distances on either side to the pipeline, but could rather be a small localized surface feature with gentle slopes to aid in levee maintenance. The evaluation should be performed using actual soil properties, site conditions, and geometry.

3.3. Riverside cutoffs or collars. Riverside cutoffs or seepage collars may be considered for projects with exit points on the riverside of levees. For projects that enter and exit on the landside of opposite bank levees, riverside cutoffs are obviously not applicable. Seepage barriers, rings, or cutoffs are addressed in EM 1110-2-1913, DESIGN AND CONSTRUCTION OF LEVEES. If considered, seepage collars should be evaluated during design using actual site conditions, soil properties, and geometry. The materials and mixture should ensure low hydraulic conductivity, low shrinkage, and long-term stability. Placement and compaction must ensure intimate contact around the full pipeline circumference, without damage to the pipe. Laboratory tests of the hydraulic conductivity of the materials and mixture should be performed. In addition, hydraulic conductivity tests of the system may be beneficial.

4. Closure Devices. Closure devices are required for all pipes that penetrate the embankment or foundation of a levee. Closure devices (valves) could serve a critical purpose in an emergency and should be considered with regard to pipelines beneath levees. Valves are required for liquefied petroleum pipelines by U.S. Department of Transportation regulation, Part 195, Section 260(e), at water crossings longer than 100 feet. Valves are not required on gas pipelines since there is no danger of spills.

5. Relief Wells. Relief wells are not considered necessary under normal circumstances. The objective of proposed relief wells has been to vent the high drilling fluid injection pressures and avoid fluid pressures that exceed earth and groundwater pressures. The directional drilling process uses relatively high drilling fluid pressures and flow rates to the injection nozzle. These reported pressures have caused concerns about hydrofracturing. However, these pressures are quickly attenuated within a short distance of the nozzle. Relief wells may be effective for dissipating high seepage pressures on the landside toe of levees during high water events.

6. All excavation and backfill for the proposed utilities or miscellaneous support structures should be accomplished in accordance with the Section: EXCAVATIONS AND BACKFILL

7. Pervious backfill is not allowed within the critical area of the levee system. Permanent penetrations through the blanket materials can only be justified based on underseepage analysis. Pipes located within the critical area must have watertight joints.

8. Connections, type of bedding, or other structures within the critical area should meet applicable COE criteria as listed in the topics PIPING and STRUCTURES. Pipe selection and analysis should be checked referencing EM 1110-2-2902, CONDUITS, CULVERTS, & PIPES. .

9. Any evidence of impending danger to the flood protection project should be immediately forwarded to the drainage district. Should anything go wrong, the drilling operation should immediately cease, all equipment should be pulled and the entire progress of drilling should be grouted. Sufficient grout should be available on site to seal the hole immediately.

10. Any surface evidence of drilling fluid return or any surface fracturing will require complete excavation and removal of the affected foundation blanket and flood protection levee. Levee and blanket replacement should meet COE design standards.

11. Emergency notification and contingency plans should be explicitly stated in the plans,

12. Recommended References.

12.1. CPAR-GL-95-2, GUIDELINES FOR TRENCHLESS TECHNOLOGY, U.S. Army Corps of Engineers, Waterways Experimental Station, Sept. 1995, includes the following:

(1) Guidelines for directional drilling.
(2) Curred in place pipes and formed pipes.
(3) Mini-horizontal directional drilling.
(4) Microtunneling

12.2. CPAR-GL-98-1, INSTALLATION OF PIPELINES BENEATH LEVEES USING HORIZONTAL DIRECTIONAL DRILLING, U.S. Army Corps of Engineers, Waterways Experimental Station, April 1998, includes recommendations for design and construction of directional drilling.

12.3. EM 1110-2-2902, CONDUITS, CULVERTS, & PIPES, includes piping system requirements in the critical area of flood control projects.

SAMPLE DIREECTIONAL BORING WORK PLAN

NOTE:

METHOD AND MEAN SHOWN IN THE PLAN FOR TEMPLATE PUPOSE ONLY ..

Drilling Plan Narrative:

This plan is for installation of a____

This installation is proposed to replace an undersized x" Ductile Iron Force Main attached to the Hwy xxx Bridge.

As the new utility crossing is a force main, grade and entry/exit locations are less critical than establishing a successful path for installation.

This installation is proposed to replace an undersized x" Ductile Iron Force Main attached to the Hwy xxx Bridge.
Nearest geotech boring was approximately 2000 lf upstream of Line A-1, and adjacent to soccer field . The project geotechnical engineer has stated that those boring results are applicable to the line A and A-1 crossing site.(See xxx and Associates enclosed report dated 4/1/2019.)

CONTENTS:

Sequence of Work:

1. Underground Service Alert to mark out the work area prior to survey staking of all pits, and planned alignment.
2. Survey crew to stake entry and exit pit locations as shown on thesubmitted drawing
3. Pothole and expose any marked utilities within the work are and record/verify location and elevation prior to any pit excavation orboring activities
4. Bore crew to excavate entry pit #1 (open cut to x' maximum depthutilizing 1.5:1 slope, with equipment entry ramp.)
5. Frac Out contingency measures (per the risk contingency plan) to be audited and in place prior to start of drilling activities
6. Horizontal Directional Drilling equipment placed at entry pit
7. Commence pilot hole drilling operations
8. In the event of a refusal, withdraw the drill head and make field adjustment to entry alignment and/or angle, and restart the drilling process. (repeat a maximum of four times per location)
9. If previous location experiences refusals or other issues, proceed to the next entry pit location and repeat the process.

Hazard Assessment

Primary hazards that will be encountered during this work scope are :

- Excavation Safety

Contractor to comply with all Cal/OSHA permit requirements with regard to trench and excavation safety.

Erect barriers around all open excavations

- Existing utilities within the work area

To remediate potential conflict with existing utilities, USA will mark out any recorded utilities or underground installations in the work area. Marked utilities within the work area and alignments will be potholed and exposed to verify location and elevation prior to commencement of any excavation activities.(See Installation Plan for additional details)

- Potential for Frack Out during drilling process (See Contingency Plan below)

Frac-Out Contingency Plan

1.1 Introduction and Purpose

Directional drilling operations have a potential to inadvertently release fluids into the surface through frac-outs. Frac- outs occur when drilling fluid is released through fractured bedrock into the surrounding rock and sand and eventually travels toward the surface. Drilling fluid (mud) consists of bentonite clay which is a naturally mined mineral, so it does not classify as a hazardoussubstance, but may result in sediment-laden discharge.

Frac-outs can occur in any area of a directional bore. However, they are most likely to occur near the entry and exit pits of the bore due to the shallow depths at these points. This Frac-Out Contingency Plan establishes operating procedures and responsibilities for prevention, containment, clean up, and disposal of drilling fluid if a frac-out does occur. All The drill crew personnel and sub-contractors must follow this plan during the directional drilling operation.

This plan's objectives are:

1. Minimize the potential for a frac-out associated with directional drillingactivities.
2. Provide the timely detection of frac-outs
3. Protect any environmentally sensitive areas.
4. Ensure an organized, timely, and minimum impact response.
5. Ensure that all appropriate notifications are made.

2.1 Description of Work.

The proposed xxx Crossing's will be conducted for the John lei Development. This project consists of a approximately 500' of (1) x" HDPE casing.

2.1.1 Pre-Construction Measures

Prior to the start of construction, the appropriate BMPs will be set in place provided by the customer per the requirements of the Owner for the project. The BMPs for the XXXX operation will consist of berms made from sand bags or native soil, placed around the drill in order to contain any bentonite drilling fluid that may leak off the drill as the rods are being disconnected from the drive chuck and added throughout the bore.

In the event of a leak, the drill crew will have spill kits in their job box on site that will have absorbing rags and other absorbents to help contain the spill.

Prior to the start of work the site supervisor must ensure that all the drill crew membershave received training in the following:

1. The provisions of the Frac-out Contingency Plan, equipment maintenance and

site-Specificrequirements.
2. Inspection procedures for release prevention and containment equipmentand materials.
3. Contractor/crew obligation to immediately stop the drilling operation upon first detection of afrac-out.
4. Contractor/ crew member responsibilities during the event of a frac-out.
5. Operation of release prevention and control equipment and location of release control materials.

2.1.2 Construction Measures

Once the appropriate pre-construction measures have taken place, the drill crew will then begin the set up and commence the drilling portion of the job.

The drill crew's stationary equipment will have plastic placed underneath the equipment with straw waddle containment on the outside. The site supervisor will be responsible for:

1. All Boring equipment and vehicles are checked daily for leaks.
2. Spill kits and spill containment materials are always available on site and that the equipment is in good workingorder
3. Equipment required to clean up a frac-out shall always be available on site duringthe drilling operation or at a maximum of x minutes away at an off-site yard. The following items shall be on the frac-out trailer;
    - Sand bags
    - 55-gallon plastic drum
    - Straw waddle
    - x Square Shovels
    - x round shovels
    - x push brooms
    - Vacuum Hose
    - (2) 5-gallon buckets
4. If equipment is required to enter a river bed area absorbent pads should be placed under any motorized equipment while it is operating to ensure that no fluidscontaminate the river bed.
5. Ensure that vac trucks have adequate amount of hose prior to the start of drilling to reach all areas of the job site so a frac out can be reached.

The following procedures shall be followed each day, prior to the start of work. The Frac-out Contingency Plan shall be available on-site during all construction. The site supervisor/ foreman shall be on-site at any time that the drilling is occurring or is planned to occur. The site supervisor/ foremen shall ensure a job briefing meeting is held at the start of each day of drilling to review theappropriate procedures to be followed in the event of a frac-out.

Drilling pressures shall be closely monitored so they do not exceed what is needed to successfully drill through the formation. Pressure levels shall be monitored continuously throughout the day by operator.

A frac out trailer shall be on-site and used if a frac-out occurs. A vacuum truck, or 800-gallon tow behind vacuum, shall be readily available on-site prior to and during all drilling operations, the truck shall be parked within the vicinity of the XXXX operation either on the entry or exit side no further than a mile away. Containment materials (straw, silt fencing, sand bags, and frac- out spill kits) shall be staged on-site at a location that is easily accessible.

Once the drilling operation has begun the operator shall notify the site supervisor/ foremen if any drops or spikes in pressure occur, or if there is a lack of fluid returns into the entry pit. The site shall be monitored for frac-outs at this point. It is important to realize that just because fluid returns may be minimal does not mean a frac out is occurring. It is common for the bentonite drilling fluid to escape into the surrounding soil where it will eventually form a filter cake to seal off voids. If this occurs a fluid loss additive will be added to help reduce the amount of fluid loss.

In the event a frac-out occurs, drilling operations will be halted by the drilling crew immediately. Once the stop has occurred the clean-up shall begin immediately. The site-supervisor shall notify management and safety personnel immediately. A frac out trailer will be on site and used if a frac-out occurs. A vacuum truck will always be on site during the drilling operation. Containment materials such as straw waddle may also be used to help contain the frac-out. The Boring site supervisor will evaluate the situation and direct the crew with what actions need to be taken.

3.1 Site Supervisor/ Foremen Responsibilities

The site supervisor/foremen will have the responsibility for implementing this Frac-Out Contingency Plan. The supervisor will ensure that all members of the drill crew are properly trained and briefed prior to drilling. The site supervisor/foremen will be responsible for ensuring that the safety department and management are aware of the frac-out. They will also be responsible for theresponse, cleanup, and notification to the customer if a frac-out occurs. The site supervisor/foreman will also ensure that all bentonite that is cleaned up is properly transported and disposed of.

The site supervisor/foremen shall be familiar with all aspects of the drilling process, the Frac-out Contingency Plan contents, and the conditions of approval under which the activity is permitted to take place. The site supervisor/foremen will have the authority to stop work and commit the appropriate resources to implement this plan. The site supervisor/foremen will always have a copy of this plan on site and ensure that all the drill crew employees on site are familiar with thisplan.

4.1 Field Response to a Frac-Out occurrence

The response of the field crew to a frac-out release shall be immediate and in accordance with procedures identified in this plan. All appropriate actions that do not pose an additional threat to the surrounding area should be taken as follows:

1. Directional boring will stop immediately.
2. The drill rod will be tripped back to relieve the down hole pressure
3. The site supervisor/foremen will be notified to ensure that management and the safety department is notified, as well as the customer foremen.
4. The site supervisor/foremen shall evaluate the situation and recommend the type and level of responserequired.
5. If the frac-out is minor, easily contained, a leak stopping compound will be

added. To help seal the frac-out.

6. If the frac-out has reached the surface, a berm will be constructed, and the vacuumtruck will be mobilized to suck up any drilling fluid that hasescaped.

5.1 Response Close-out Procedures

When the release has been contained and cleaned up, response closeout activities will be conducted under the direction of the site supervisor/ foremen and will include the following.

1. The recovered drilling fluid will either be disposed of legally or taken over to the entry pit to be recycled.
2. All containment measures will be removed and cleaned up to the state prior to the frac- out.

6.1 Construction Re-start

Once the frac out has been contained, drilling operations will continue. The drill crew will either add a fluid loss control agent to the mud and/or thicken up the viscosity of the drilling fluid. Generally, a fluid loss agent will be added first to increase the gel strength of the drilling fluid which will help seal off the bore hole.

The frac-out may have to be contained and managed via vacuum truck until a filter cake is formed and the frac-out is sealed.

7.1 Notification

In the event of a frac-out the site supervisor will notify the safety department and the management team. The following information will be documented with 24 hours of a frac-out and given to customer, so they can notify the water quality and other appropriate agencies.

1. Name and telephone number of person reporting
2. Location of the frac-out
3. Date and time of the frac-out
4. Estimated quantity of drilling fluid released
5. How the release occurred
6. The type of activity that was occurring during the frac-out
7. Description of the methods used to clean up or secure the site

7.2 Communication with Customer

The site supervisor/ foremen will contact customer when there is a frac-out. They will follow with the above-mentioned documentation. In order to keep clear lines of communication it is recommended that only the site supervisor/ foremen communicate to the customer about the inadvertent return.

7.3 Documentation

The site supervisor/foremen shall record the frac-out event in his daily log. The log will include the following information: Details on the frac-out, estimate of fluid loss, location and time of release, sizeof the affected area, and the sources used to clean up. The log report shall also include the: name and telephone number of the person reporting: Date, How the release occurred; the type of activity that was occurring when the frac-out happened, and a description of the method used for clean-up. This daily log will can be copied and given to customer upon request

INSTALLATION PLAN

Engineering & Project Management

The XXXX Manager and XXXX Superintendent will identify key technical issues prior to construction and have the appropriate tooling and equipment onsite. The team will determine the methodology to be used and the XXXX Manager will generate the required XXXX submittals based on the proposed methods.

Ongoing project documentation will be made available to the drilling crew as required. The drilling Superintendent will be responsible for the execution of all drilling operations and will be the onsite representative for the XXXX operations.

Work Hours

The drill crew will work single 10-hour shifts, 5 days per week for the xx portion of the project. If needed due to bore hole instability the request to work longer hours to prevent inadvertent returns may be made. Pullback operations will be worked continuous without stopping until the pipe is in.

Preconstruction

Prior to the start of construction, the driller will call in USA Dig Alert ticket 48 hours in advance. Prior to mobilization, the drill crew will walk the job site with its key personnel and identify the lay down area and confirm that all necessary utilities have been potholed and that there are no conflicts.

Geological Conditions.

The type of soil in the path of the installation determines the type of equipment and materials that are best suited for the job and whether XXXX is a suitable tool for installing the utility. The Geotechnical Report to be referenced for the XXXX project was prepared by John Lei and Associates, Inc. Titled “Off-Site Sewerer improvements Line A1 Sewer Force Main Subsurface Crossing of xxxxxxx South” dated April 1, 2022. The boring logs BHD-1 and BHD-2 show that the XXXX will be conducted in Gravely Silty Sand. Cobble and boulders are referenced in the report and are anticipated to be encountered during the XXXX operations.

Rig Up

Placement of Drilling Rig and Ancillary Equipment

The drilling rig spread will be moved to the site on several tractor-trailer loads. The equipment will be unloaded and positioned on location by crane, track hoe, and excavator. The Superintendent and surveyor, with the assistance of the crew, will place the rig on centerline and lift it to the proper entry angle. The recycler, support connex, haul off bins, pumps, and generator will be positioned and rigged up. Racks of drill pipe and palletized bentonite will also be stored on location.

Water Source

Water will be needed for mixing drilling mud. The drilling crew will receive fresh water from city hydrants utilizing a hydrant meter provided by others. Water is a critical part of the XXXX process and should be positioned as close to the site as possible.

Installation

Pits

A 710 style backhoe is anticipated to be used for digging the XXXX pits. The pits will be dug per the plans and shored to OSHA standards.

Pilot Hole

For the Project, it is anticipated that a jetting housing with a minimum of a 6" bit will be used. The drilling assembly will also consist of a 4' drill housing attached to the lead drill rod. The locating beacon will be placed in the center of the drill housing and calibrated prior to start to confirm accuracy.

Every effort will be made to minimize the possibility of producing inadvertent drilling fluid returns to the surface. The quantity and pressure of the drilling mud pumped will be carefully monitored to ensure the levels are not excessive.

The pilot hole sequence will consist of drilling along the design plan and profile, maintaining the prescribed radii and design constraints.

Volume of drilling fluid for pilot

Formula: Día * Día / 24.5 = Gallons per lineal foot.

xy x xy / 24.5 = 1.47 Gallons per lineal foot x bore length = Total Volume

Reaming

After the pilot bore is completed the bottom hole assembly will be broken off and the reaming tool will be attached. Multiple ream passes may be deemed necessary by the drill crew to get through the soil. The final ream pass will be based off the industry standard 1.5x the OD of the pipe.

During the ream the fluid returns will be constantly monitored. The superintendent will communicate with the driller and mud man to ensure that there is constant flow during the reaming process. The reaming rate will be slowed if needed by the mud supervisor on site, and the mud mixture will be changed based upon viscosity, yield point, filter cake, etc. During the ream, the drill crew may choose to trail drill rod so that the bore hole is never vacant. As the pull ream is taking place the drill crew will be adding rod at the exit in single pipe lengths.

Once the ream is completed, and prior to pullback, a swab pass may be elected to clear the bore hole prior to pull back. The swab would consist of pulling an x-inch barrel reamer through the bore hole to clear it.

Volume of drilling fluid for ream

Formula: Dia * Dia / 24.5 = Gallons per lineal foot.

ss x ss / 24.5 = 18 Gallons per lineal foot x bore length = Total Volume

Pullback

The drill crew will pullback the x-inch casing in though the reamed hole using the drill rig. Drilling fluid will be pumped from rig side to the reamer in the pullback assembly. A swivel will be connected to the reamer so that the rotation of the drill string and barrel reamer will not be transferred to the pipe. The swivel will be connected to the pullhead, which will be welded to the pipe.

Clean Up / Finish

Once the pipe has been pulled the drill crew will remove the swivel from the pipe pulling head and remove the tooling from the drill stem. The remaining rod will be shuttled into the machine and stored. The remaining drilling fluid will be vacuumed and removed from the pits.

Rig Down

After the installation, has been completed, the XXXX company will rig down its equipment and demob off site.

As-Built Information

Upon completion of the project, the drill crew will submit as built cuts to center line of the pipeline that the design can be transferred to the drawings.

Mud Composition and Management

The drilling mud is an important component to the success of any directionally drilled installation. The drilling mud has physical characteristics designed to preserve the integrity of the drilled hole, remove cuttings, and lubricate the bit and down-hole components.

Make-up Water

The driller will collect fresh water from a local hydrant to mix with the bentonite for drilling fluid. The water will be metered and delivered by water truck to an onsite frac tank (if needed).

Mud Testing

The drill crew will regularly check the viscosity, mud weight, sand content, fluid loss, and chloride content of the drilling fluid. This data will be recorded on a Mud Report Form while testing. The mud manager and superintendent will determine any adjustments to the viscosity. Sand content in the fluid coming out of the hole will ideally be kept near 20%. Should the content become higher, the reaming rate will be slowed down to ensure proper down hole mud.

Content list of Drilling Fluid Test Kit

Mud Scale – used to measure mud density

Sand content screen & funnel / sand content tube – used to measure solids (larger than 200 mesh) in the drilling fluid

pH strips / hardness strips – used to determine the pH and the hardness of the make-up water and drilling slurry.

Marsh Funnel and Cup – used to determine viscosity

Drilled Cuttings Control.

The penetration rate of the drill determines the amount of drilling mud that will have to be added to the system. The volume of drilling fluid pumped down hole is dependent upon the activity being performed. Regardless of the activity, the volume of drilling mud returns should be equal to the amount pumped down hole less the amount required to displace the solids being removed allowing for loss of fluid into the surrounding formation. If the volume of drilling fluid returns is less than the volume of returns after accounting for the amount needed to displace the cuttings being removed, we can then reasonably suspect that the difference is going into the formation. This loss into the formation can occur as a seep or a fracture. As a seep, the fluid goes into the surrounding formation until a wall cake is created by the bentonite, sealing off future losses. As a fracture, the drilling fluid flows into a weaker formation until the pressure equalizes or until it surfaces. The drill crew will use the entry pit, a transfer pump and the mud mixing/cleaning system to contain the surface drilling mud in the closed loop system. A minimum of a 1-foot freeboard above the drilling mud levels will be maintained at the entry and exit pits.

Contingency Plans

Spoils Test Positive for H2S and/or Petroleum

In the event that the drill crew encounters H2S and /or petroleum in the spoils the drill crew would stop drilling, notify the Owner's representative, attempt to isolate the contaminated spoils and dispose of them at a legal disposal site. The drill crew would have discussions with the Owner's representative about a possible redesign of the pilot hole to miss the location of contamination.

Spoils do not Settle/Separate with the Slurry Equipment on site

In the event that the drill crew has problems with the separation of solids and drilling fluid, the Superintendent would either change screens on the shakers or repair the shakers or hydro cyclones as required.

Drill Tool lost in hole

In the instance of a drill tool twist-off in the hole, the drill crew would try to determine the location of the break and send fishing tools down hole. The tools would be used to extract the pipe section and drill or jetting assembly. If the drill crew was unable to extract the tool, the drill crew would meet with the Owner's Representative and get permission to attempt to drill around the obstacle in the hole and install the pipe section.

Steering System Fails to Provide Accurate Information

If the steering tool fails to provide accurate information, the drill crew would work with the steering tool technician to determine if the tool was just being distorted by some magnetic influence in the area or if the tool was broken and in need of recalibration. If the tool was damaged, the drill crew will trip out of the hole and replace the defective components.

Sudden Increase in Pull and Torque

When sudden increases in pull and torque occur, the drill crew would flush the bore hole and add polymers to reduce the pullback load.

Swivel Failure during Pullback

In the event of a swivel failure during the pullback, the drill crew would stop pulling and check the swivels action. If rotation could not be restored, the drill crew would attempt to dead pull the HDPE pipe to the rig entry.

Loss of Directional Control due to Geology

If the drill crew were to lose directional control due to a change in geology would back up the pilot hole and attempt to reestablish directional control in the same area. If this proved ineffective, the drill crew would contact the Owner's Representative and discuss changing the design of the profile in order to intersect the formation at a more advantageous angle.

Adverse Weather

The major weather adversities to directional drilling projects are heavy rainfall during rig-up/rig-down and lightning. The drill crew will shut down operations in the event of lightning.

April 1, 2019

Project No. cxxxxxxx

John Lei Community Builders, LLC

xxx
Santa John, California 93060

Attention: Mr. dxxxxxxx, Vice President / Project Manager

Subject: Off-Site Sewer Improvements
Line "A1" Sewer Force Main Subsurface Crossing of xxxxx Creek
South of SR-xx, xxxxxxxxxxxxxx Development
x California

Introduction

At your request, John Lei and Associates, Inc. (John Lei) has prepared this letter in response to Army Corps of Engineers (ACOE) comments regarding the subsurface soils that are anticipated to be encountered during horizontal directional drilling (XXXX) of the proposed 8-inch-diameter "A1" Sewer Force Main crossing underneath Santa Paula Creek south of SR-xxx.

Background

The proposed 8-inch-diameter Line "A1" Sewer Force Main will cross beneath Santa Paula Creek approximately 15 feet to 20 feet below the channel floor at a location of about 78 feet south of State Route xxx. The sewer line will be approximately 479 linear feet in length, and the deepest portions will extend to a depth of approximately 41 feet to 45 feet below the existing ground surface. The contractor will complete a pilot bore prior to drilling the full diameter boring in order to assess the subsurface conditions.

The purpose of this letter is to discuss the types of soils that may be encountered at this location during construction, without site-specific subsurface exploration (per our correspondence with you). The closest existing borings approximately 2,250 upstream of the proposed creek crossing have been used in our evaluation.

Previous Explorations

Becker Hammer borings BHD-1 and BHD-2 (Appendix B) were drilled to a depth of about 70 feet below ground surface at the proposed Santa Paula Street crossing of Santa Paula Creek, including one boring each on the west and east side of Santa Paula Creek. The borings were located about 2,250 feet to 2,315 feet upstream of the proposed Line "A1", but immediately adjacent to Santa Paula Creek. The subsurface materials encountered in the borings are alluvium, primarily comprised of very dense silty sand with gravel, cobbles, and boulders (coarse-grained alluvium).

At locations east-northeast of the Becker Hammer borings, soils of very similar composition were encountered at hollow stem auger borings, tests pits, and during grading of areas within the west portion of the Harvest at Limoneira development. Finer-grained beds were noted within the central to eastern portions of the development. However, observations suggest that the subsurface materials are likely to be coarser-grained near Santa Paula Creek.

Discussion and Conclusion

The alluvium observed in the borings drilled adjacent to Santa Paula Creek for the proposed bridge consists of very dense silty sand with gravel, cobbles, and boulders, with a minimum thickness of about 70 feet. We anticipate that the soils encountered in the bridge borings (coarse-grained alluvium) are generally representative of the soils that will be encountered in the XXXX boring for the proposed Line "A1". Bedrock is unlikely to be encountered in the XXXX boring. Based on our understanding of the project, we conclude that this soil information is suitable and adequate to represent the site of the sewer crossing.

Closure

We appreciate the opportunity to be of service to you on this project. If you have any questions or if we can be of further service, please contact us at (xxx-0000-0000 specifically, at the phone extensions or e-mail as listed below.

RH/GF/JDH/GIM/gv

Attachments: Appendix A – References
Appendix B – Field Exploration Logs

Distribution: (1) addressee (PDF via e-mail)

APPENDIX A

REFERENCES

APPENDIX A

REFERENCES

.

John Lei and Associates, Inc., 2007, Preliminary Geotechnical Investigation Report for East Area 1 Specific Plan, Santa Paula Area of Unincorporated Ventura County, California, Project No. xxxxxxxxxxx, dated April 19, 2007.

_____, 2017, Preliminary Geotechnical Foundation Report, xxxxxxx Bridge and Channel Modification, Harvest at xxxx, City of Santa john, California, Project No. xxxx, dated January 23, 2017.

APPENDIX B

FIELD EXPLORATION LOGS

GEOTECHNICAL BORING LOG BHD-1

Project No. —

Reviewed By Gareth Mills

Project Drilling Co.

Elevation Feet	Depth Feet	Graphic Log (N / S)	Bounce Chamber Pressure (psi)	Becker Hammer Blows Per Foot	Sample No.	Sample Blows Per Foot	Dry Density pcf	Moisture Content, %	Soil Class. (U.S.C.S.)	SOIL DESCRIPTION *This Soil Description applies only to a location of the exploration at the time of sampling. Subsurface conditions may differ at other locations and may change with time. The description is a simplification of the actual conditions encountered. Transitions between soil types may be gradual.*	of Tests
	0				B1				SM	**Alluvial Fan Deposits (Qhfy)** GRAVELLY, SILTY SAND, dry to slightly moist, grayish light brown, dense, fine to coarse grined sand, gravels predominantly angular, gravels and possible cobbles broken by drilling, some sandy silt layers with fine sand, slightly moist, seen in cuttings near the surface	
320											
			x	30							
			17	65							
			16	187							
	5		17	135	SPT-1	69/10"				Poor recovery, color changes to pale brown, dry, no silty layers observed, coarser material incease in abundance.	
315			16	119							
			18	182							
			19	151							
			20	74							
	10		16	52	RING-1 B2	50/3"			ML	No recovery GRAVELLY, SANDY SILT, slightly moist, reddish brown, fine sand, gravels predominantly angular, gravels broken from drilling	CR
310			15	93							
			15	60							
			11	36					SM	GRAVELLY , SILTY SAND, dry to slightly moist, light grayish brown, dense, fine to coarse sand with angular gravels and cobbles, coarser materials broken from drilling, sand predominantly fine grained	
			15	107							
	15		20	130	SPT-2	50/5"				Poor recovery	
305			16	95							
			15	50						17'-18' siltier, fine sand, drilling easier, more dust observed	
			17	97							
			19	x0							
	20		21	100	RING-2 B3	50/2"				No recovery	
300			20	137							
			22	178							
			22	175							
			28	248							
	25		25	243	SPT-3	50/3"				Poor recovery	
295			16	177							
			22	155							
			19	116							
	30		16	75							

SAMPLE TYPES:
- B BULK SAMPLE
- C CORE SAMPLE
- G GRAB SAMPLE
- R RING SAMPLE
- S SPLIT SPOON SAMPLE
- T TUBE SAMPLE

TYPE OF TESTS:
- -200 % FINES PASSING
- AL ATTERBERG LIMITS
- CN CONSOLIDATION
- CO COLLAPSE
- CR CORROSION
- CU UNDRAINED TRIAXIAL
- DS DIRECT SHEAR
- EI EXPANSION INDEX
- H HYDROMETER
- MD MAXIMUM DENSITY
- PP POCKET PENETROMETER
- RV R VALUE
- SA SIEVE ANALYSIS
- SE SAND EQUIVALENT
- SG SPECIFIC GRAVITY
- UC UNCONFINED COMPRESSIVE STRENGTH