APPENDIX G.2

CIVIL DESIGN AND GEOTECH ANALYSES

CIVIL DESIGN

PURPOSE

The Leon Creek feasibility study is being conducted under the Guadalupe-San Antonio River Basin Watershed authority. This study addresses opportunities relating to flood damage reduction within the Leon Creek watershed, investigation of environmental restoration features to include protection of aquifer recharge and sensitive karst components, and investigating appropriate linear open space areas for recreation to supplement the City of San Antonio Creek-Based Greenways.

EXISTING CONDITIONS – GENERAL DESCRIPTION

The Leon Creek watershed is located entirely within Bexar County along the western section of the county, stretching from the county's northwestern limits to the confluence of Leon Creek, with the Medina River southwest of the city of San Antonio. The lower portion of the watershed is located inside the city limits of San Antonio and is highly urbanized. This portion of the watershed has experienced significant ecosystem degradation and flooding as a result of the urbanization. The upper and western portions of the watershed are still in relatively undeveloped areas. Elevations within the watershed range from 1600 feet to 455 feet National Geodetic Vertical Datum (NGVD).

The Leon Creek watershed includes several major tributaries including: Culebra Creek, Huebner Creek, French Creek, Slick Ranch Creek, Indian Creek, Helotes Creek, Babcock Tributary, Huesta Creek, plus numerous smaller tributaries.

The shape of the Leon Creek watershed is unique in that the portion upstream of Huebner Creek is relatively wide, with an average width of approximately 10 miles and a length of about 18 miles. The portion of the watershed downstream of Huebner Creek is relatively narrow, with an average width of approximately 4 miles and a length of about 16 miles.

A variety of types and intensity of development exist within the Leon Creek watershed. The portion of the watershed upstream of the upper Interstate Highway 10 crossing is relatively undeveloped with scattered residential and agricultural structures. Downstream of the upper Interstate Highway 10 crossing the watershed is comprised of extensive residential and commercial development. The area south of State Loop 1604 and north of Loop 410 is primarily residential, and the existing creek banks have been improved due to the development of the area.

The area within Loop 410 is a mixture of residential and commercial development. Lackland Air Force Base and Port of San Antonio (PSA) (formally Kelly Air Force Base) are situated within this part of the watershed. One of the tenants at the PSA is Lockheed Martin Engine Test Cell Division, which is located adjacent to Leon Creek. An existing levee surrounds this facility; however, the levee has deteriorated and now overtops during more frequent storm events. Storm drainage that drains the area from the Lackland AFB runways uses concrete open ditches that run on the east side of the facility and drain into Leon Creek. It should be noted that the Test Cell Facility has sustained flooding on several occasions.

Across Leon Creek there are 41 total bridge crossings, which consist of both vehicle and railroad bridge crossings. There are three railroad bridges that cross Leon Creek at two locations. There are two areas where the crossings are actually low-water crossings with a flood gauge marker. During flood events the city will close these street crossings. The remaining bridge crossings vary in width and length, but all are pier-supported bridge structures. No evidence was found that indicates flows under the bridges are constricted; however, there was some scouring around the pier supports. Coarse grain sediment deposits were also found under the bridges. Typically, the channel cross-section for Leon Creek is defined with a limestone channel bottom and side slopes consisting of sands, silts, or clays. In some areas the limestone bottom is fractured or broken-up, while in others it is evident along the sloped bank to a height of no more than 5 feet above the channel bottom. In areas along residential development, the natural channel has been improved with uniform side slopes, which has native grasses growing on the slopes. In the areas where the creek has remained natural or undeveloped, there are heavy growths of vegetation and natural pool areas.

Since the creek runs through urban and developed areas, major utility lines for sanitary sewer, water, and gas traverse the creek bottom or are elevated and supported by a bridge superstructure. In some areas, major power lines cross and run adjacent to the creek. It should be noted that once the exact locations and the various types of flood damage reduction projects are defined, further research will be performed to identify major utility infrastructure, bridge crossings, or structural buildings that may require relocation or modifications.

Flood damage reduction features that will be evaluated in the plan formulation phase will be channel improvements, levee construction, and/or structural buyouts. Cibolo Creek, within the potential detention dam sites, is perennial in nature and is characterized by intermittent flows, large lagoons, pools, and riffle areas. Leon Creek receives water from rainfall, storm water discharge, and various tributaries along the creek’s reach.

SAMPLE PHOTOS OF EXISTING CONDITIONS

Leon Creek - Culebra St Bridge Piers Looking Downstream

Culebra Creek - DS of Old Grissom Rd Culvert at Low Water Crossing


Culebra Creek - Culebra St Bridge Looking Upstream


Culebra Creek - Culebra St Bridge Piers Scouring

Leon Creek - Levee Around PSA Test Cell Area

Leon Creek - PSA Test Cell Area SW Drainage Ditch

Leon Creek - Ingram Road Low Water Crossing

Leon Creek - Grissom Rd Bridge Looking Downstream from Upstream side

Leon Creek - Prude Rd From Under Bridge Looking Downstream

FORMULATED ALTERNATIVES

Multiple flood mitigation alternatives (both structural and non-structural) within the Leon Creek watershed were analyzed as part of the Leon Creek Interim Feasibility Study (IFS) and Alternatives Formulation Briefing (AFB) document. Based on the measures detailed in the Leon Creek IFS and AFB, three distinct plans were recommended for further development either as standalone plans or a combination of measures. The following alternative plans were reviewed further to develop a final recommended plan:

1. Helotes Creek Quarry Pond – This alternative consists of a pond being located at an existing quarry along Helotes Creek northwest of Loop 1604 and south of FM 1560. This alternative involves the diversion of a portion of Helotes Creek flood flows into the quarry site.
2. Floodplain Evacuation Plan along Babcock Trib – This alternative involves the buyout of structures along Old Cedar Road and Babcock Road that are flooded up to the 4% ACE event.
3. Test Cell Facility Levee and Floodwall – This alternative involves the construction of a levee along Leon Creek to protect the PSA property and Lockheed Martin Test Cell Facility. Channelization along a portion of Leon Creek would also be required to mitigate the increases in water surface elevations associated with the levee.

Helotes Creek Quarry Pond

The Helotes Creek Quarry Pond consists of utilizing an existing quarry along Helotes Creek northwest of Loop 1604 and south of FM 1650 for flood detention storage. The approximately

50-acre quarry is excavated to 100 feet below natural grade to provide approximately 5,000 acre-feet of storage. A weir structure would need to be constructed to divert flood flows into the quarry, and a pump station would be required to evacuate the flood storage following an event.

Since the quarry is located in an active mining area, Helotes Creek has been diverted and is naturally spilling into some of the quarry areas today. A site visit by USACE SWF staff in August 2013 indicated that flood flows along Helotes Creek are already spilling into the quarry, so benefits are already in place today. As a result, further analysis associated with the Helotes Creek Quarry Pond was not recommended at the present time.

Floodplain Evacuation Plan Along Babcock Trib

Area of Interest-4 is located south of Loop 1604 and west of Babcock Road. It is subject to flooding from Babcock Creek. The proposed buy-out alternatives include four single-family residential structures (two subject to damages from the 10% AEP event and two subject to damages from the 4% AEP event) and 32 townhouses, all subject to damages from the 20% AEP event. The structures are located on five tracts totaling 3.85 acres.

Preliminary coordination with resource agencies indicates that the buyout of townhomes and residential structures included in this alternative result in only minimal temporary adverse impacts to the natural environment. Trees adjacent to the structures would be preserved to the extent possible, and following demolition and removal of debris, the disturbed areas would be replanted with grasses to stabilize the soil against erosion. Approximately 3.85 acres of floodplain lands would be available for use by the sponsor for open space uses. This alternative is not expected to require environmental mitigation other than compliance with best management practices during demolition to control dust emissions and surface erosion into the aquatic environment.

Test Cell Facility Levee and Floodwall

Purpose

One of the alternatives investigated is a combination of levee, floodwall, and Leon Creek channelization in the vicinity of the Jet Engine Test Cell Facility (Test Cell) located along Leon Creek near S.W. Military Drive in San Antonio, Texas. Alternative levee and floodwall alternatives were analyzed for PSA by HDR Engineering, Inc. in 2007. This site has experienced flooding from Leon Creek on multiple occasions in the past. An existing levee is in place, but is in a state of deterioration and does not provide protection from less frequent flood events. The Test Cell was impacted by a flood along Leon Creek as recently as May 2013.

A conceptual design was completed to develop construction quantities for the USACE so a cost estimate could be prepared and the risk and uncertainty with that estimate established. The conceptual design did not include any additional geotechnical, hydraulic, or field survey analyses. The design was based upon information in the IFS, aerial photographs, LiDAR topographic data, utility locator maps, and previous geotechnical/engineering reports prepared by others.

In August 2013, the Project Delivery Team (PDT) held a meeting to begin to establish the Risk Register associated with the Test Cell project. The following sections summarize the conceptual design, assumptions, limitations, and risk/uncertainty associated with the various project elements. This document is prepared to assist with determining the overall risk/uncertainty associated with the anticipated construction costs. Plan sheets developed as part of this process are to aid in the development of construction quantities. These plan sheets are PRELIMINARY and are not intended for construction purposes.

Test Cell Facility Background

Lockheed-Martin operates the Kelly Aviation Center Test Cell Facility (Building P652) on the site. The Test Cell Facility is located on PSA property. A groundwater contamination treatment plant (GWTP) is operated by the United States Air Force CEC restoration section on the east side of the property.

PSA has contracted with Pape-Dawson to investigate the feasibility of an interim flood protection project for Building P652. The project is just underway, but PSA and Pape-Dawson are investigating Flood Break Walls and concrete walls to provide additional flood protection for Building P652. These interim measures would not provide 1% ACE protection.

The U.S. Air Force (through CBI Federal Services) operates the GWTP to the east of the Lockheed-Martin facility. The GWTP treats 0.2 to 0.6 MGD of contaminated groundwater. The system consists of 1-3” and 1-4” HDPE pipes that bring contaminated groundwater in from Lackland Air Force Base (AFB) to the GWTP. The GWTP also receives flow from multiple groundwater wells on the southeast corner of the site near Leon Creek. The groundwater from these wells is lifted via the Zone 2 Lift Station to the GWTP. The treated effluent is discharged via a 12” or 14” pipe directly into Leon Creek. Lackland AFB also has a lift station (Zone 1 Irrigation) to take a portion of this treated effluent directly from the pipe before it reaches Leon Creek to an open storage tank on site where it can be pumped to Lackland for irrigation purposes. The existing known utilities are shown on the “Utility Relocation and Demolition Plan” sheet.

Data Collection

As noted, this preliminary effort did not involve additional detailed analyses to support the design beyond information that was readily available. The following is a list of data sources utilized in developing this preliminary design and construction cost estimate.

- Leon Creek Interim Feasibility Study
- Test Cell Levee Feasibility Analysis – Port San Antonio (HDR, 2007)
- Geotechnical Study – Test Cell Levee Feasibility Analysis (HVJ, 2006)
- Flood Control Structures Alternatives Assessment – Test Cell Levee Feasibility Study (HVJ, 2006)
- Aerial Photographs
- SAWS water and sewer locator maps
- CPS electric and gas locator maps

- S.W. Military Drive Bridge at Leon Creek Construction Plans (TxDOT, 1942 and 1962)
- Topographic Data – 2005 LiDAR

In addition to these data sources, Halff Associates, Inc. had phone conversations with Lockheed-Martin, PSA, Pape-Dawson Engineers, and CBI Federal Services personnel to aid in the development of the preliminary design. A brief summary of those discussions is provided below.

- *Lockheed-Martin (Ed VanderPooten)* – Lockheed-Martin is not associated with the groundwater monitoring wells and water treatment plant activities in the vicinity of the Test Cell. The Lockheed-Martin main facility is Building P652 located on the northwest side of the area. The underground fuel tanks have been abandoned and removed from the north side of Building P652. A Fuel Farm is now located above ground on the northwest corner of Building P652. The proposed project layout was provided to Mr. VanderPooten.
- *Port San Antonio (John Farrow)* – The U.S. Air Force operates and maintains groundwater monitoring wells and the water treatment plant. Pape-Dawson Engineers is working on general drainage projects for PSA including Interim Flood Protection Measures for the Test Cell. The proposed project layout was provided to Mr. Farrow.
- *Pape-Dawson (Stephen Dean)* – Pape-Dawson is working on a feasibility study and a preliminary design of Interim Flood Protection Measures for Building P652. These measures include Flood Break Walls and concrete floodwalls. Pape-Dawson is also working on the design of an emergency egress road from Building P652 in the event of high water. The proposed project layout was provided to Mr. Dean.
- *CBI Federal Services (David Poole)* – CBI Federal Services operates the Groundwater Treatment Facility on the site for the U.S. Air Force. Details related to the existing GWTP infrastructure were provided by Mr. Poole and are summarized in the “Test Cell Facility Background” section. The proposed project layout was provided to Mr. Poole.

Floodwall Alternative

Initially, a 1,260 linear foot floodwall was proposed to tie into the proposed earthen levee and extend along S.W. Military Drive. The top of proposed floodwall was at elevation 649.0. Based on the limited geotechnical information available, two floodwall options were analyzed. The first option involved the use of drilled shaft piers to support a concrete floodwall and footing. The total width of this proposed structure would be approximately 20 feet.

The second floodwall alternative involved the use of PZC 37 sheet piles driven into the hard dark bluish-grey clay stratum at approximate elevation 608.0. A concrete facing could be included on the exposed sheet pile surfaces to improve the aesthetic look. The USACE geotechnical representative noted that typically sheet piles cannot be driven through material with blow counts greater than 50. Based on the geotechnical boring B-10 (the one closest to the floodwall), a blow count of 50 will be reached near elevation 615.0. An auger could be used to initially loosen the soil and enable the sheet piles to be driven through the harder material. Due to the hydrostatic loading on the exposed sheet pile floodwall, the section modulus controls the design. The thickness of the sheet pile cannot be reduced, even with the use of an auger to loosen the soil.

The proposed floodwall is within seventy feet of Test Cell Building P652 at the closest point. The potential impacts of the sheet pile driving on Building P652 cannot be analyzed without further geotechnical analysis and a determination of the sensitivity of equipment housed within Building P652.

Further guidance from the SWF geotechnical ITR indicated concerns with the assumption that the sheet piles (Alternative 2) could be driven through the anticipated material. Therefore, for this preliminary investigation with limited geotechnical information, the drilled shaft option was quantified. This alternative will have a larger footprint than the sheet pile alternative. The existing driveway around Building P652 may also have to be removed and shifted slightly to allow space for the floodwall since it has a wider footprint than Alternative 2. Given the existing ground elevations and short duration of hydraulic loading, seepage may not be a major concern for the floodwall section. Elimination or a reduction of the sheet pile cutoff or soil-bentonite slurry wall may be practical following a more detailed geotechnical analysis during design.

Based on the preliminary cost estimates associated with the floodwall, the feasibility of eliminating the floodwall and extending the proposed earthen levee along Military Drive was investigated. Ultimately it was decided to eliminate the floodwall and move forward with only an earthen levee as detailed in the following sections.

Earthen Levee

Based on existing pipelines, lift stations, and groundwater wells, the proposed earthen levee was not extended as far to the southeast as shown in the IFS document. Instead, the levee is turned and tied to high ground approximately 280 feet to the west of the location shown in the IFS. This change will eliminate conflicts with multiple existing groundwater wells, pipelines, a lift station, and GWTP effluent discharge pipeline just to the east of this new tie-in.

The proposed earthen levee will extend approximately 3,700 linear feet from high ground on the southeast side of the PSA area and wrap around Building P652 along Military Drive to high ground as shown in the “Concept Plan” sheet. The levee was aligned in an attempt to provide adequate benching between the riverside toe and the Leon Creek channelization for stability reasons, as well as to avoid existing buildings on the Test Cell site. The top of levee was set to provide adequate freeboard above the 1% annual chance exceedance (ACE) event in accordance with FEMA regulations (44 CFR 65.10). A 12’ top width was assumed and will provide a maintenance/patrol access route along the top of the levee. Side slopes of 3.5:1 (H:V) were also assumed for this preliminary design. The proposed levee will be over 21 feet high near the existing low point at Station 21+50. Landside toe ditches will be graded to convey interior runoff to the proposed sump area. The proposed levee toe will be within thirteen feet of Building P652 at the closest point. Access to the Test Cell Fuel Farm will also be impacted with the proposed levee alignment.

Access to the levee will be provided at the southeast terminus via an existing concrete driveway and on the north side terminus via an existing driveway. The levee patrol road will be constructed of base course material.

Additional geotechnical analyses are required to determine the global stability of the levee, suitability of excavated on-site materials to be used for levee construction, and seepage potential. Preliminary geotechnical analyses and limited borings indicate the existing soils that the levee will be founded on are alluvial soils (10-20 feet deep) consisting of clay, silt, sand and gravel. There are high plasticity (fat) clays below the alluvial soils. Due to the poor condition of the existing on-site levee/berm, it was assumed that this structure and fill would be completely removed prior to construction of the proposed levee.

Initially, as part of the Risk Register exercise completed with the PDT, it was decided to assume that the levee could be constructed of 50% on-site soils (sump/channel excavation) and 50% would need to be imported. It was also assumed that 100% of the levee core/cutoff would need to be imported material. The levee core/cutoff was assumed to include an eight-foot wide core beginning 3 feet below the top of the levee with 1:1 side slopes to natural ground and the top of the proposed soil bentonite slurry wall.

Permeability tests of the on-site soils are not available. The Leon Creek watershed at the Test Cell is over 200 square miles. The watershed is relatively steep and is heavily developed. Therefore, it has a quick (flashy) response to rainfall. A USGS streamflow gauge (USGS 08181480) is located at IH-35 along Leon Creek downstream of the Test Cell. Streamflow records for a few historic high flow events along Leon Creek were analyzed and are shown in Figure 1. Based on the preliminary HEC-RAS hydraulic model, a flow rate of approximately 6,100 cfs will begin to impact the toe of the proposed levee. As shown in Figure 1, Leon Creek does not remain at high stages for long periods of time. The May 2013 and August 2007 events were only above the levee toe flow threshold for 10-17 hours. The July 2002 event represented a wet cycle with successive high flow events. The longest sustained period with Leon Creek flows greater than 6,100 cfs during this 2002 wet cycle was less than 1.5 days.

Although the anticipated duration of hydraulic loading on the levee is relatively short, with the limited geotechnical information showing considerable sand and gravel soils, the SWF geotechnical ITR recommends the inclusion of a soil-bentonite slurry wall to provide additional seepage control along the full length of the levee for this preliminary analysis. The soil-bentonite slurry wall was assumed to be 48 inches thick and would extend from the top of the levee to approximately elevation 604.0 based on guidance provided by SWF. With the inclusion of the soil-bentonite slurry wall, an inspection trench was not included as part of the levee construction. By extending the slurry wall to the top of the levee, import of select material for the levee construction is not anticipated. Additional geotechnical analyses, in combination with anticipated hydraulic loading of the levee and the construction of a clay core, may result in the elimination or reduction of the soil-bentonite slurry wall for a detailed design.

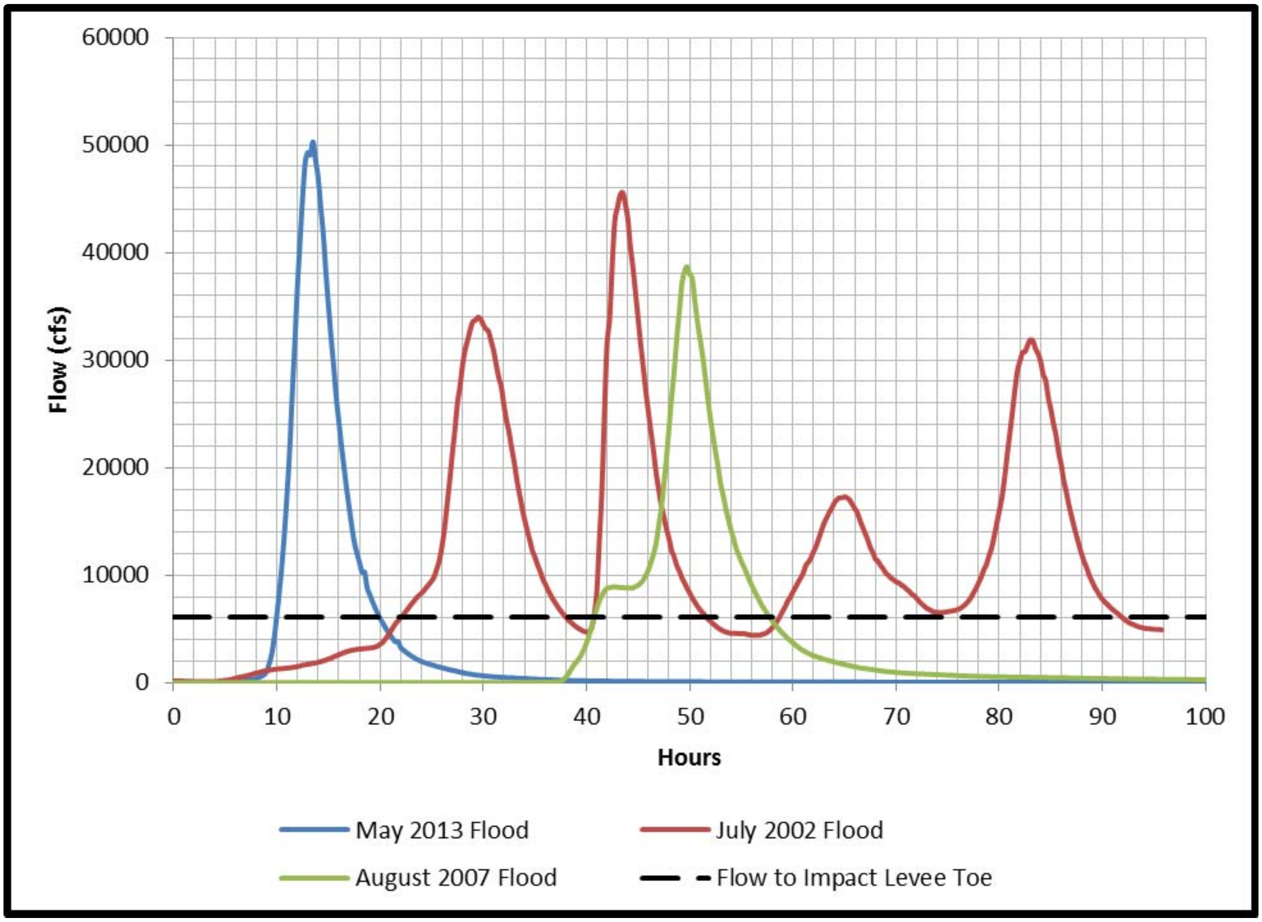


Figure 1. Historic Flows at the Leon Creek at IH-35 Streamflow Gauge (USGS 08181480)

The levee side slopes will be vegetated following construction of the levee. Preliminary hydraulic model results indicate that velocities along the riverside levee will be 8.5 to 9.5 feet per second between proposed levee Stations 23+00 to 39+00 with shear stresses between 3 and 5 pounds/square foot between the levee and Leon Creek channel. Based on these velocity and shear stress values, it is recommended that a permanent turf reinforcement mat (Landlok Woven TRM or equivalent) be installed along the riverside of the levee in these areas to provide additional erosion protection. The Texas Department of Transportation guidelines indicate that an established stand of mowed Bermuda grass can withstand shear stresses of 1 pound/square foot.

IDENTIFIED RISKS: Detailed geotechnical analysis may indicate the need for additional global stability measures (shelves, stability berms, etc…) and/or changes to seepage control (cut-off walls, toe drain collection system, etc…). Proximity of the levee to Building P652 and loss of access around the northwest corner of Building P652 may not be acceptable.

Sump Area

The total interior drainage area inside the proposed levee and floodwall is approximately 43 acres. It was assumed that interior runoff would be drained through the levee via a gravity sluice structure dependent on Leon Creek tailwater. No pumps are assumed for evacuating floodwaters from the interior of the proposed levee and floodwall.

If the ultimate intent of the proposed flood control project is to remove the Test Cell Facility buildings from the 1% ACE floodplain, the interior drainage facilities must be sized accordingly. For detailed design, USACE EM 1110-2-1413 would be utilized to analyze the interior drainage considering coincident flows along Leon Creek. Given the preliminary nature of the current design and limited time, a complete interior drainage analysis was not feasible. Based on the USGS Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas, the 24-hour, 100-year rainfall depth for Bexar County is approximately 10 inches. Based on existing land uses and impervious areas within the interior drainage area, it was assumed that 80% of the rainfall volume would runoff (20% would infiltrate). If this entire runoff volume needed to be stored (i.e., unable to discharge to Leon Creek due to high tailwater elevations), the total required sump storage volume is 28.7 acre-feet. As shown in Figure 1, Leon Creek typically rises and falls relatively quickly, which should enable stored interior runoff to be evacuated from the sump via the gravity sluice.

The proposed sump is shown in the Concept Plan Sheet. A “shelf” (50-feet wide) is provided between the landside toe of the levee and the sump area for stability/seepage purposes. A detailed geotechnical investigation would be required to further refine this distance. The existing on-site 48” storm drain line will be outfalled into the proposed sump area. Rock riprap and concrete riprap protection will be needed at locations where inflows to the sump are concentrated (toe ditches and the 48” storm drain outfall) to provide erosion protection. Details related to the gravity sluice are provided in the “Sluice Structure” section of this document. Access ramps will ultimately need to be provided to allow for maintenance and mowing in the sump area.

The currently proposed sump area provides approximately 27 acre-feet of storage below elevation 626.0. The proposed sump bottom as currently designed is at elevation 617.0. The limited geotechnical analysis that is available indicates that this elevation is close to the “normal” groundwater level in this area, although the groundwater level typically fluctuates with Leon Creek water surface elevations. If the bottom elevation of the sump has to be raised, this will further restrict the storage capacity of the proposed sump.

Although there are no known groundwater wells (as identified by CBI Federal Services) in the vicinity of the proposed sump, the locations of any groundwater contamination plumes are not known by the A/E at this time. The proposed sump excavation could disturb these plumes if they are in the area. More details on location and depths of the plumes will be required for the detailed design.

IDENTIFIED RISKS: Insufficient sump storage provided due to higher groundwater levels or longer periods of storage without evacuation. Unable to excavate to this depth or in this area due to groundwater contamination plume disturbance.

Sluice Structure

The sump storage area will be drained via a gravity sluice to Leon Creek. A 5’x5’ reinforced concrete box (RCB) is assumed for the sluice structure. This size box will allow for periodic maintenance access. The box structure will outfall into Leon Creek and rock riprap will be placed to provide erosion protection. A flap gate will be installed at the outfall and serve as the primary means of preventing Leon Creek backflow through the box culvert and into the sump area. A manually operated sluice gate structure will be installed with access from the top of the levee. The sluice gate provides back-up protection in the event that the flap gate is compromised during an event. Structural concrete quantities are based on a similar size sluice structure designed by Halff Associates, Inc. for the USACE Wharton Colorado River Flood Control project.

A detailed analysis of the sluice structure and sump evacuation times considering historic Leon Creek events was beyond the scope of the current project, but would need to be evaluated during detailed design. For sump headwater elevations over 621.0 (top of box is 622.0), the sluice can discharge over 100 cfs with a 1-foot head differential between the headwater and the tailwater. This would equal over 8.2 acre-feet/hour of storage evacuation when the headwaters and tailwaters are in this range.

IDENTIFIED RISKS: Sluice structure would need to be larger to provide quicker evacuation times of the sump based on a more detailed analysis.

Leon Creek Channelization

The proposed levee and floodwall at the Test Cell Facility will result in increases in the water surface elevation along Leon Creek. In order to mitigate this rise, channelization is proposed for Leon Creek from downstream of S.W. Military Drive to near the existing low water crossing/dam near the southeast terminus of the proposed levee (approximately 2,900 river feet). The proposed channel has a 60-foot bottom width with variable side slopes. Environmental impacts and mitigation associated with the channelization are being addressed by others at the USACE. The focus of Halff Associates, Inc. is the preliminary civil design and hydraulic analysis of the channelization.

The hydraulic analysis is based on an existing HEC-RAS hydraulic model developed from LiDAR topography (no survey other than at structures). For a detailed design of the channelization, field survey would be needed and additional cross-sections would be added to the hydraulic model. The transitions at the upper and lower limits of the channelization would also need to be analyzed and designed in greater detail.

The proposed channel grading and incorporation with the proposed levee grading is shown on the “Concept Plan” sheet. A “shelf” is included between the riverside levee toe and top of the Leon Creek channelization bank for stability of the levee. A detailed geotechnical and stability analysis would be required to further refine the size and limits of this “shelf”.

The proposed channelization was based on a 0.04 Manning's n-value following construction. This would indicate a grass-lined and maintained channel through the limits of the channelization. A maintained grass-lined channel was selected to limit the extents of channelization and disturbance along Leon Creek. The USACE is working on the mitigation associated with the project which includes re-establishment of native vegetation, trees, and riffle structures. Since a detailed design and iteration between the USACE and Halff Associates was not possible for this preliminary effort, the USACE recommended utilizing a 0.085 Manning's n-value for the proposed channel to account for the environmental mitigation work. When the roughness value was increased to 0.085, significant water surface elevation increases resulted along Leon Creek compared to the originally designed channel with a 0.04 Manning's n-value. After discussions with the USACE, it was decided to not increase the Manning's n-value for this preliminary design. Instead, the computed earthwork quantities were increased by 20% to account for additional channelization that may be required for hydraulic considerations as a result of more detailed mitigation design. In addition to the potential for increased earthwork, moving the channelization extents downstream will require improvements to the existing low water crossing/dam and moving upstream may require work under the S.W. Military Drive Bridge.

Velocities in the proposed channel are shown in Table 1, as well as without project conditions (no levee and no channelization) for the 1% ACE event. Under without project conditions, the 1% ACE velocities through this reach of Leon Creek are high. The proposed channelization project will further increase these velocities, so erosion protection is recommended. The velocity increases related to the channelization propagate upstream of S.W. Military Drive approximately 4,100 river feet. A more detailed model and further design of transitions may enable these upstream velocity increases to be mitigated or eliminated. A permanent turf reinforcement mat is included in the preliminary design throughout the channelization limits to provide additional erosion/scour protection.

No trees/shrubs should be planted or allowed to grow within 15 feet of the proposed levee toes as this is the Vegetation Free Zone.

Table 1. Channel Velocities (Preliminary)

Hydraulic Model Station	**Proposed Channel Velocity (fps)**	**Without Project Channel Velocity (fps)**
87864	13.5	13.0
87627	14.1	11.7
87518	17.8	12.3
87210	14.6	24.3
86710	15.0	16.5
86207	16.1	13.9
85866	7.6	5.7
85691	6.2	4.5

IDENTIFIED RISKS: Channelization extents may be extended with more detailed survey, hydraulics, and environmental mitigation details. This has the potential to significantly increase the costs if the environmental mitigation results in increased channelization for hydraulic purposes.

Utilities

Existing utility locator maps for the Test Cell were obtained from the San Antonio Water System (SAWS) for water and sewer service and CPS for gas and electric service. Aerial photographs were also used to locate above ground utilities. Given the preliminary nature of this project, the existing utilities shown and to be re-located are approximate and should not be considered a comprehensive list. There are over 2,800 linear feet of overhead electric distribution lines and associated power poles/transformers that will need to be relocated for the levee, channel, and sump construction. No power poles will be allowed within the levee footprint or within 15 feet of the toes. Any crossings of OH electric lines over the levee will need to be raised a sufficient height to provide clearance for levee patrol and maintenance vehicles to pass along the top of the levee.

Based on the sanitary sewer plans, there is a large 54” diameter main along the southside of Leon Creek. The proposed Leon Creek channel improvements should not impact this sewer line. There is a 4” sanitary sewer force main line that crosses under S.W. Military Drive just beyond the limits of the proposed floodwall based on the locator maps. It is not anticipated that this force main will need to be re-located for the floodwall construction. There is also a 4” plastic supply gas and a 8” cast iron water service line that passes under S.W. Military Drive and the proposed levee near Station 44+00. These utility lines will need to be re-located around the levee. Existing water lines and service along the northwest corner of Building P652 will need to be removed for the proposed levee construction. There is a 6” cast-iron water line identified in a corner of the proposed sump grading where the ground will be cut approximately seven feet below existing grade, so this water line will need to be re-located as well. A fire hydrant in this area will also need to be re-located.

Based on conversations with Lockheed Martin personnel, there is an existing Fuel Farm facility located near the northwest corner of Building P652. The proposed levee will limit access to this facility and may result in the need for re-location or adjustments to the existing infrastructure.

The 3” and 4” HDPE pipes that convey contaminated groundwater from Lackland AFB to the on-site GWTP will need to be relocated. The existing lines are just a few feet deep and are located within the footprint of a large portion of the proposed levee and directly through the proposed sump area. The pipes will be routed along the riverside toe of the levee to near Station 27+00 where they will be enclosed in casing pipe under the future levee. Control valves need to be installed fifteen feet from each toe of the levee. The re-located lines will then pass through the side slope of the proposed sump before connecting back to the existing pipes near the GWTP.

The utilities identified for this project are preliminary in nature. A more comprehensive investigation including survey/SUE would be required to identify additional utilities that may be in conflict with the proposed project. Given the long history of this site (military operations) and the current industrial use, there is a fairly high probability that additional utility conflicts are present.

IDENTIFIED RISKS: Unknown utility locations and elevations. Unknown impacts to the Fuel Farm.

Demolition

Demolition associated with the proposed project is based on a review of aerial photos. The demolition quantities do not include any field site verification or detailed field survey. The demolition will include removal and disposal of 380 linear feet of existing 48" RCP storm drain. An existing 7,600 square foot metal building near levee Station 28+50 will also most likely need to be removed to allow for construction of the levee toe ditch. Miscellaneous fence and concrete pavement sections will also be removed as part of the project.

In conversations with CBI Federal Services, the remnants of an abandoned water treatment plant facility are located near the levee and sump footprints at Stations 15+00 to 19+00. An old sludge dewatering basin and concrete basin were noted and are shown on the "Utility Relocation and Demolition Plan" sheet, but there may be additional features and debris buried in this location. The depths of these features are not known.

IDENTIFIED RISKS: Features not readily identifiable from aerial photos.

Military Drive Drainage

There is an existing concrete-lined channel parallel to Military Drive that conveys runoff from a 5'x5' RCB to Leon Creek. With the proposed levee in this area, this concrete-lined channel will need to be removed and re-graded. The existing 5'x5' RCB will need to be extended approximately 600 linear feet to outfall back into the existing ditch away from the proposed levee as shown in the "Concept Plan".

Given the close proximity of the proposed levee to Military Drive, it is also recommended that a metal beam guard fence be installed along the edge of the pavement.

Summary of Earthwork Quantities

Table 2 provides a summary of estimated earthwork quantities for the project assuming a 10% compaction factor for fill soils. The Leon Creek channelization quantities also include the 20% contingency for the environmental mitigation. It is assumed that a 48" thick slurry wall will be constructed from the top of levee to elevation 604.0 so no import of material will be required.

Table 2. Summary of Earthwork Quantities

Component	Cut	Fill
Levee	2,645 (BCY)	151,150 (LCY)
Sump	71,815 (BCY)	3,475 (LCY)
Leon Creek Channelization	123,690 (BCY)	16,450 (LCY)
TOTAL	**198,150 (BCY)**	**171,075 (LCY)**

In summary, all but approximately 27,100 CY of soil will be balanced on-site. The excess material will need to be spoiled at on off-site location. A portion of this excess material may be disposed of by overbuilding the levee section towards the channel side between stations of 34+00 to 38+00. This overbuilt template design along with any impacts to Leon Creek hydraulics shall be analyzed during the Preconstruction, Engineering, and Design (PED) phase of the project.

Conclusions

Several assumptions had to be made for this preliminary design based on limited detailed data and information. For each component of the proposed project, major factors affecting the uncertainty and risks associated with the quantities/costs have been identified and summarized in this document. Major issues affecting the risk and uncertainty related to the construction costs will be the extents of the channelization effort, seepage control requirements for the proposed levee, and unknown utility conflicts.

GEOTECHNICAL DESIGN

Site visit

On 10 May 2007 a preliminary evaluation for potential storm water retention structure sites including foundation problems, proximity of possible borrow material sources, and environmental concerns was conducted along Leon Creek in Bexar County, Texas. The retention structures are to be sited at locations in the watershed that are potentially within the Edwards Aquifer recharge zone to allow storm waters to infiltrate the aquifer. Ten locations were observed in the Leon Creek watershed.

Leon Creek

Typically, the Leon Creek channel consists of a wide, shallow, jointed and fractured limestone bed with low banks. Significant coarse grained material deposits ranging from fine sand to cobble and boulder size exist. Stream banks are generally about 5 to 15 foot high and consist of very gravelly dark gray to black medium to high plasticity clay or poorly graded clayey gravel. Stream flow in the area observed is intermittent with occasional pools of standing water due to the karstic nature of the area. A significant flow was observed at the lower portion of the area which is attributed to the sewer plant discharge from former Kelly Air Force base.

Overburden materials are typically comprised of Quarternary terrace deposits consisting of sand, silt, clay, and gravel in various proportions, with gravel more predominant in older, higher terrace deposits. The material is locally indurated with calcium carbonate (caliche) in terraces along streams. The USDA classifies the overburden soils along the portion of Leon Creek examined in the study as Trinity or Frio clays. These soils are characterized as calcareous clay or gravelly clay that is dark gray to grayish brown and has increasing gravel with depth.

Primary materials encountered over the extent of the alignment visited for this study consisted typically of fractured, thinly to massively bedded limestone or clay shale. The Edwards Formation is exposed in the northern portion of the Leon Creek Channel. The Edwards Formation consists of gray to white, dense, hard, semi-crystalline limestone of both calcium limestone and magnesium limestone. Surface water dissolves the Limestone at a relatively rapid rate, forming cavities in the stone. The lower portion of the Leon Creek Channel is underlain by the Navarro Group and Marlbrook Marl, undivided, overlain with Quaternary (recent) stream deposits. This formation is composed of marl, clay, sandstone, and siltstone, with concretions of siderite and siliceous limestone.
At potential retention structure locations along the upper reaches of the watershed the fractured and jointed limestone primary materials encountered will require considerable effort to construct an appropriate foundation. Large amounts of the gravelly overburden will require removal and disposal as the existing material may not be appropriate for

reuse as retention structure fill material and require the location of an offsite source for fill materials. The fractured, jointed limestone encountered in the upper reaches of the study area may also require grouting of the foundation to control seepage.

General Geology

San Antonio and Bexar County are on the boundary between the Gulf Coastal and Great Plains physiographical provinces. Dividing these two provinces in this region of Texas is the Balcones Escarpment, part of the Balcones Fault Zone. The escarpment extends from near Del Rio, Texas northwest through Bexar County to Austin. Remnants of the escarpment extend as far north as Waco. The Balcones Escarpment rises approximately 1,000 feet above the coastal prairie to the south and east, creating a marked influence on the area's environment. Northwest of the escarpment lies the Edwards Plateau area of the Great Plains Province. Since the plateau's formation, it has eroded, becoming a rugged hilly region dissected by numerous small streams with elevations ranging from 1,100 to 1,900 feet. Southeast of the escarpment and running along at the base lies the Blackland Prairie area of the Gulf Coastal Province, with its gently rolling hills. The San Antonio and Bexar county area are comprised of eight minor physiographic Divisions. These are: the Glen Rose Hills, the Edwards Flint Hills, the Del Rio Hills, the Austin Hills, the Taylor-Navarro Plain, the Stream Terrace Plain, the Midway-Wilcox Hills, and the Sand Hills. Most of San Antonio lies on the Taylor-Navarro Plain that forms a wide belt passing through the center of Bexar County. The relatively nonresistant strata of the late Cretaceous and early Tertiary formations formed the plain. Overlaying the Taylor-Navarro Plain is the Stream Terrace Plain, an alluvial gravel terrace deposited by streams eroding the Edwards Plateau and Balcones Escarpment. The Austin Hills form a belt passing north of the Taylor-Navarro Plain and through the northern portion of the city of San Antonio. North of the Austin Hills lie the Del Rio Plain, the Edwards Flint Hills, and the Glen Rose Hills. The Del Rio Plain is located north of and adjacent to the Austin Hills division. The Edwards Flint Hills are located north of, and adjacent to the Del Rio Plain division and along the northern extremity of San Antonio. The Edwards Flint Hills is a belt of hilly country in which the flint rock is extremely abundant in the soils and surface debris. The prevailing rock is the Edwards limestone from which the flints have been derived by weathering. The Glen Rose Hills are located north of, and adjacent to, the Edwards Flint Hills division, and north of San Antonio. The Glen Rose Hills division, being northwest of the Balcones Escarpment, forms the eastern margin of the Edwards Plateau. This area is of the maximum elevation for the county, approximately 1,900 feet above sea level. South of Taylor-Navarro Plain of San Antonio are the Midway-Wilcox Hills and the Carrizo Sand Hills. The Midway-Wilcox division forms a belt across the country which includes low hills together with level lands. The Carrizo Sand Hills division is located south of and adjacent to the Midway-Wilcox Hills division. The surface exposures of the Carrizo formation are characterized by low hills and very sandy soil.

Leon Creek is located on the western edge of San Antonio in Bexar County. The area is within the Balcones Fault Zone, an area characterized by numerous parallel and en echelon faults, downthrown to the south. The topography is characterized by a gently rolling land surface that slopes southeastward toward the Gulf of Mexico. Primary material underlying the Leon Creek area examined for this study consists of strata belonging to three geologic formations. The Edwards Limestone underlying the northern portion of the area. The Taylor Marl, underlying the middle portion consists of soft to moderately hard, calcareous shale. The southern portion of the area is underlain by the Navarro Group consisting of sandy, silty clay shale.

Subsurface Hydrology

The Comanche Peak, Edwards, and Georgetown Limestone formations comprise a hydrologic unit known as the Edwards Underground Reservoir, or Edwards Aquifer. This aquifer extends along the Balcones Fault Zone from Kinney County through Uvalde, Medina, Bexar, and Comal counties, terminating in Hays County. Seventeen cities and communities are dependent on the Edwards Aquifer for their domestic water supply, with San Antonio being the largest city in the United States that obtains its entire water supply from underground sources. Where these formations exist on the Edwards Plateau, they form an extensive, percolated water table from which the residents derive their water. In places where the Edwards Aquifer outcrops to the south, numerous springs and seeps issue forth forming the base flow for several of the perennial steams in the area. In the area below the escarpment where the Edwards outcrops, water reenters the formation through solution cavities that have developed along fractures in the limestone. At various places down slope from the recharge zones, water reaches the surface under hydraulic pressure through faults that reach the surfaces. The water sources have formed some of the more famous of Texas springs and artesian wells. Recharge to the aquifer is primarily from streams that flow across its outcrop in the Fault Zone although some recharge is from direct precipitation on the outcrop.

Surface Hydrology

Bexar County and the San Antonio area are located in the San Antonio River Basin. Major streams of the basin, all of which flow through Bexar County include the Medina River, Leon Creek, Salado Creek, Cibolo Creek, and the San Antonio River. Drainage is southward and southeastward off the Balcones Escarpment. Some of the flow of Leon Creek within the upper reaches is lost to the Edwards Aquifer as it passes over the recharge zone. This is due to the porous nature of the underlying limestone.

Soil Conditions

The San Antonio area and Bexar County are comprised of several general soil associations. Two major soil associations classified by the USDA occur along the extent of the Leon Creek alignment examined for this study. They are the Trinity Unit found above the Commerce Street bridge and the Frio unit below.

Trinity Series

The Trinity series consists of alluvial soils that are deep, dark colored, and nearly level. These soils are on the bottom land in the eastern and southwestern parts of the county. The surface layer is dark-gray, calcareous clay and is about 50 inches thick. It has medium, subangular blocky structure and is firm when moist. The subsurface layer is gray, calcareous clay and is about 15 inches thick. This layer has weak, subangular blocky structure. The underlying material is recent clayey alluvium washed from the clayey, upland soils. The surface layer ranges from black to grayish brown in color and from 40 to 70 inches in thickness. It is generally clay in texture. The subsurface layer ranges from 4 to 20 inches in thickness and from gray to light grayish brown in color. The depth to strata of water-worn gravel ranges from 4 to 12 feet.

Frio series

The Frio series consists of limy alluvial soils that are moderately deep, grayish brown or dark grayish brown, and nearly level. The surface layer is grayish-brown or dark grayish-brown clay loam and is about 20 inches thick. It has weak, granular structure, is friable, and is easily worked. This limy layer contains few to many worm casts and snail fragments. The subsurface layer is light brownish gray. It is more loamy and more compacted than the surface layer; the texture is light clay loam or loam. This layer has weak, fine, granular structure. It is limy, firm but crumbly when moist, and about 5 inches thick. The parent material is limy, friable, loamy alluvium. In places it contains thin layers of more sandy or more clayey material. There are a few beds of water-rounded limestone gravel at a depth of 3 to 6 feet. The surface layer of Frio soils ranges from 8 to 25 inches in thickness and from loam to clay loam and silty clay loam in texture. The finer textured soils are the darker colored. The subsurface layer is 5 to 20 inches thick. It has moderate, fine, granular and subangular blocky structure and is friable when moist. The underlying material ranges from sandy loam through light loam and stratified loam to clay loam in texture.

Test Cell Facility Site

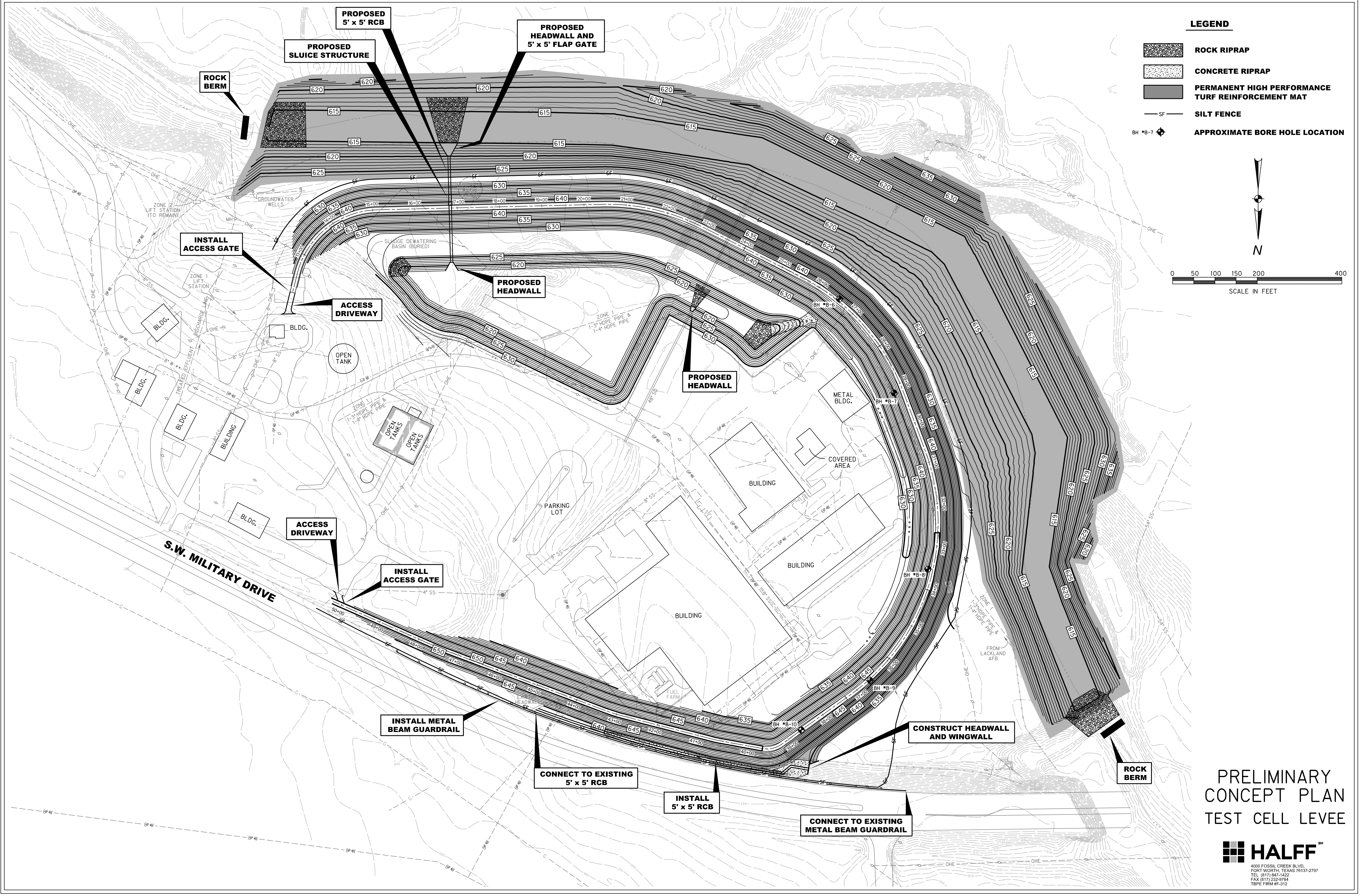
The final recommended plan from the Leon Creek IFS and AFB includes the construction of a levee, floodwall, sump, and Leon Creek channelization in the vicinity of the Port San Antonio (PSA) property which includes the Lockheed Martin Jet Engine Test Cell Facility (Test Cell). There is limited geotechnical information available from a previous feasibility study authorized by the PSA for the Test Cell. HVJ Associates, Inc. was the geotechnical consultant to HDR Engineering, Inc. as part of a 2006-2007 feasibility study. An existing levee (in poor condition) is located along Leon Creek on the proposed PSA property, but it is breached and overtopped for less frequent events. A summary of the HVJ Associates, Inc. analysis and findings is presented below. These excerpts are taken directly from the HVJ Associates, Inc. April 2006 report, *"Geotechnical Study – Test Cell Levee Feasibility Analysis, San Antonio, Texas"*.

1. A preliminary geotechnical investigation was performed that included drilling and sampling 10 borings along the crest of the existing levee structure. Laboratory testing was performed on select samples to characterize the engineering properties of the subsurface strata.
2. The subsurface stratigraphy consists of approximately 25 to 30 ft of alluvial soils comprised of soft to hard/dense clay, silt, sand and gravel over highly overconsolidated, high plasticity clay.
3. Groundwater was encountered at all boring locations. It is anticipated that the groundwater level is consistent with the level in Leon Creek.
4. The layers of soil at the level of the groundwater table (approximately 15 ft below grade) are very compressible and have essentially no undrained shear strength.
5. The alluvial strata are very permeable, i.e., have a high hydraulic conductivity; the underlying clay stratum has a very low permeability and essentially acts as a hydraulic barrier resulting in perched groundwater conditions.
6. The condition of the existing levee is poor. The soils are non-uniform and uncharacterized containing layers of sand and construction debris. Localized slope failures and areas of subsidence were observed. Most important, multiple penetrations parallel to, on top of, and longitudinally along the levee were observed and are causing detrimental impacts to the structure.
7. The levee should not be used in whole or in part for the long-term flood-control solution.

Geotechnical Investigations, Testing, and Analyses to be Completed during PED

A geotechnical investigation will be conducted during the PED phase to supplement the information obtained during planning. This information is necessary to substantiate site-specific conditions by drilling borings along and within the alignments of project features. Soil and rock samples collected will be tested to obtain engineering properties in order for design parameters to be developed, in addition to obtaining information on potential borrow sources within the project boundaries, and construction limitations associated with the use of these materials. Groundwater conditions will also be monitored to determine the impact on the flood control features associated with this project.

All analyses performed during the PED phase shall be in accordance with current USACE criteria using site-specific information. The analyses shall address foundation design conditions, slope stability requirements, and seepage mitigation measures for the flood control features. Seepage and stability models developed shall reflect design project cross-sections, actual soil types, with associated geotechnical engineering properties, and groundwater conditions. The geotechnical investigation will also document construction techniques, limitations, and problems associated with the in situ conditions of the project site.

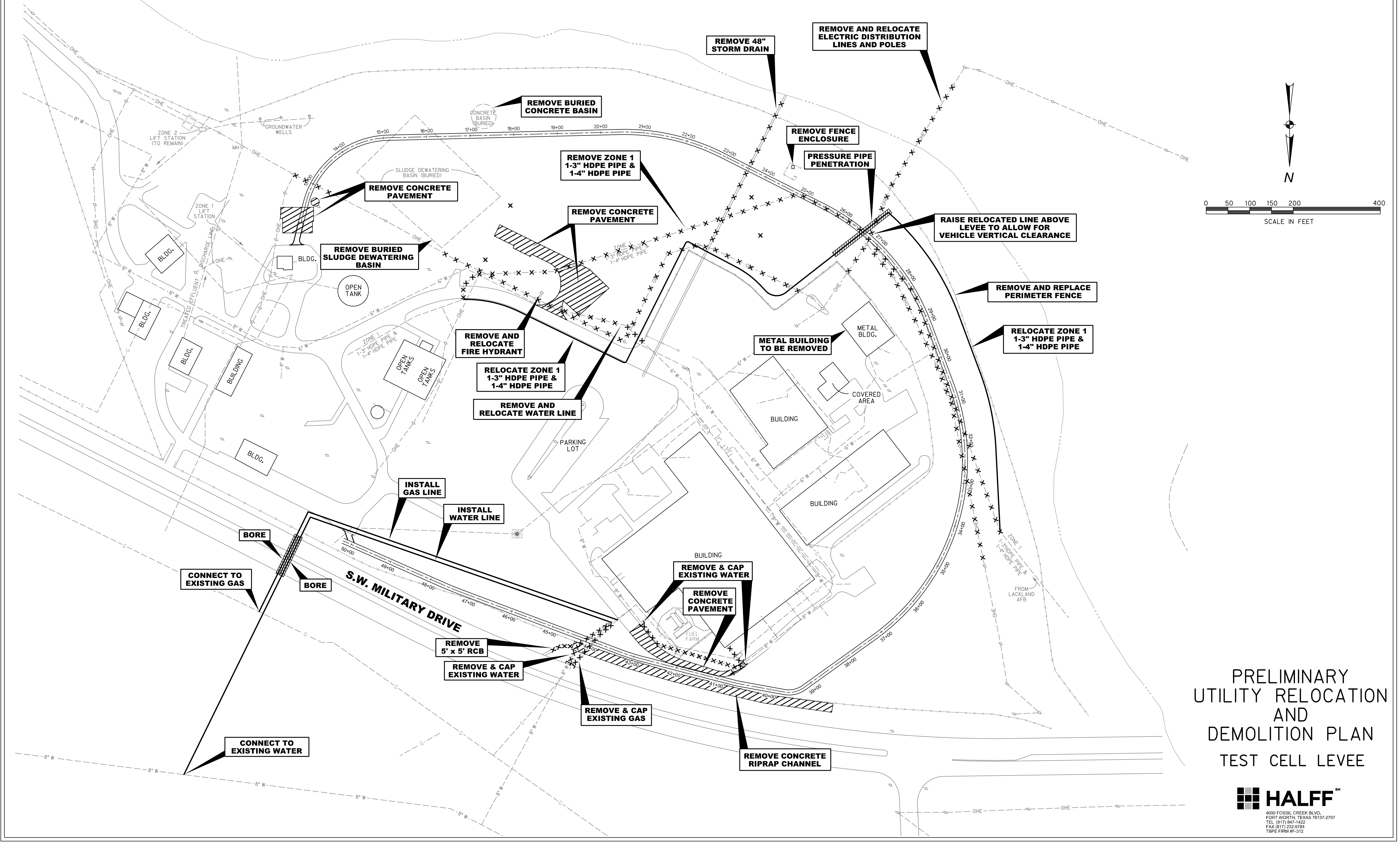


PRELIMINARY CONCEPT PLAN
TEST CELL LEVEE

HALFF℠
4000 FOSSIL CREEK BLVD.
FORT WORTH, TEXAS 76137-2797
TEL (817) 847-1422
FAX (817) 232-9784
TBPE FIRM #F-312

NOTE:

NO POWER POLES OR OTHER FEATURES MAY BE RELOCATED ON THE LEVEE OR WITHIN 15' OF THE LEVEE TOES.



PRELIMINARY UTILITY RELOCATION AND DEMOLITION PLAN

TEST CELL LEVEE

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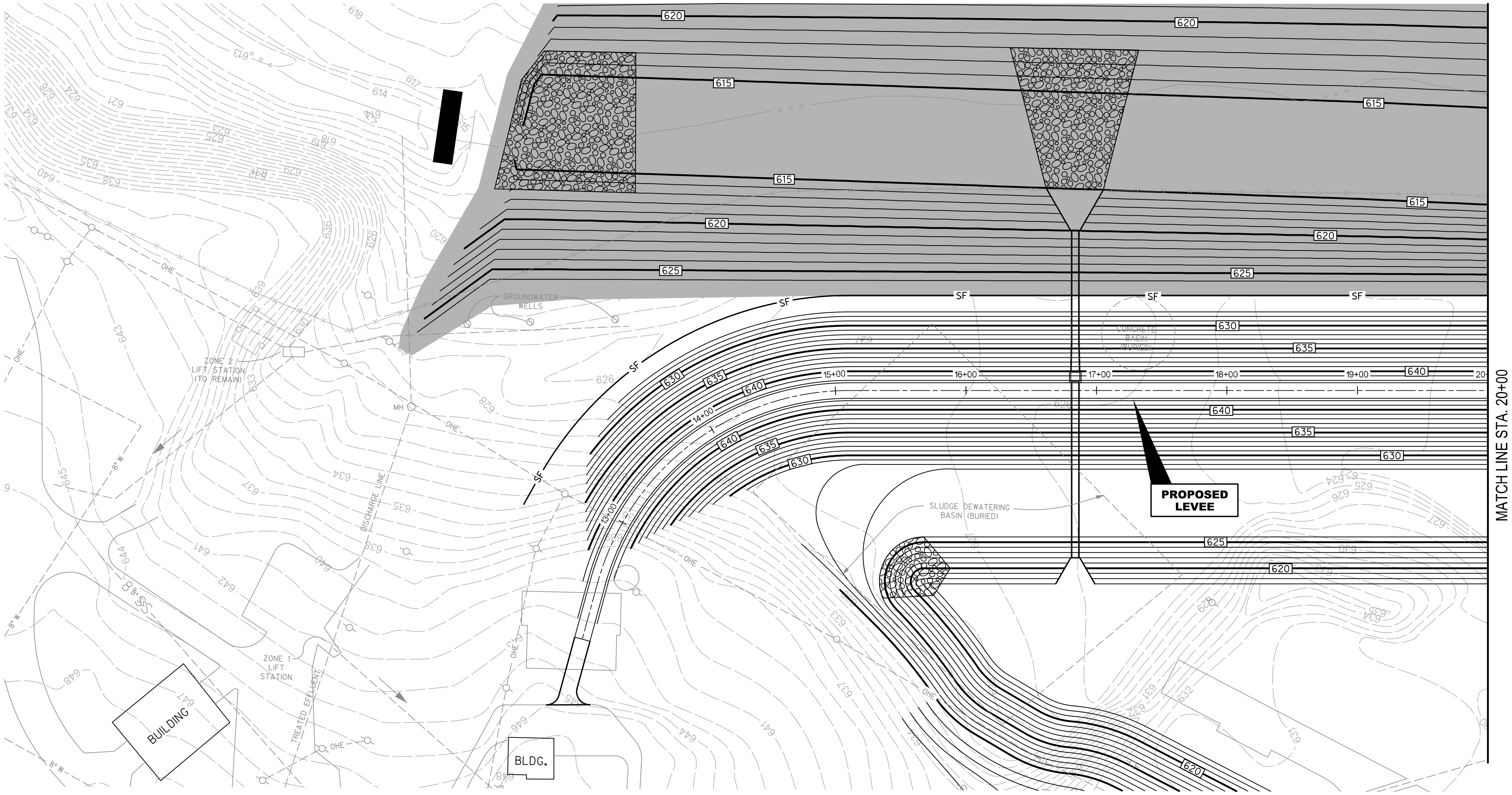

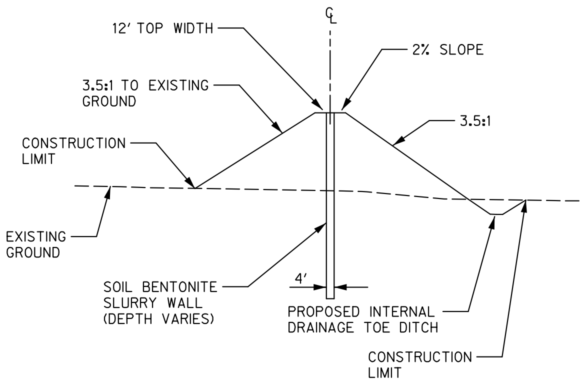

TYPICAL SECTION

NOT TO SCALE

NOTES:

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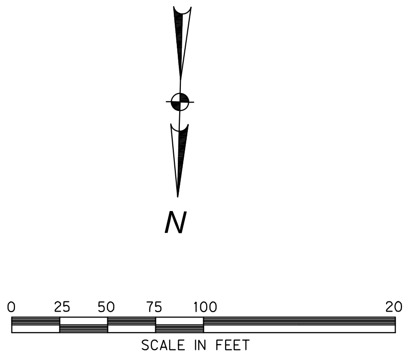
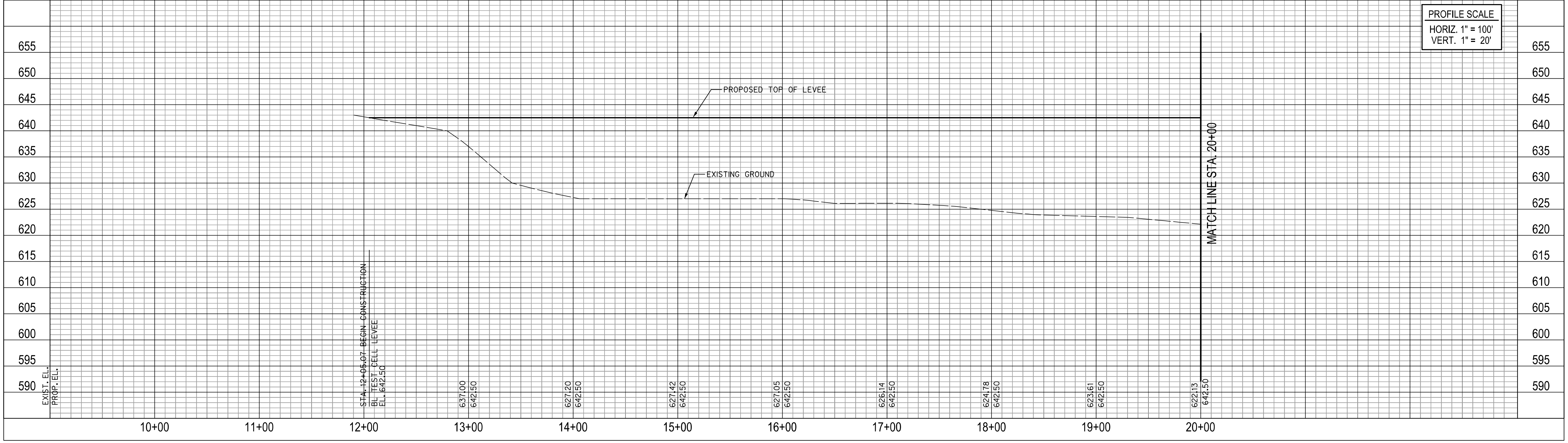
2. EXISTING UTILITIES TO REMAIN, UNLESS OTHERWISE NOTED.





LEON CREEK
INTERIM FEASIBILITY STUDY

U.S. ARMY CORPS
OF ENGINEERS

HALFF℠

4000 FOSSIL CREEK BLVD
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ANDREW D. ICKERT	94698
NAME	P.E. NO.
DATE	10/23/2013
TBPE FIRM #F-312	

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Checked By:	ADI

Sheet Title

TEST CELL LEVEE ALT
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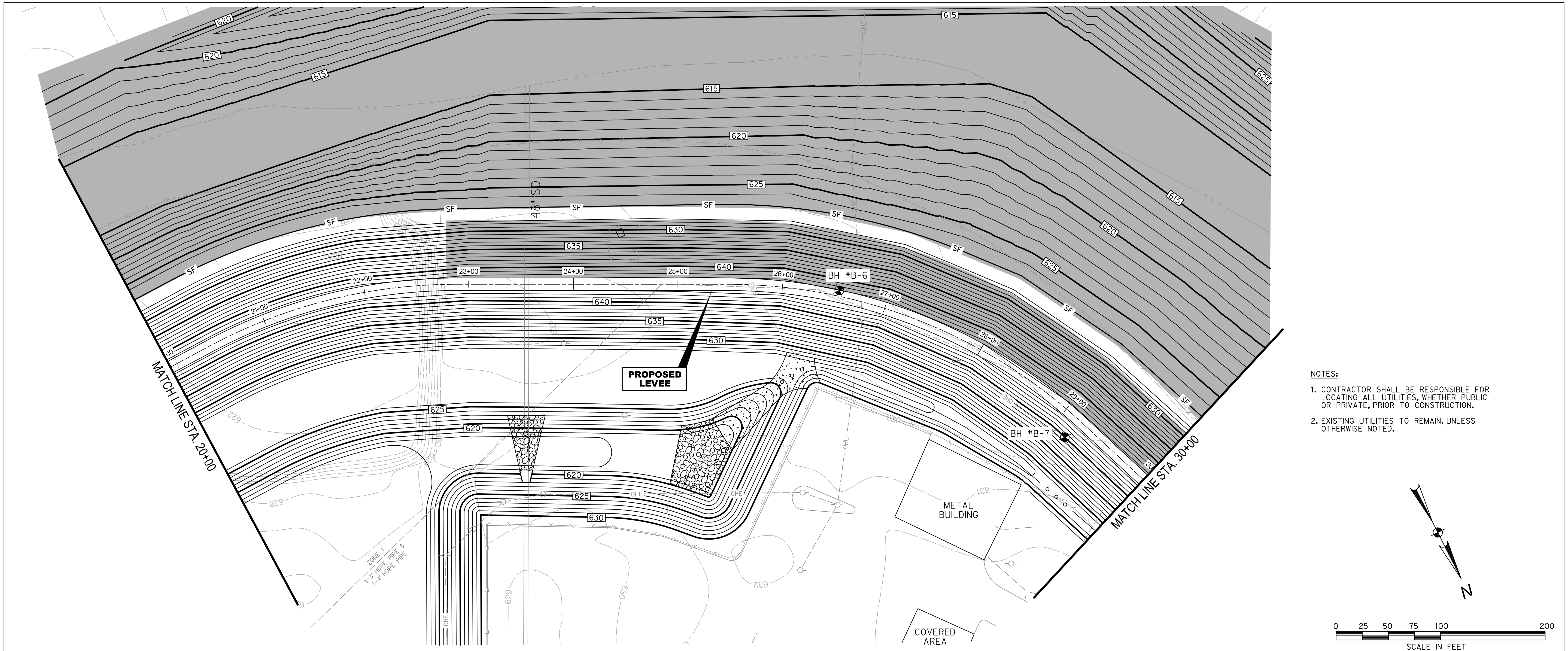

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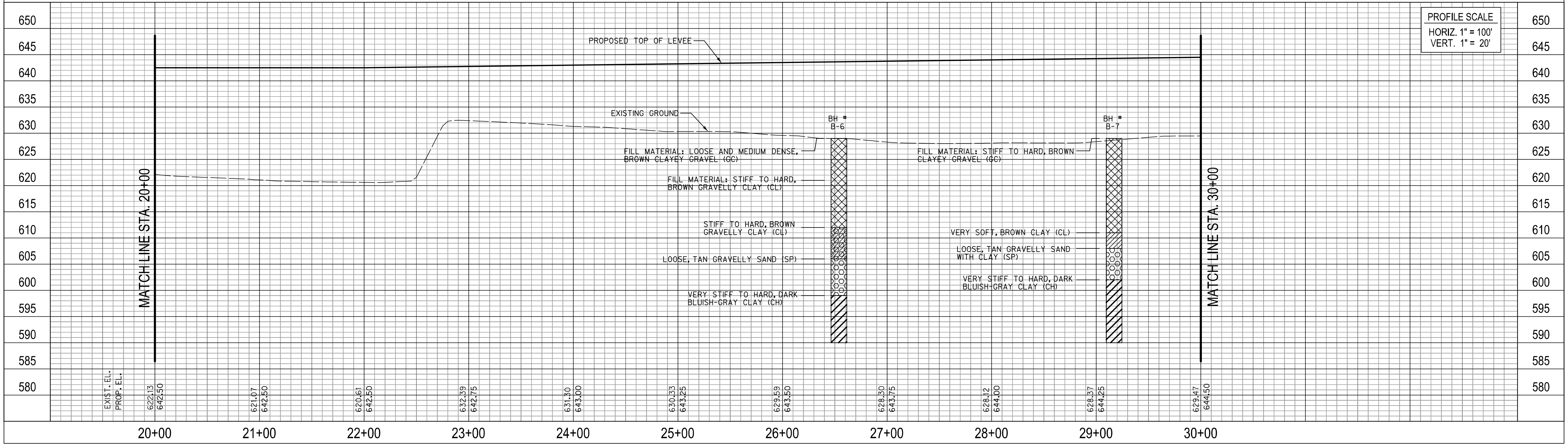

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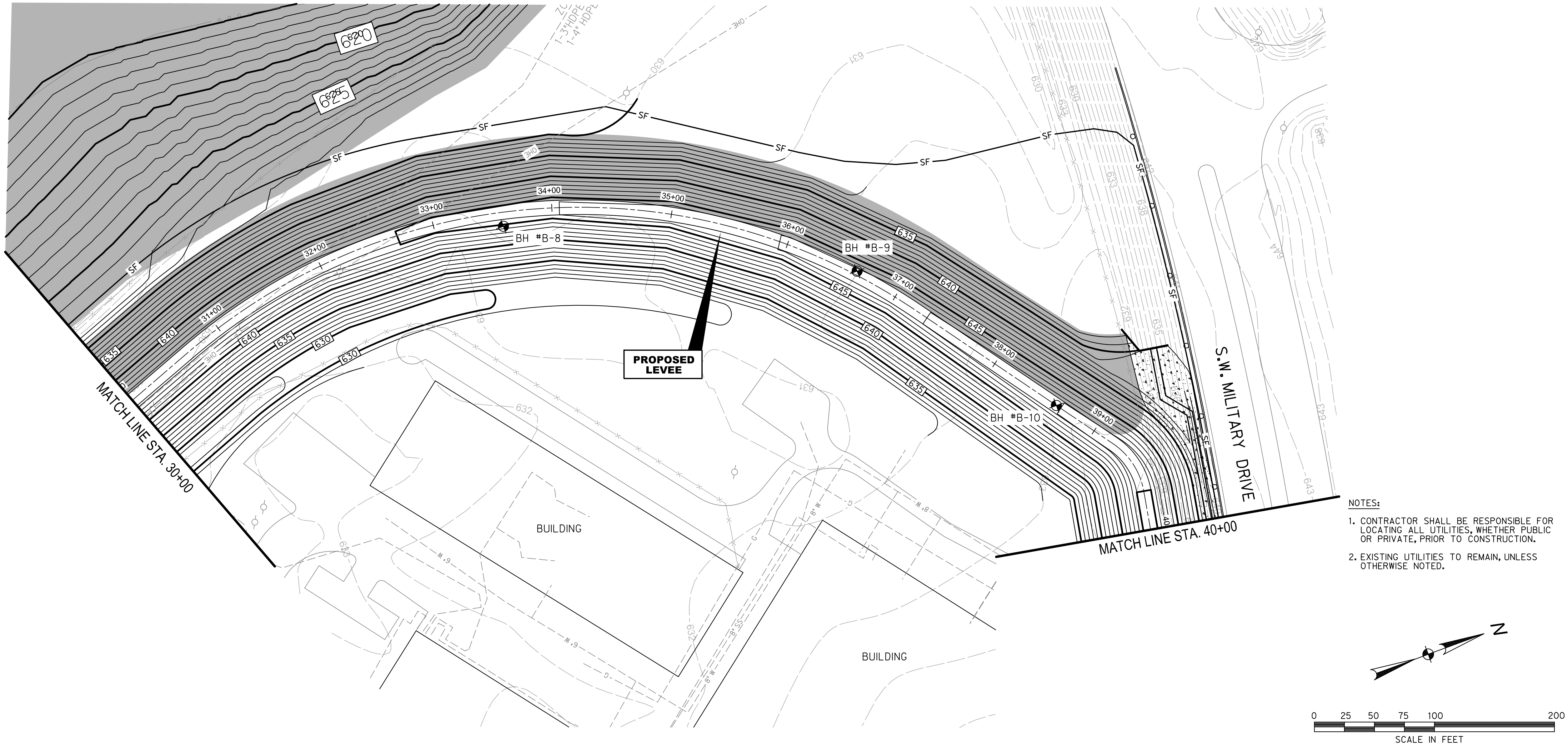

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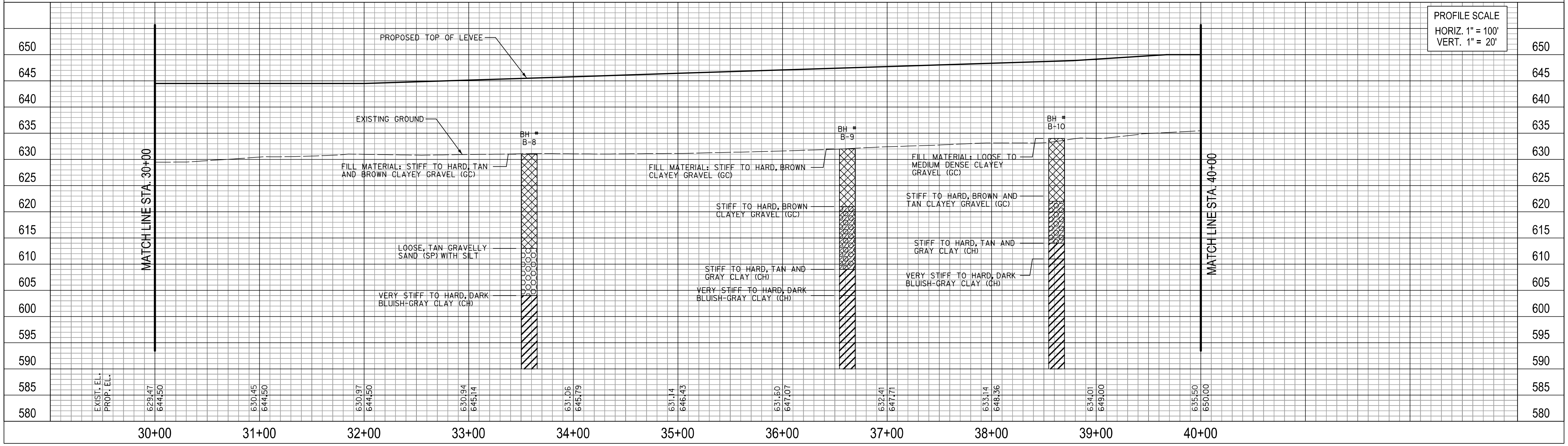

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EXIST. EL.	629.47	630.45	630.97	630.94	631.06	631.14	631.60	632.41	633.14	634.01	635.50
PROP. EL.	644.50	644.50	644.50	645.14	645.79	646.43	647.07	647.71	648.36	649.00	650.00

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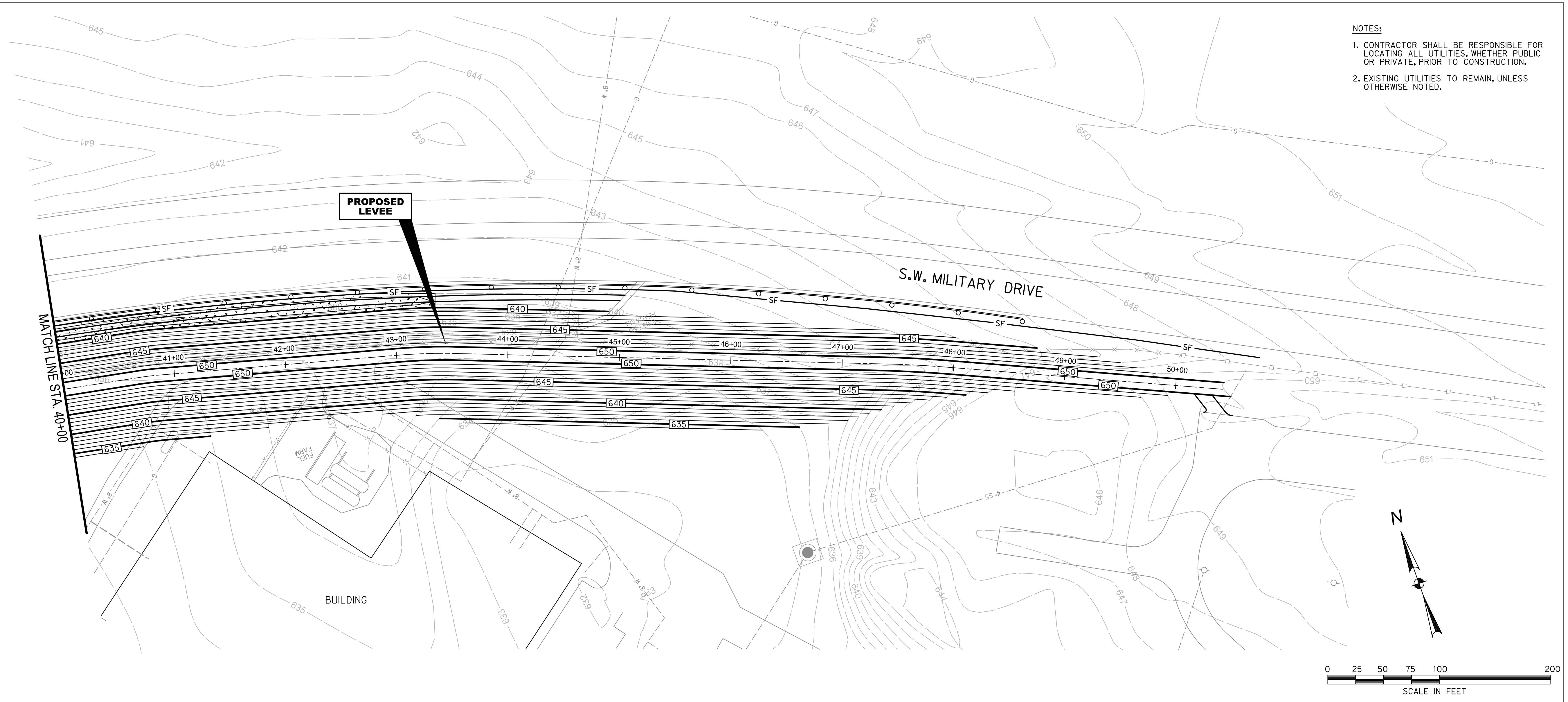

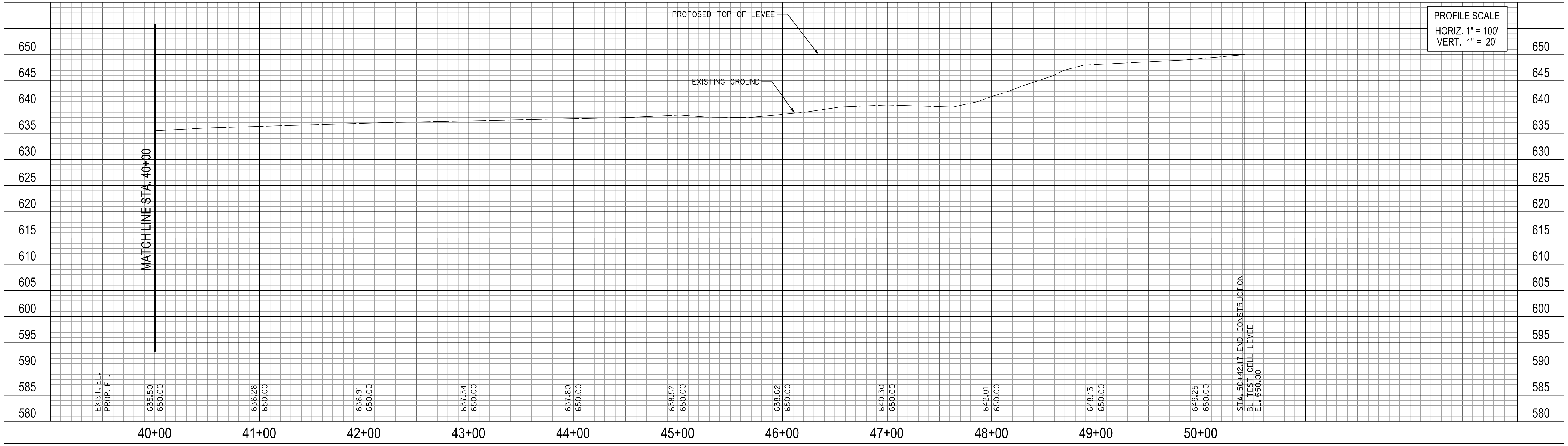

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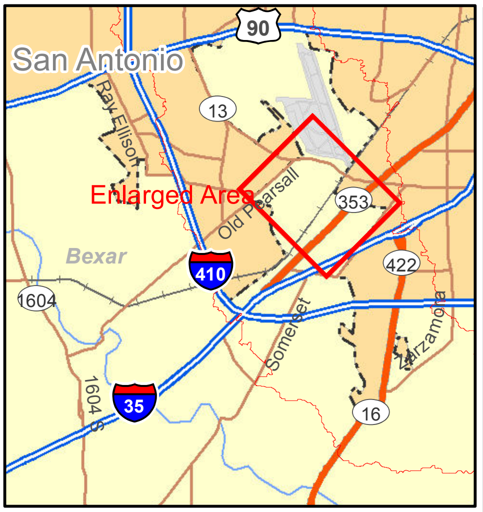
Leon Creek- Regional Faulting NearTest Cell Levee



Legend

▬ ▬	Regional Faults
▨	Ecological Mitigation Area
▨	Sump - Inside
▨	Sump - Outside
▨	1% AEP Levee
▨	Excavation Area
▨	Channel Area

0 250 500 1,000 1,500 Feet

N E S W

Project: Leon Creek
Project Manager: Nova Robbins
Section: CESWF-PER-PT
Date: October 22, 2013
Author: Jennifer Holland
Location: \\swf-netapp1\Civil\
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Austin, TX 78744-1045
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512.443.3442 Fax
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March 21, 2006

Mr. John Marler, P.E.
HDR Engineering, Inc.
4401 Westgate Blvd., Suite 400
Austin, Texas 78745

Re: Flood-Control Structure Alternatives Assessment
Test Cell Levee Feasibility Analysis
San Antonio, Texas
Owner: Port Authority of San Antonio
HVJ Report No. 02-155GA-0

Dear Mr. Marler:

Submitted herein is our letter report summarizing alternatives for a flood-control structure at the project site and a preliminary outline of the potential failure modes for the alternatives identified. The discussions presented herein were developed from a brief review of the available information, a site visit and preliminary results from a field investigation. In addition, Dr. Roy E. Olson, professor at the University of Texas at Austin was consulted and provided input. This report is intended as preliminary and should be used as the basis for future investigations and more detailed study.

Flood-Control Structure Alternatives

The selection of a suitable flood-control structure for the project site depends primarily on three variables, 1) the purpose of the structure, 2) the permeability of the in-situ alluvial soils underlying the project site, and 3) the available space for construction. After review of the available data, these three factors were determined to be the driving factors in the selection of the alternatives presented in the table below. After the engineering, the cost is the next significant factor. The inclusion of a variety of different types of structures was aimed at addressing this issue. It is anticipated that other factors affecting the design and not considered in this assessment will be considered in later phases.

Purpose of Flood-Control Structure

The purpose of the flood-control structure at this project site is to maintain dry conditions within the structure with sufficient reliability. The design level of reliability is undetermined at this time. However, the selection of the alternatives was focused on typical geotechnical structures for which their reliability could be estimated from available data from similar projects.

Permeability of In-situ Soils

The permeability of the in-situ soils will determine whether a sufficient pathway exists for groundwater flow between Leon Creek and the project site. Specifically, the duration of time that elapses between a given rise in Leon Creek and a response directly under the project site is significant to the design. In addition, the depth of water that can be sustained outside a given structure will also be limited by the permeability, i.e. the gradient across the structure. At the project site specifically, it is important to note that the subsurface conditions consist of approximately 25 ft of alluvial deposits over very low permeability clays. This discussion is, therefore, aimed at the upper 25 ft of deposits.

Space Availability

The type of structure that can be constructed and used is dictated by the space available. Along the length of the proposed levee, it appears as if there are areas where sufficient space exists and other areas where only designs that cover a limited area can be used. An additional factor in determining available space is the property limits and coordination with adjacent owners. The actual space restrictions are unknown at this time.

Alternatives

The various conditions for each variable and the associated flood-control alternative are presented in the following table. These alternatives were considered suitable for construction at the project site with typical construction effort.

Site Specific Variables		**Flood-Control Structure**	
Available Space	**Subsurface Permeability**	**Surface Structure**	**Cut-off Structure**
sufficient	high	engineered earthen levee	grout curtain
limited	high	earth covered sheet-piling	sheet piling
sufficient	low	engineered earthen levee	none
limited	low	cantilever retaining wall	none

It should be noted that a combination of the two alternatives due to the varying space conditions is likely. One additional alternative component that was considered was the use of pumps or a drain system on the land side of the flood-control structure to maintain dry conditions. However, a thorough seepage analysis given the specific site and design flood conditions is required to even determine whether it is a feasible option. The feasibility of this alternative is undetermined at this time but should be considered after additional data are available.

Failure Modes

The modes of failure identified in this letter report for the flood-control structures presented in the table above are limited to failures resulting from the in-situ soil conditions provided a sufficient design and quality construction of the structure itself. Specifically, the permeability of the soils and the loading that will result from the design flood event are the focus of this failure mode assessment. It should be noted, however, that neither of these variables are known at this time. In addition, the existing flood levels estimated by FEMA are currently being updated and are anticipated to increase in response to recent flood events. Therefore, the failure modes identified at this time are speculative and should be used to identify areas where additional data are needed.

The primary mode of failure for all the structures is excessive seepage. Again, it is assumed that the structures themselves are engineered for the site-specific conditions. For the alternatives that do not include a below-grade cut-off, the gradient that will be produced across the structure could result in significant loss of strength of the subsurface soils leading to a piping failure and 'boiling' of the land-side soils resulting in a bearing failure of the foundation. However, construction of a cut-off in the alluvial soils that sufficiently seals all pathways down to the low permeability clays will be difficult. A more complete analysis of each structure will be possible when estimated loadings and characterization of the in-situ soils is complete.

It has been a pleasure to work for you on this project and we appreciate the opportunity to be of service. Please notify us if there are questions or if we may be of further assistance.

Sincerely,

HVJ ASSOCIATES, INC.

LIZAN N. GILBERT
91796

Lizan N.Gilbert, P.E.
Project Engineer

3/21/06

Copies submitted: 1 electronic (Marler)

The seal appearing on this document was authorized by Lizan N. Gilbert, P.E. 91796 on March 21, 2006. Alteration of a sealed document without proper notification to the responsible engineer is an offense under the Texas Engineering Practice Act.

GEOTECHNICAL STUDY
TEST CELL LEVEE FEASIBILITY ANALYSIS
SAN ANTONIO, TEXAS

SUBMITTED TO
HDR ENGINEERING, INC.
4401 WESTGATE BOULEVARD
SUITE 400
AUSTIN, TX 78745

BY
HVJ ASSOCIATES, INC.
APRIL 4, 2006

REPORT NO. 02-155GA-0

HVJ
ASSOCIATES

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April 5, 2006

Mr. John Marler, P.E.
HDR Engineering, Inc.
4400 Westgate Boulevard
Suite 400
Austin, Texas 78745

Re: Test Cell Levee Feasibility Analysis
San Antonio, Texas
Owner: Port Authority of San Antonio
HVJ Report No. 02-155GA-0

Dear Mr. Marler:

Submitted herein is the Geotechnical Study for the above referenced project. In general, this report presents the boring logs, a boring location plan, laboratory test results and a description of the existing levee condition. The investigation was performed in accordance with our proposal number 02-155GA-0.

It has been a pleasure to work for you on this project and we appreciate the opportunity to be of service. Please notify us if there are questions or if we may be of further assistance.

Sincerely,

HVJ ASSOCIATES, INC.

LIZAN N. GILBERT
91736

Lizan N.Gilbert, P.E.
Project Engineer

4/5/06

Copies submitted: 4 hard copies HDR (Marler)
1 electronic copy HDR (Marler)

TABLE OF CONTENTS

PLATES

APPENDICES

I. EXECUTIVE SUMMARY

HVJ Associates, Inc. was retained by HDR Engineering, Inc. to perform a geotechnical study of the existing levee at the Test Cell Facility in San Antonio, Texas. The project site is comprised of the structures for a jet engine test facility surrounded by an earthen levee. The study consisted of three primary objectives, 1) determine the in-place condition of the existing levee structure, 2) perform a preliminary geotechnical investigation, and 3) identify alternatives for a flood-control structure at the project site. The first two objectives are outlined in this report. The third objective, the list of alternatives is presented in a separate letter report, "Flood-Control Structure Alternatives Assessment," written by HVJ and dated March 21, 2006. The results of the first two are summarized briefly below.

1. A preliminary geotechnical investigation was performed that included drilling and sampling 10 borings along the crest of the existing levee structure. Laboratory testing was performed on select samples to characterize the engineering properties of the subsurface strata.
2. The subsurface stratigraphy consists of approximately 25 to 30 ft of alluvial soils comprised of soft to hard/dense clay, silt, sand and gravel over highly overconsolidated, high plasticity clay.
3. Groundwater was encountered at all boring locations. It is anticipated that the groundwater level is consistent with the level in Leon Creek.
4. The layers of soil at the level of the groundwater table (approximately 15 ft below grade) are very compressible and have essentially no undrained shear strength.
5. The alluvial strata are very permeable, i.e., have a high hydraulic conductivity; the underlying clay stratum has a very low permeability and essentially acts as a hydraulic barrier resulting in perched groundwater conditions.
6. The condition of the existing levee is poor. The soils are non-uniform and uncharacterized containing layers of sand and construction debris. Localized slope failures and areas of subsidence were observed. Most important, multiple penetrations parallel to, on top of and longitudinally along the levee were observed and are causing detrimental impacts to the structure.
7. The levee should not be used in whole or in part for the long-term flood-control solution.

A thorough review of this report and all data presented herein is required for a complete understanding of this data summary.

1 INTRODUCTION

1.1 Project Description

HVJ Associates, Inc. was retained by HDR Engineering, Inc. to perform a geotechnical study of the existing levee at the Test Cell Facility in San Antonio, Texas. The study consisted of three primary objectives, 1) determine the in-place condition of the existing levee structure, 2) perform a preliminary geotechnical investigation, and 3) identify alternatives for a flood-control structure at the project site. The first two objectives are outlined in this report. The third objective, the list of alternatives is presented in a separate letter report, "Flood-Control Structure Alternatives Assessment," written by HVJ and dated March 21, 2006.

1.2 Purpose and Scope of Work

The purpose of this portion of the study was to gather sufficient information on the in-place soils of the existing levee structure at the project site and perform a preliminary geotechnical investigation at the site to facilitate the selection of flood-control alternatives, including an evaluation of the existing levee structure. Our scope of work included:

1. Drilling and sampling ten (10) soil borings at various locations along the levee structure to depths of 40 ft.

2. Performing field and laboratory tests to determine physical properties and engineering characteristics of the soils.

3. Observing and measuring in-situ groundwater levels during drilling.

Subsequent sections of this report contain descriptions of the field investigation, laboratory-testing program, and general subsurface conditions.

2 FIELD INVESTIGATION

2.1 General

The field investigation was initiated on December 13, 2005. In total ten (10) borings were drilled to depths of 40.0 ft along the alignment of the existing levee. The boring logs are presented on Plates 4 through 13. The keys to terms and symbols shown on the borings logs are presented on Plates 14A and 14B. The locations of the soil borings are presented on Plate 3, Plan of Borings.

2.2 Sampling Method

During dry advancement of the boring, 3-inch diameter thin-walled tube samplers were pushed into the soil to obtain samples of cohesive soil strata in accordance with ASTM D1587. The samples were extruded in the field and visually classified. An estimate of the undrained shear strength was obtained by means of the pocket penetrometer. Upon refusal of the thin-walled samplers or when cohesionless soils were encountered, split-spoon samplers, with an outside diameter of 2 in., an inside diameter of 1.375 in. and a barrel length of 21 inches, were driven into the soil strata to obtain disturbed samples. Standard Penetration blow counts were recorded as the number of blows to drive the sampler three (3), 6-inch increments using a 140-lb hammer for a maximum of 50 blows for 6 inches of penetration (ASTM D1586). The Standard Penetration N-value is the sum of the number of blows for the last two, 6-inch intervals. Samples were subsequently wrapped and sealed for transport to our laboratory. Detailed descriptions of the soils encountered in the borings are given on the boring logs.

2.3 Borehole Completion

Upon completion of drilling, all project borings were backfilled with bentonite chips.

3 LABORATORY TESTING

The laboratory testing program was aimed at determining the physical properties and engineering characteristics of the selected soil samples. The soil strata were tested to determine their Atterberg limits, sieve analyses, unconfined compressive strength, water contents and moisture-density relationships. All tests were performed in accordance with the relevant ASTM Standards. The sieve analyses were run on samples obtained from the fill material that comprises the earthen levee. The laboratory test results are presented on the boring logs at their respective depths and in the Appendix, Laboratory Test Results Summary. The results of the sieve analyses and moisture-density relationships are presented in the Appendix, Sieve Analysis Results and Moisture-Density Relationships.

4 SITE CHARACTERIZATION

4.1 Site Characterization

The project site is located directly adjacent to Leon Creek and south of SW Military Drive on the old Kelly USA in south west San Antonio, Texas. A site vicinity map is presented on Plate 1, Vicinity Map. The site currently contains the jet engine test facility structures surrounded by an earthen levee on roughly three sides. The site slopes in the direction of flow in Leon Creek, south-southeast, from approximately 641 ft to 639 ft. The site is within the 100 year floodplain, although the exact elevation is currently being determined. Survey data for the site and the borings was not available at the time of this report. The site has minimal vegetation.

4.2 General Geology

According to the Geologic Atlas of Texas[1], the project area is underlain by alluvial deposits of Leon Creek over clay of the Taylor Group. The alluvial soils are comprised of a mixture of normally consolidated clay, silt sand and gravel. The grain size of the soils generally increase with depth with gravel and sand layers located directly above the Taylor clay. Water is generally encountered within these sand and gravel layers. The Taylor clay is comprised of highly plastic and blocky clay and shale. The clay has a very low hydraulic conductivity and, therefore, acts as a hydraulic boundary to groundwater. A generalized map of the surface geology is included as Plate 2, Geology Map.

---

[1] W. L. Fisher, 'Geologic Atlas of Texas, San Antonio Sheet' Bureau of Economic Geology, The University of Texas at Austin, 1983.

4.3 Subsurface Stratigraphy and Engineering Properties

The subsurface stratigraphy is comprised of fill material, i.e., the levee, over alluvial soils comprised of lean clay, silt, sand and gravel over highly overconsolidated fat clay and shale. A thorough review of the boring logs is required to develop a sufficient understanding of the subsurface conditions. A brief description of the subsurface strata is presented below.

The fill for the earthen levee is comprised of uncharacterized material including clay, sand and gravel as well as debris, e.g., asphalt and concrete. The thickness of fill varies from 11.0 ft to 18.0 ft as the levee height is inconsistent along its length. The standard penetration values are inconsistent with depth, although a slight trend towards a decrease with depth, i.e., material becoming more loose with depth, occurs at a few boring locations. Classification tests indicate percentages of material passing the No. 200 sieve ranging from 2 to 69 (average 29). The material is generally non-cohesive and samples within this material were recovered exclusively using split-spoon samplers. In addition, the results of the eight (8) sieve analyses indicate a well graded material with a maximum particle size of approximately 7/8 inches. Sand layers were also encountered at various boring locations within the fill material. Last, moisture-density relationships were developed for material sampled from the levee. The results indicate a maximum dry density varying between 108 pcf to 120 pcf with associated optimum water contents of 15 percent and 10 percent, respectively. These results also indicate a non-uniform material placement.

Below the fill, clay, silt, sand and gravel layers were encountered to depths ranging from 20.0 to 30.0 ft below grade. As discussed above, it should be noted that the actual thickness of alluvial soils is undetermined as the elevations of the borings are undetermined. It is anticipated that the contact between the alluvial soils and the underlying clay and shale is generally consistent, although the presence of an eroded channel within the clay is possible. The results of the classification tests indicate a liquid limit (LL) ranging from 31 to 47 percent (average 41 percent), the plasticity index (PI) ranging from 16 to 31 percent (average 22 percent) and the percentage of material passing the No. 200 sieve ranging from 7 to 81 (average 43). Groundwater was encountered within this layer at depth of approximately 15 to 18 ft below grade. The SPT values in the immediate vicinity of the water table were very low at all boring locations. At the B-7 boring location specifically, a penetration of 18 inches was observed for 1 blow. The soils in this layer are characterized as very soft and very compressible, i.e. essentially no undrained shear strength. They are, however, highly permeable.

Highly plastic, fat clay was encountered below the alluvial soils. These soils are highly overconsolidated with SPT values indicating a hardness of very stiff to hard throughout. At the boring B-3 location, the SPT values were greater than 50 blows for a penetration of 6 inches. These results are indicative of shale, or the intact formation. The results of the classification tests indicate a liquid limit (LL) ranging from 36 to 76 percent (average 61 percent), the plasticity index (PI) ranging from 20 to 60 percent (average 42 percent) and the percentage of material passing the No. 200 sieve ranging from 78 to 100 (average 94).

4.4 Groundwater

Groundwater was encountered at all boring locations between 15 and 23 ft below the ground surface. The variation in groundwater level is not indicative of the true condition but a function of not having survey elevations for the borings. It is anticipated that the true groundwater level is consistent across the site and with the water levels in Leon Creek. In addition, a pump and treat system with monitoring wells is currently set up at the project site. This indicates a relatively high permeability of the alluvial soils, the actual value undetermined during this investigation. Groundwater levels will fluctuate with rainfall conditions and flood events.

5 EXISTING LEVEE EVALUATION

The condition of the existing levee was evaluated for the purpose of answering two questions, 1. What is the condition of the material in its current configuration, and 2. Can the existing structure be used in any manner for the long-term flood control of the Test Cell area? Historical data and the results of this geotechnical investigation were reviewed and the site was visited to answer these questions. In addition, the alternatives for constructing a long-term flood-control structure were identified, as discussed in the Introduction section of this report, to determine the possibilities for how the existing earthen levee could be utilized in future solutions.

First, the condition of the existing levee is poor. The south/south east portion of the levee has been eroded and multiple areas of localized slope failures were observed. The remaining material is inconsistent, very soft and contains construction debris. It is clear that the levee was comprised of unprocessed material such as an uncontrolled on-site stockpile and placed without construction oversight typical for this type of structure.

Perhaps more important than the in-place condition of the material is the number of penetrations into and through the levee. Multiple telephone poles were founded at various points along the crest of the levee, a flexible pipeline was buried longitudinally along the alignment, and at least two penetrations perpendicular to the levee, including a water line and a small concrete box culvert type structure, were constructed at the base of the levee. These by far have the most impact on the integrity of the existing levee. In fact, multiple areas of erosion directly around these structures were observed including a large, approximately 10 ft diameter and 8 ft deep sink hole was observed in the immediate vicinity of one of the buried pipes. It is anticipated that these penetrations could result in loss of material by piping and ultimate failure of any structure founded on top of or using this existing structure.

It is recommended that the existing levee should not be used in whole or in part of the long-term flood control solution. It is possible that the material could be processed and used in an alternative that included an earthen portion. However, the penetrations in the levee should be eliminated or carefully engineered for any long-term flood-control structure to operate properly.

6 LIMITATIONS

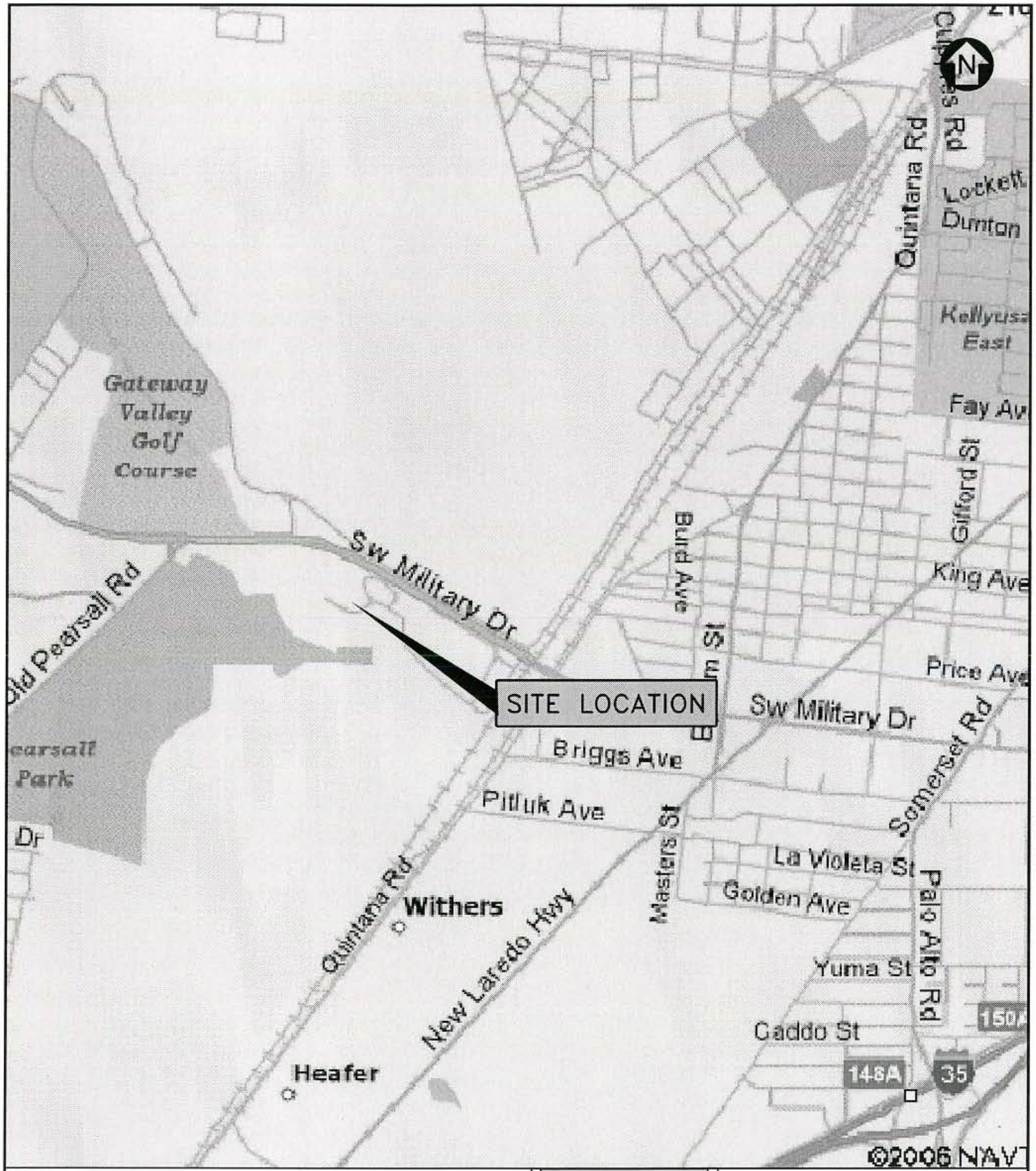
This study was performed for the exclusive use of HDR Engineering, Inc. for specific application to the proposed Test Cell Levee Feasibility Analysis in San Antonio, Texas. HVJ Associates, Inc. has endeavored to comply with generally accepted geotechnical engineering practices common in the local area. HVJ Associates, Inc. makes no warranty, express or implied.

The methods used indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Samples cannot be relied on to accurately reflect the strata variations that usually exist between sampling locations.

Should any subsurface conditions other than those described in our boring logs be encountered, HVJ Associates should be immediately notified so that further investigation and supplemental recommendations can be provided.

Subsurface conditions at the site can differ significantly from those encountered in the borings due to the natural variation of geologic conditions, which may not have been detected by the field boring program. In the event that any changes in the nature, design, or location of the improvements are made, the conclusions and recommendations in this report should not be considered valid until the changes are reviewed and the conclusions and recommendations modified or verified in writing by HVJ Associates.

PLATES



HVJ ASSOCIATES

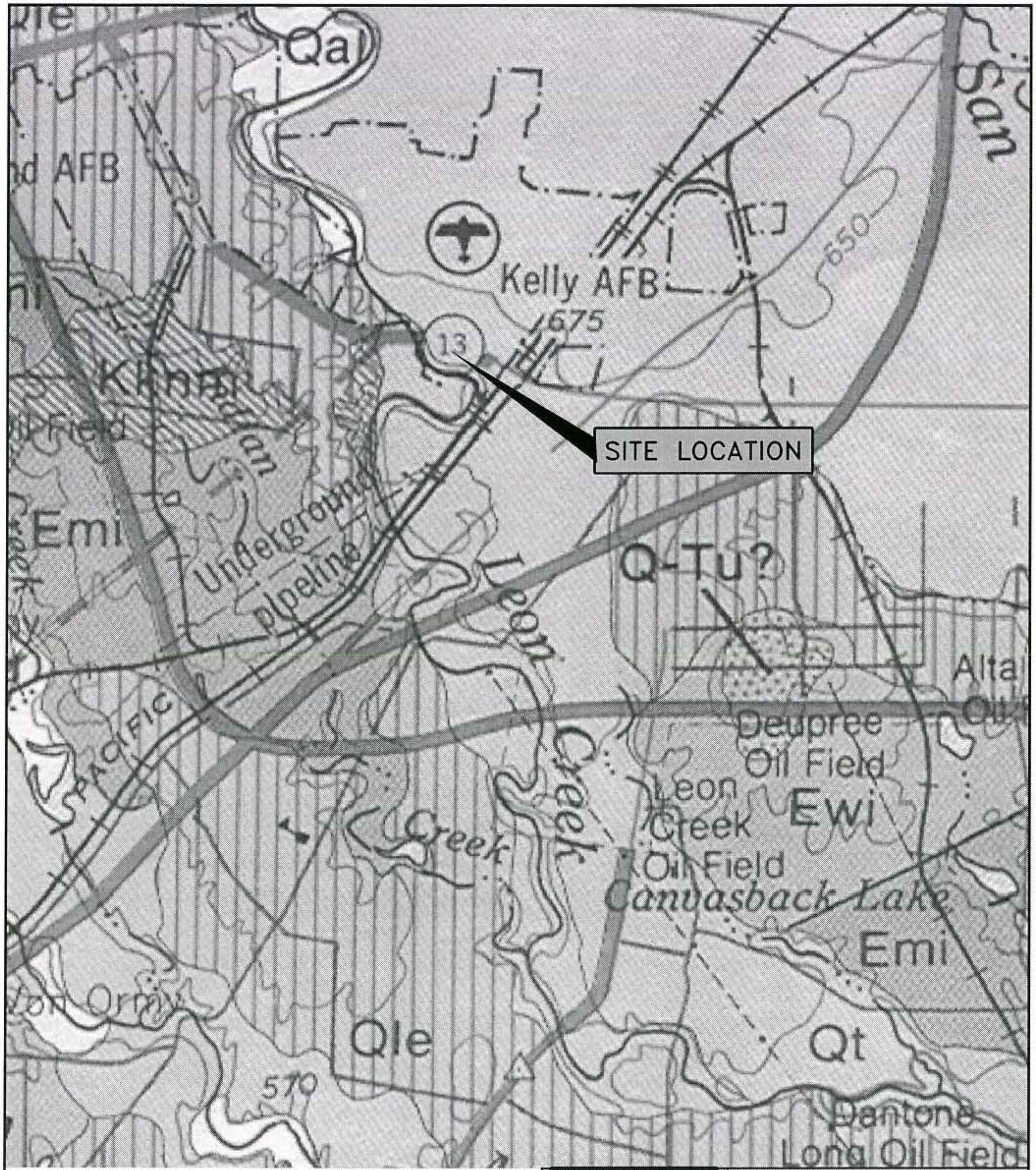
SCALE: N.T.S.

DATE: 4/5/2006

DRAWN BY:	PROJ. CHK:	APPRV. BY:
JS	JS	LG

VICINITY MAP
TEST CELL LEVEE
FEASIBILITY ANALYSIS
SAN ANTONIO, TEXAS

PROJECT NO.:	DRAWING NO.:	PLATE 1
02-155GA-0	VICINITY	



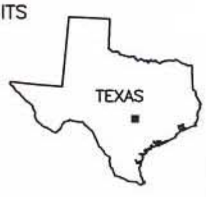
Base Map Source: Bureau of Economic Geology, GEOLOGIC MAP OF THE SAN ANTONIO AREA, TEXAS 1982

LEGEND

Qal	ALLUVIUM
Qlcr	LOWER COLORADO RIVER TERRACE DEPOSITS
Qt	FLUVATILE TERRACE DEPOSITS
Kgt	GEORGETOWN FORMATION
Kta	TAYLOR GROUP
Kau	AUSTIN GROUP
Kpt	PILOT KNOB BASALT
Kef	EAGLE FORD FORMATION
Kbu	BUDA FORMATION
Kcp	COMMANCHE PEAK FORMATION
Ked	EDWARDS FORMATION

N

NOT TO SCALE



MAP LOCATION

HVJ ASSOCIATES

SCALE: N.T.S.

DATE: 04/3/06

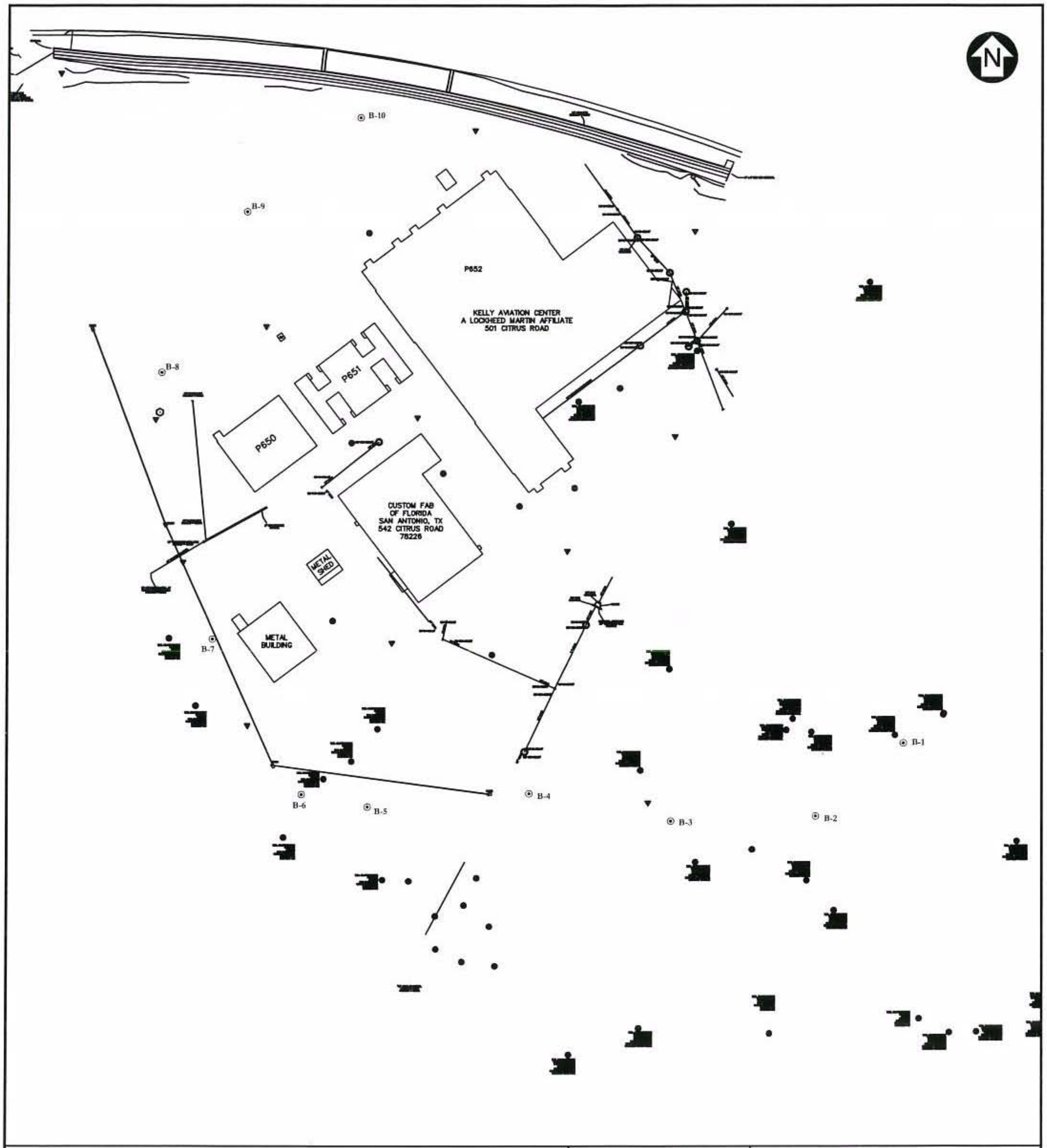
DRAWN BY:	PROJ. CHK:	APPRV. BY:
JS	JS	LB

GEOLOGY MAP
TEST CELL LEVEE
FEASIBILITY ANALYSIS
SAN ANTONIO, TEXAS

PROJECT NO.: 02-155GA-0

DRAWING NO.: GEOLOGY

PLATE 2



HVJ ASSOCIATES

SCALE: NTS		
DATE: 4/4/2006		
DRAWN BY: LNG	PROJ. CHK:	APPRV. BY: G

PLAN OF BORINGS
TEST CELL LEVEE FEASIBILITY ANALYSIS
SAN ANTONIO, TEXAS

PROJECT NO.: 02-155GA-0	FILENAME: POB	PLATE 3

DATE: LA
FILE: Drawing1.dwg

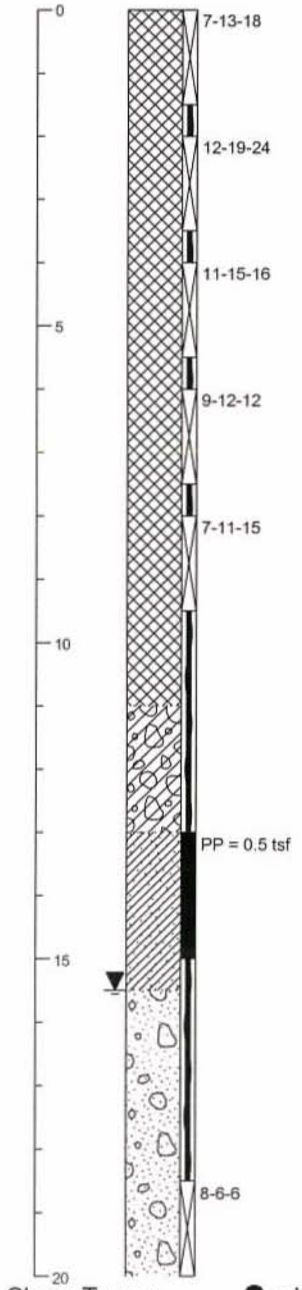
LOG OF SOIL BORING

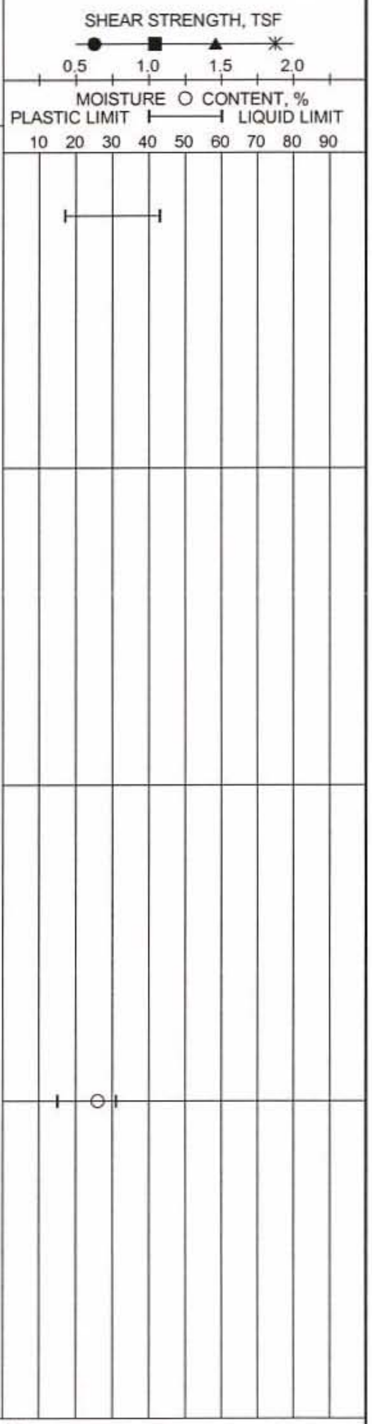
Project: Test Cell Levee Feasibility Analysis
Boring No.: B-1
Groundwater during drilling: 15.5 feet
Groundwater after drilling: ---

Date: 12-13-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --

ELEV. DEPTH, FEET / SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL DESCRIPTION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF	SHEAR STRENGTH, TSF / MOISTURE CONTENT, %
	FILL MATERIAL: medium dense to dense, brown and tan CLAYEY GRAVEL (GC).	35		
	Medium dense to dense, brown **CLAYEY GRAVEL (GC)**.			
PP = 0.5 tsf	Very soft, tan **SANDY CLAY (CL)**.	57		
	Loose to medium dense, tan **GRAVELLY SAND (SP)**.			





Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

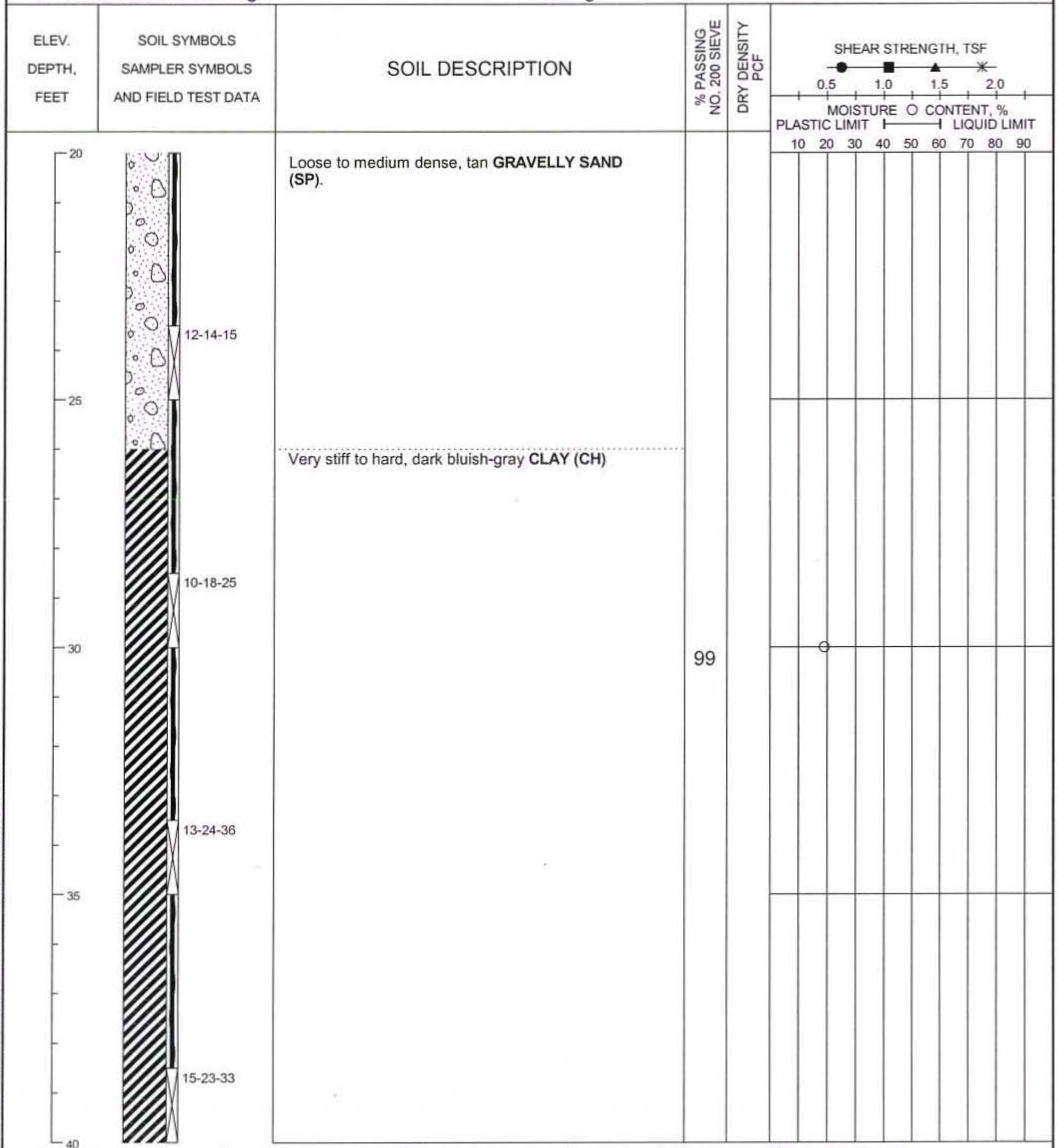
Plate 4a

LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-1
Groundwater during drilling: 15.5 feet
Groundwater after drilling: ---

Date: 12-13-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



Loose to medium dense, tan **GRAVELLY SAND (SP)**.

Very stiff to hard, dark bluish-gray **CLAY (CH)**

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

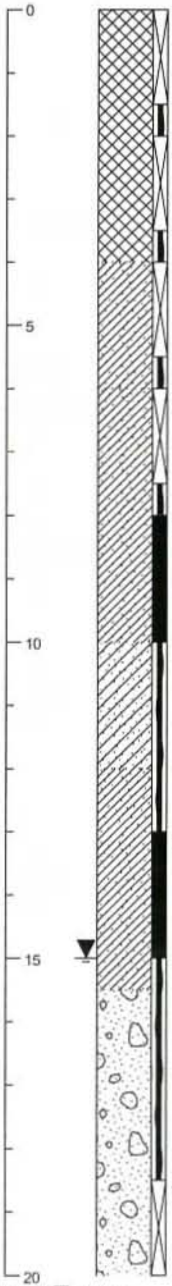
Plate 4b

LOG OF SOIL BORING

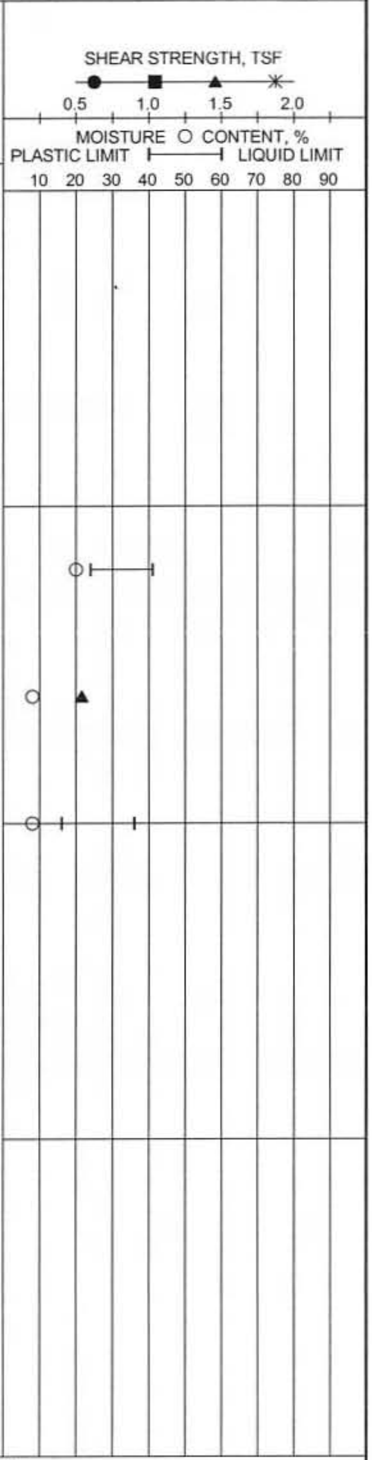
Project: Test Cell Levee Feasibility Analysis
Boring No.: B-2
Groundwater during drilling: 15.0 feet
Groundwater after drilling: ---

Date: 12-13-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL DESCRIPTION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0	7-15-17	**FILL MATERIAL:** Stiff to hard, brown CLAYEY GRAVEL (GC).		
	5-10-11			
	8-11-16	- asphalt pieces at 4.0' **FILL MATERIAL:** tan and brown SANDY CLAY (CL).		
5				
	3-2-4	Stiff, brown **SANDY CLAY (CL)**.	67	
	PP = 2.0 tsf			112
10		Loose to medium dense, brown **CLAYEY SAND (SC)**.	21	
		Very soft, tan **SANDY CLAY (CL)**.		
	PP = 0.5 tsf			
15 ▼				
		Loose, tan **GRAVELLY SAND (SP)**.		
	7-7-5			
20				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

Plate 5a

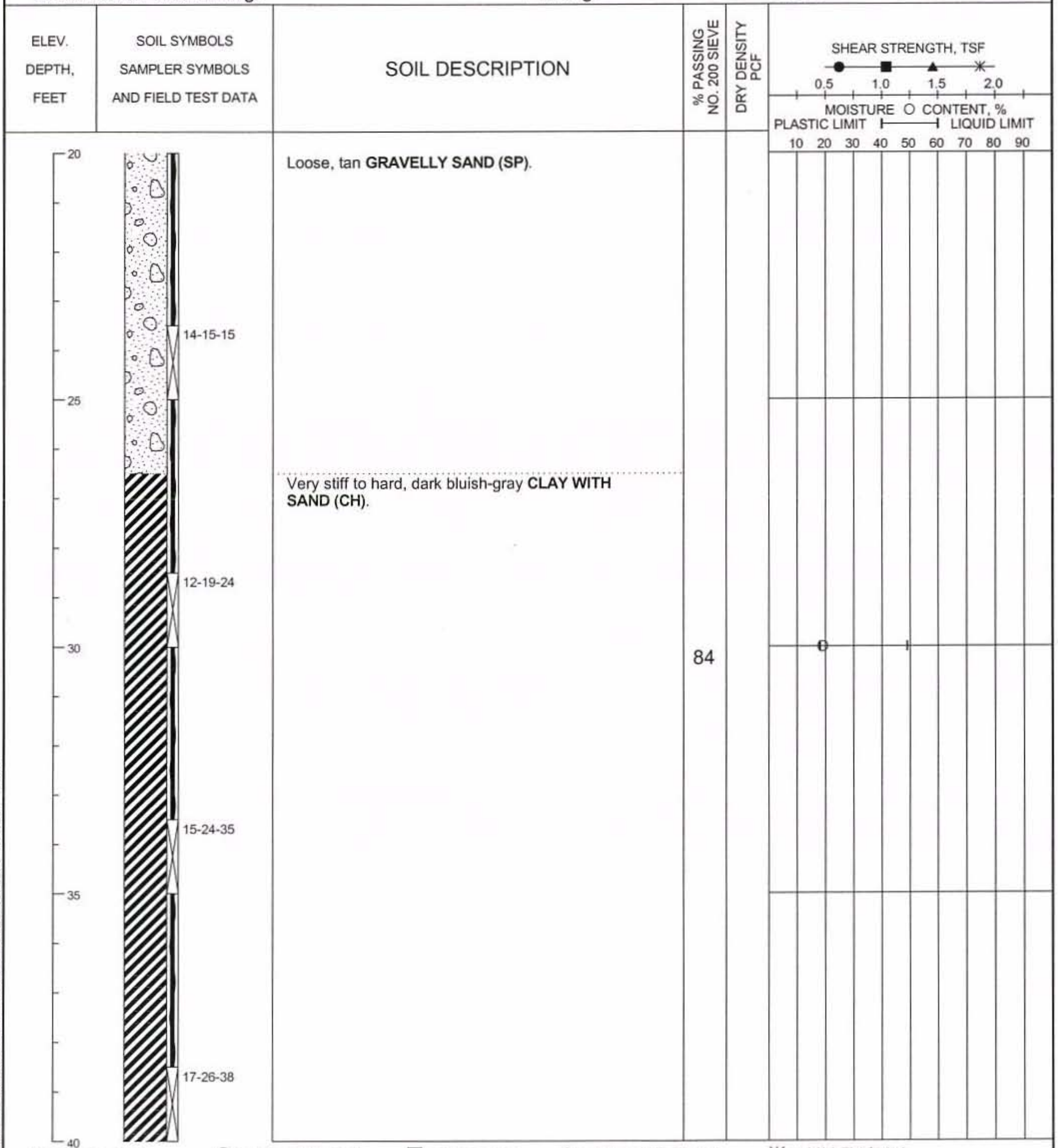
HVJ ASSOCIATES

LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-2
Groundwater during drilling: 15.0 feet
Groundwater after drilling: ---

Date: 12-13-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



Loose, tan **GRAVELLY SAND (SP)**.

Very stiff to hard, dark bluish-gray **CLAY WITH SAND (CH)**.

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

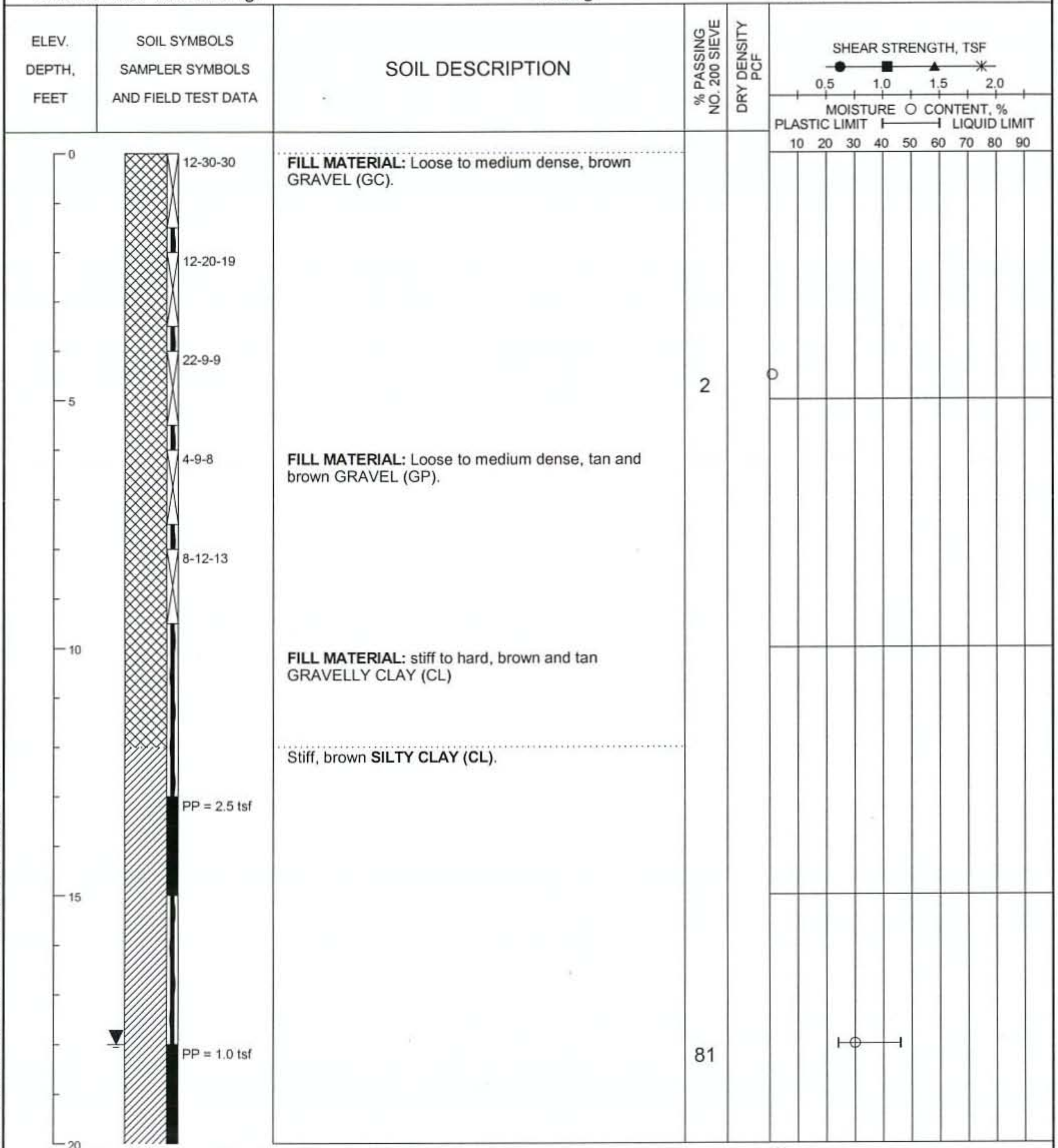
HVJ ASSOCIATES

LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-3
Groundwater during drilling: 18.0 feet
Groundwater after drilling: ---

Date: 12-12-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



FILL MATERIAL: Loose to medium dense, brown GRAVEL (GC).

FILL MATERIAL: Loose to medium dense, tan and brown GRAVEL (GP).

FILL MATERIAL: stiff to hard, brown and tan GRAVELLY CLAY (CL)

Stiff, brown **SILTY CLAY (CL)**.

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

Plate 6a

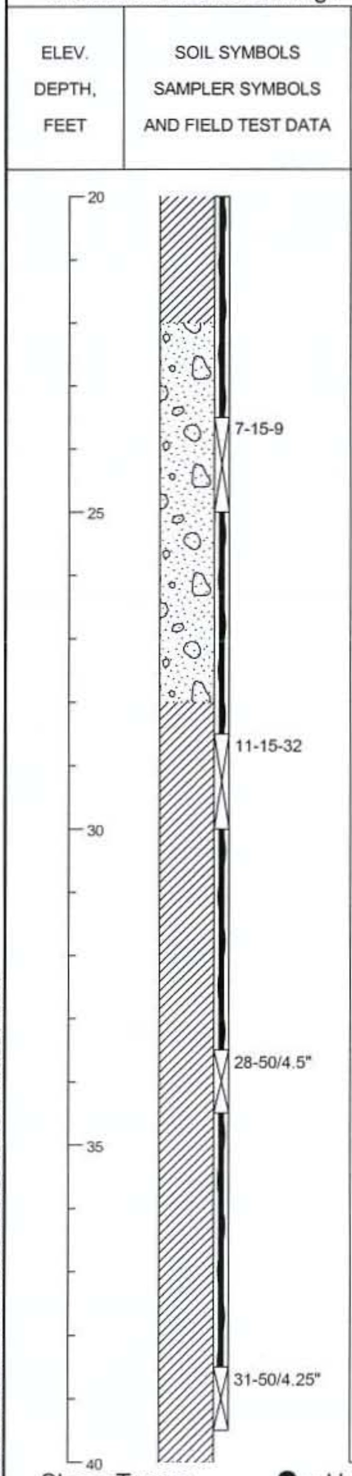
HVJ ASSOCIATES

LOG OF SOIL BORING

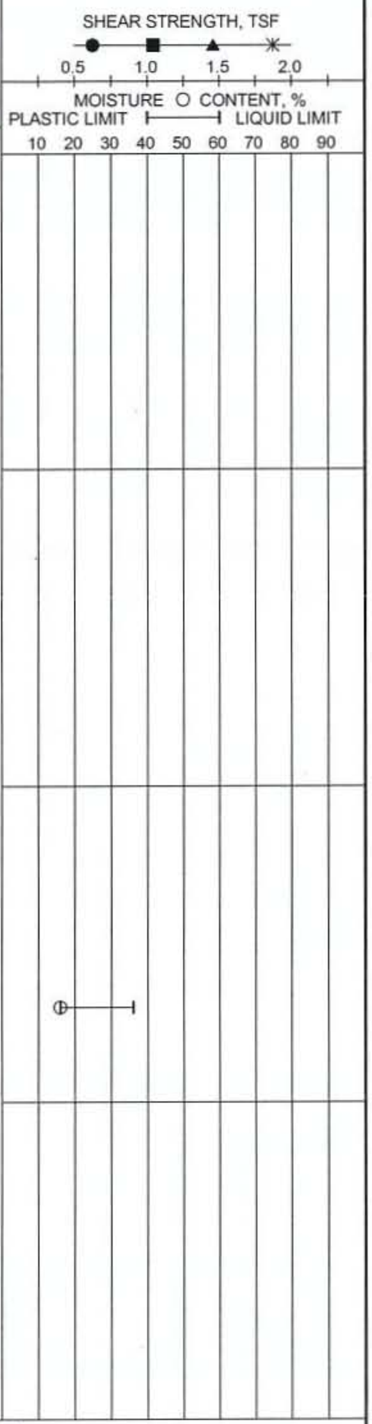
Project: Test Cell Levee Feasibility Analysis
Boring No.: B-3
Groundwater during drilling: 18.0 feet
Groundwater after drilling: ---

Date: 12-12-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



SOIL DESCRIPTION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
Stiff, brown **SILTY CLAY (CL)**.		
Loose to medium dense, tan **GRAVELLY SAND (SP)**.		
Very stiff to hard, dark bluish-gray **CLAY (CL)**.	86	



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

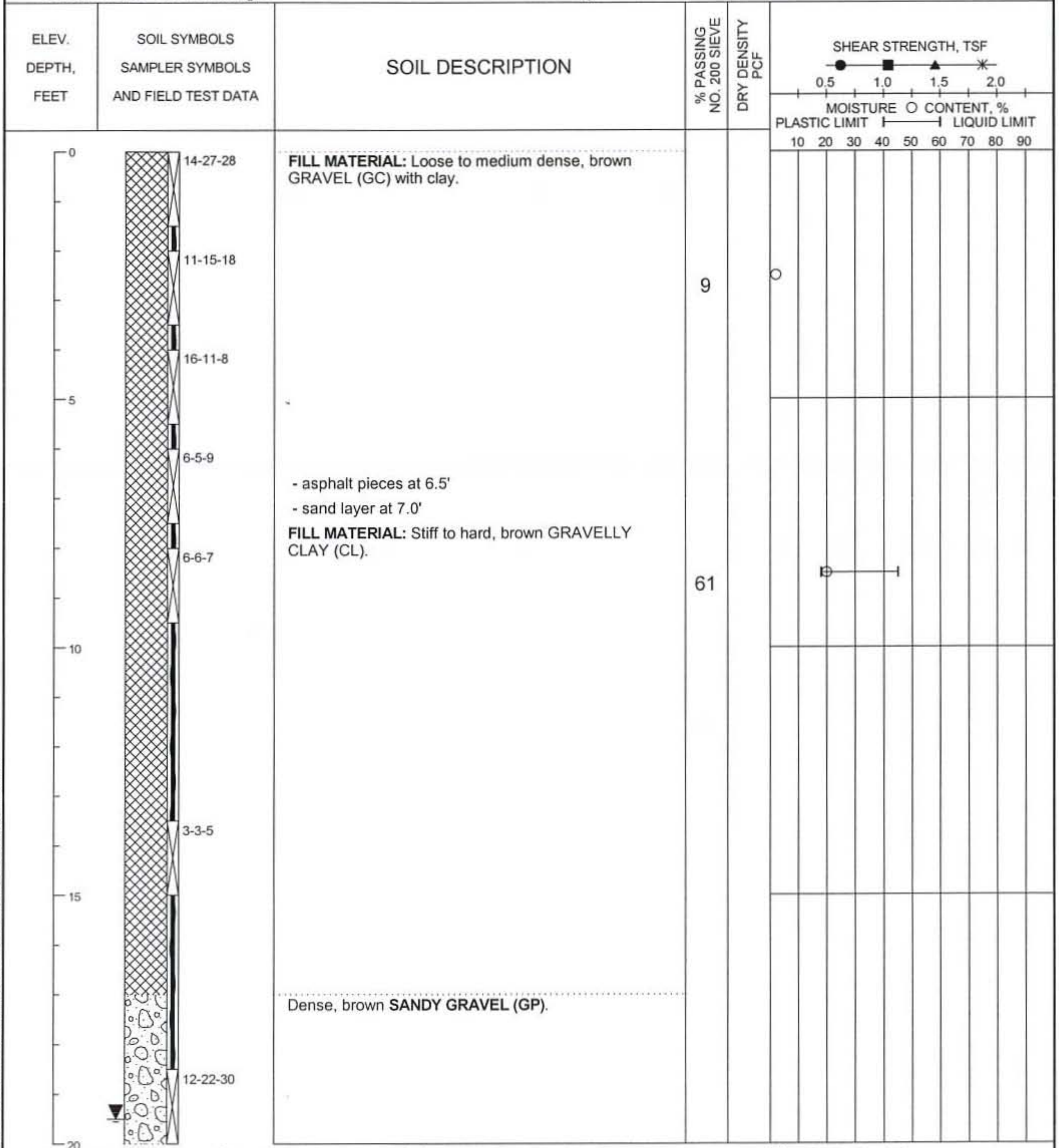
HVJ ASSOCIATES

LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-4
Groundwater during drilling: 19.5 feet
Groundwater after drilling: ---

Date: 12-13-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



FILL MATERIAL: Loose to medium dense, brown GRAVEL (GC) with clay.

- asphalt pieces at 6.5'
- sand layer at 7.0'

FILL MATERIAL: Stiff to hard, brown GRAVELLY CLAY (CL).

Dense, brown **SANDY GRAVEL (GP)**.

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

Plate 7a

HVJ ASSOCIATES

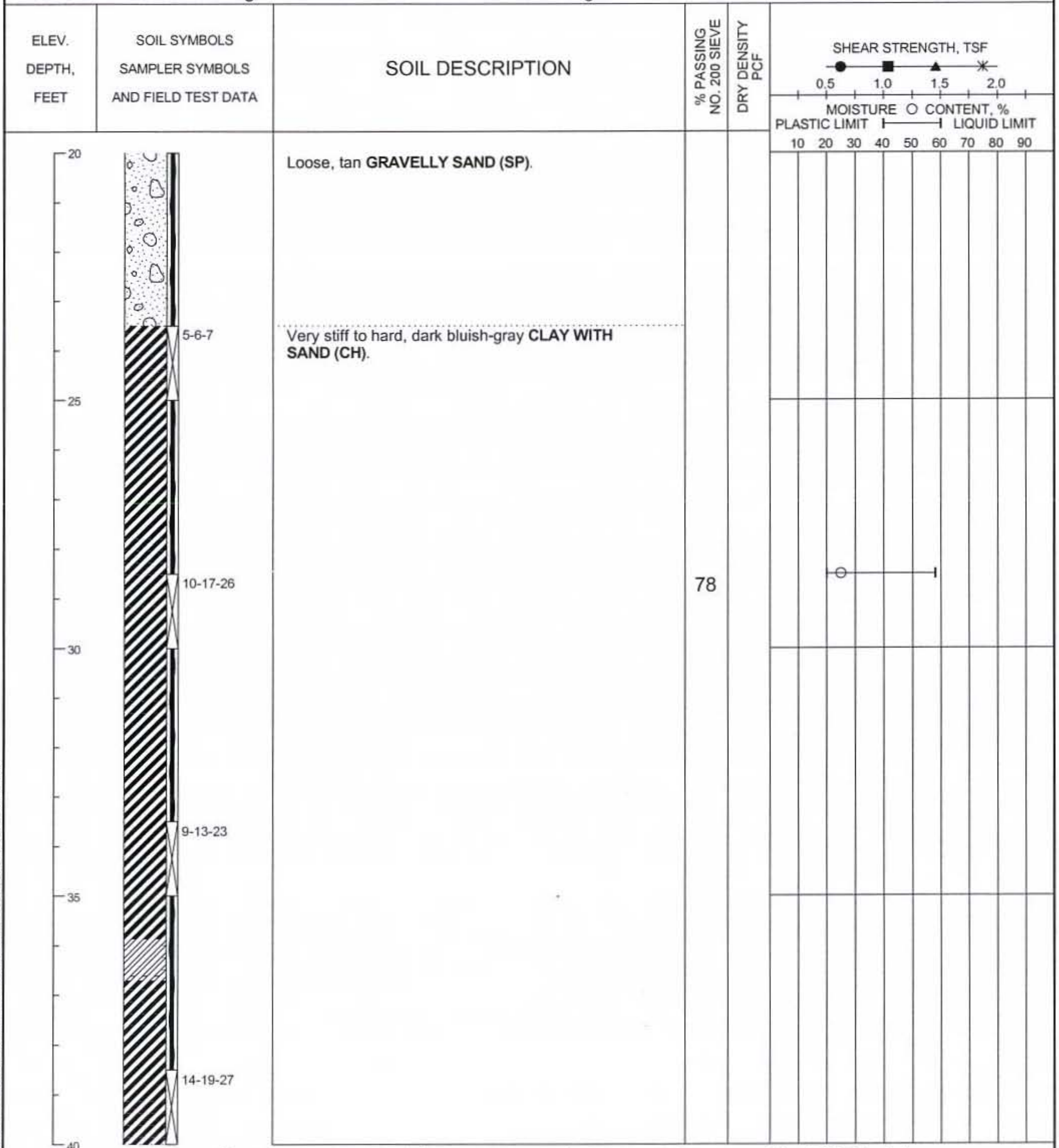
LOG OF SOIL BORING 02-155GA-0 KELLY FLOOD PROTECTION.GPJ HVJ.GDT 4/4/06

LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-4
Groundwater during drilling: 19.5 feet
Groundwater after drilling: ---

Date: 12-13-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



Loose, tan **GRAVELLY SAND (SP)**.

Very stiff to hard, dark bluish-gray **CLAY WITH SAND (CH)**.

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

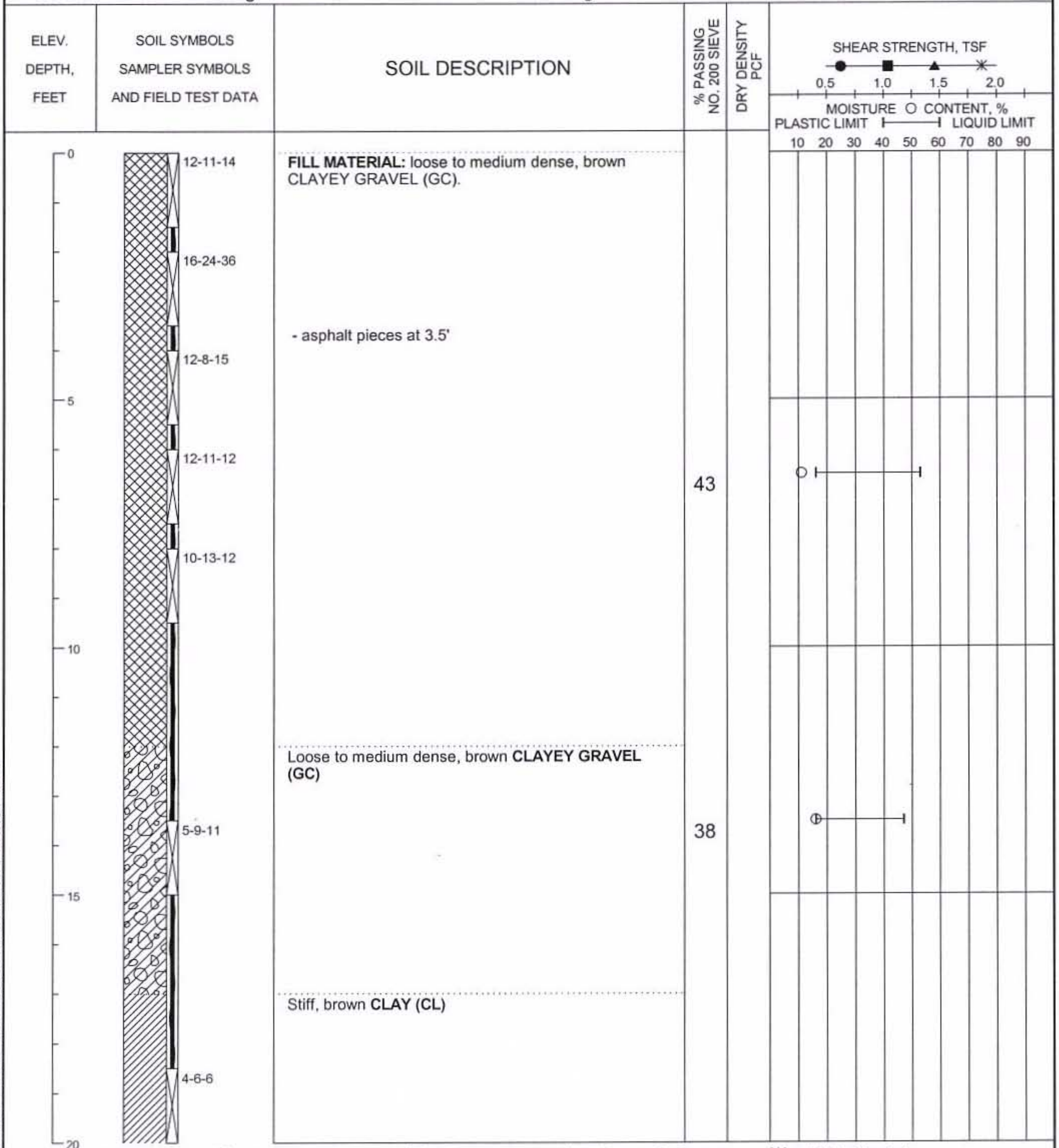
Plate 7b

LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-5
Groundwater during drilling: 22.0 feet
Groundwater after drilling: ---

Date: 12-14-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



FILL MATERIAL: loose to medium dense, brown CLAYEY GRAVEL (GC).

- asphalt pieces at 3.5'

Loose to medium dense, brown **CLAYEY GRAVEL (GC)**

Stiff, brown **CLAY (CL)**

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

Plate 8a

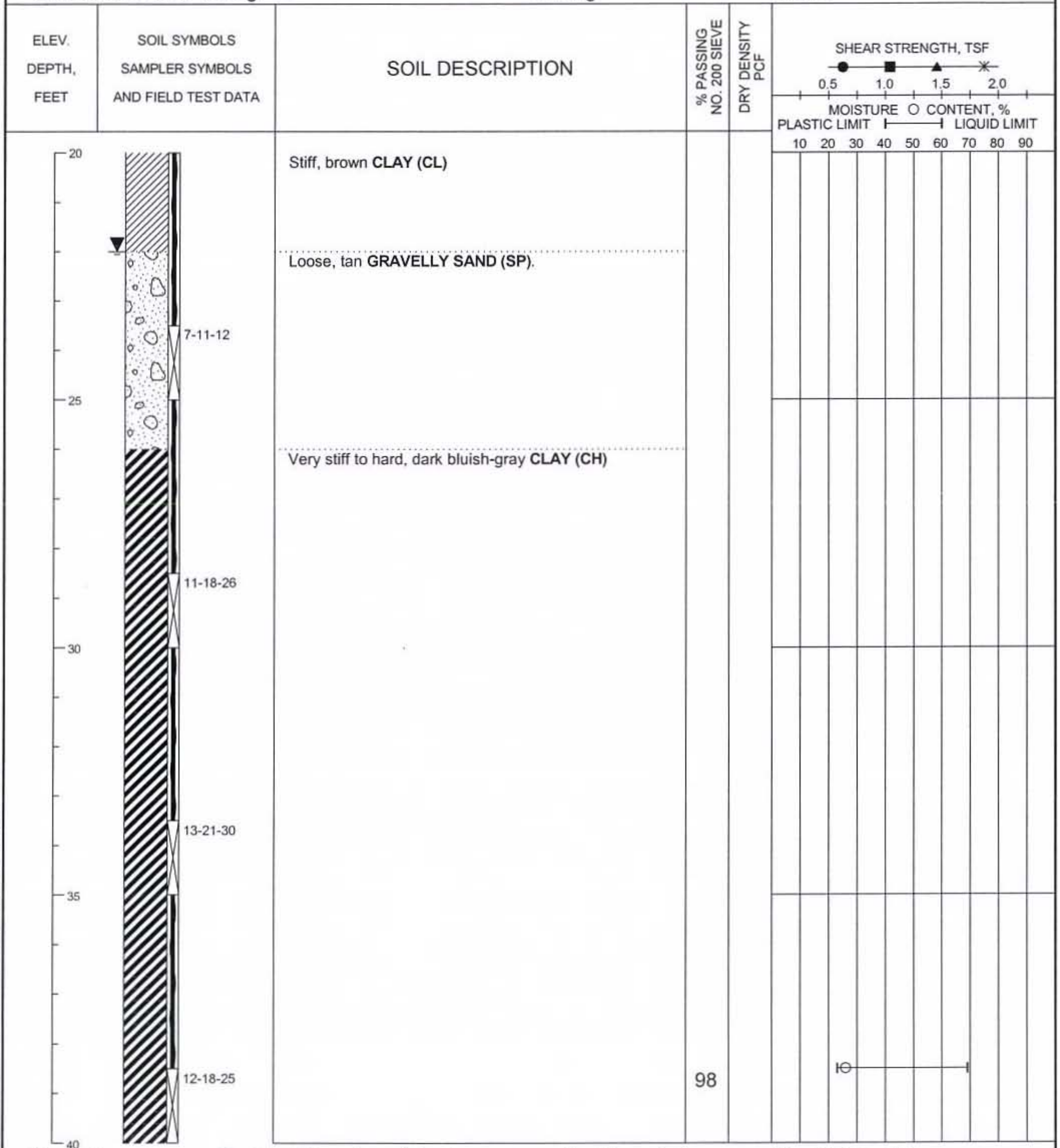
HVJ ASSOCIATES

LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-5
Groundwater during drilling: 22.0 feet
Groundwater after drilling: ---

Date: 12-14-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL DESCRIPTION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
20		Stiff, brown **CLAY (CL)**		
	▼	Loose, tan **GRAVELLY SAND (SP)**.		
	7-11-12			
25				
		Very stiff to hard, dark bluish-gray **CLAY (CH)**		
	11-18-26			
30				
	13-21-30			
35				
	12-18-25		98	
40				

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

Plate 8b

LOG OF SOIL BORING 02-155GA-0 KELLY FLOOD PROTECTION.GPJ HVJ.GDT 4/4/06

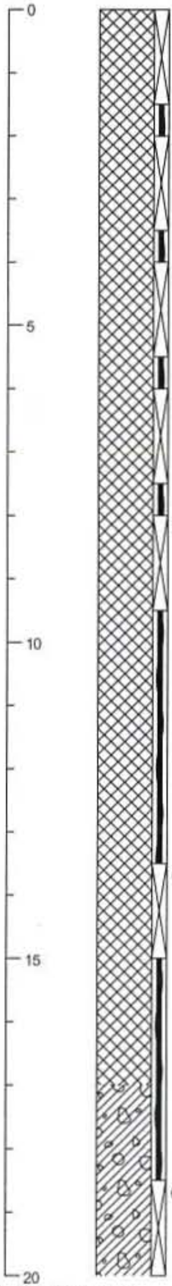
HVJ ASSOCIATES

LOG OF SOIL BORING

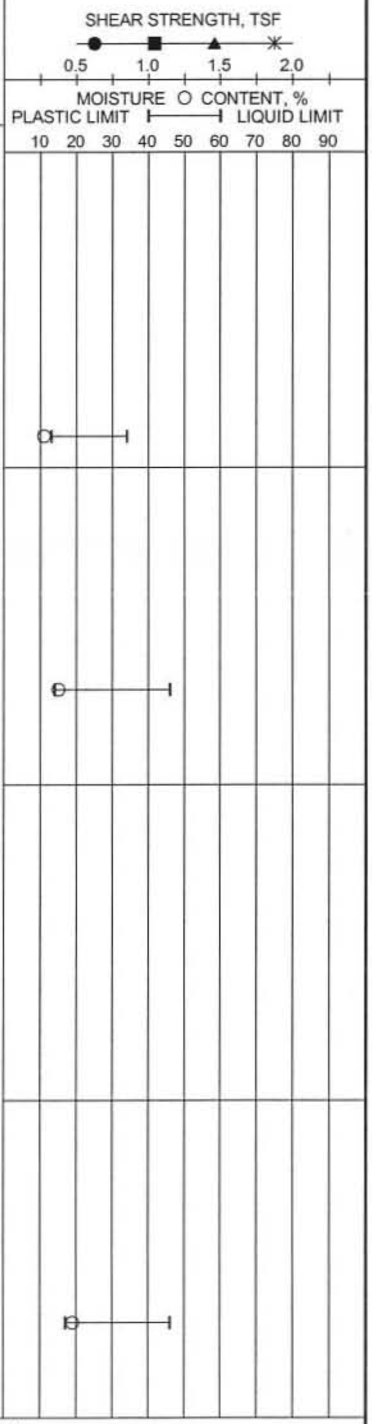
Project: Test Cell Levee Feasibility Analysis
Boring No.: B-6
Groundwater during drilling: 23.0 feet
Groundwater after drilling: ---

Date: 12-14-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL DESCRIPTION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
32-24-11	**FILL MATERIAL:** loose and medium dense, brown CLAYEY GRAVEL (GC).		
7-12-18			
14-18-20		39	
12-10-14			
	- sand seam at 7.5'		
7-9-8	**FILL MATERIAL:** stiff to hard, brown GRAVELLY CLAY (CL)	51	
6-17-11			
	- concrete pieces at 14.5'		
	Stiff to hard, brown **GRAVELLY CLAY (CL)**		
6-7-8		60	



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

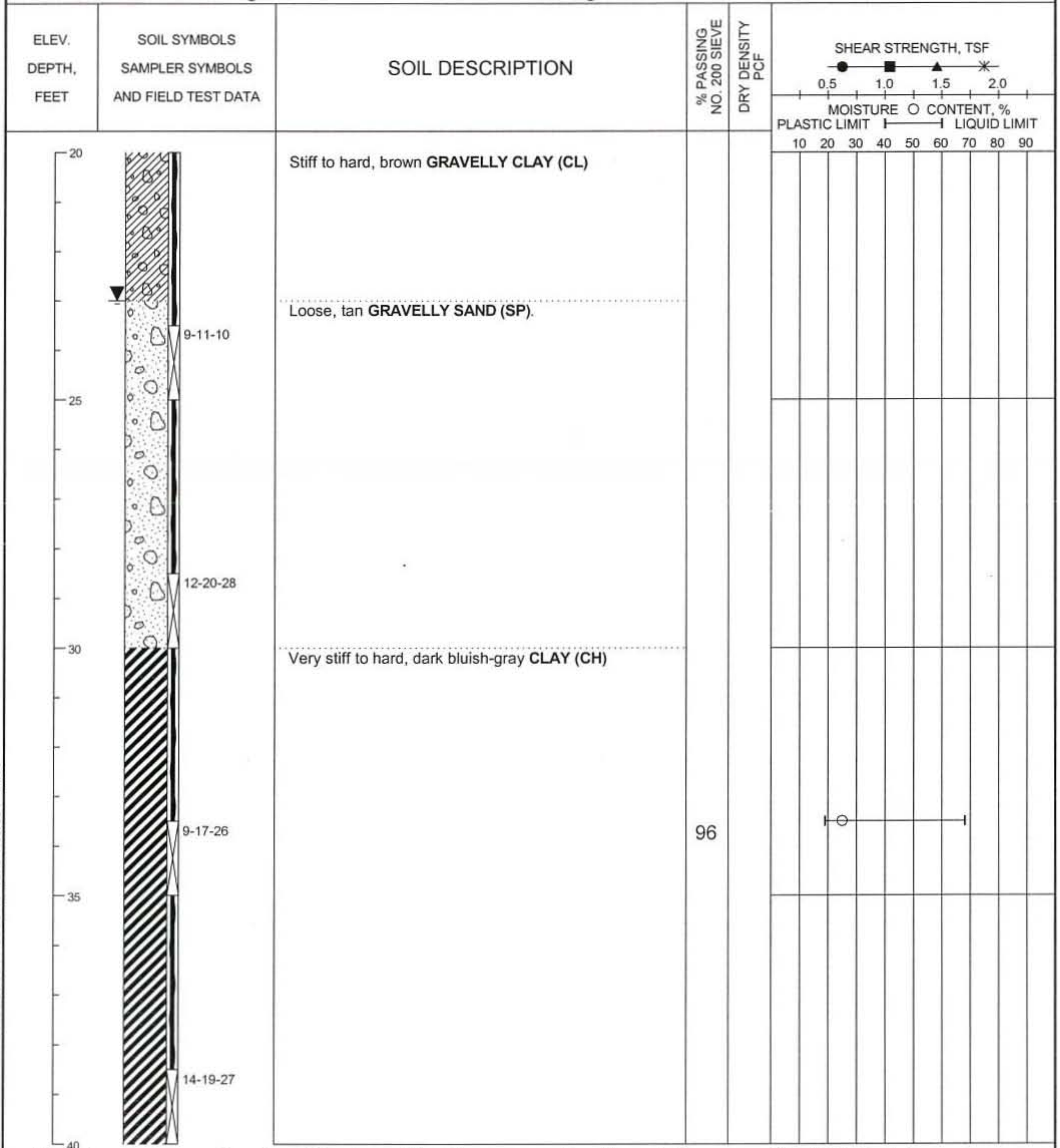
LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-6
Groundwater during drilling: 23.0 feet
Groundwater after drilling: ---

Date: 12-14-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL DESCRIPTION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
20		Stiff to hard, brown **GRAVELLY CLAY (CL)**		
	9-11-10	Loose, tan **GRAVELLY SAND (SP)**.		
	12-20-28			
30		Very stiff to hard, dark bluish-gray **CLAY (CH)**		
	9-17-26		96	
	14-19-27			



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

Plate 9b

HVJ ASSOCIATES

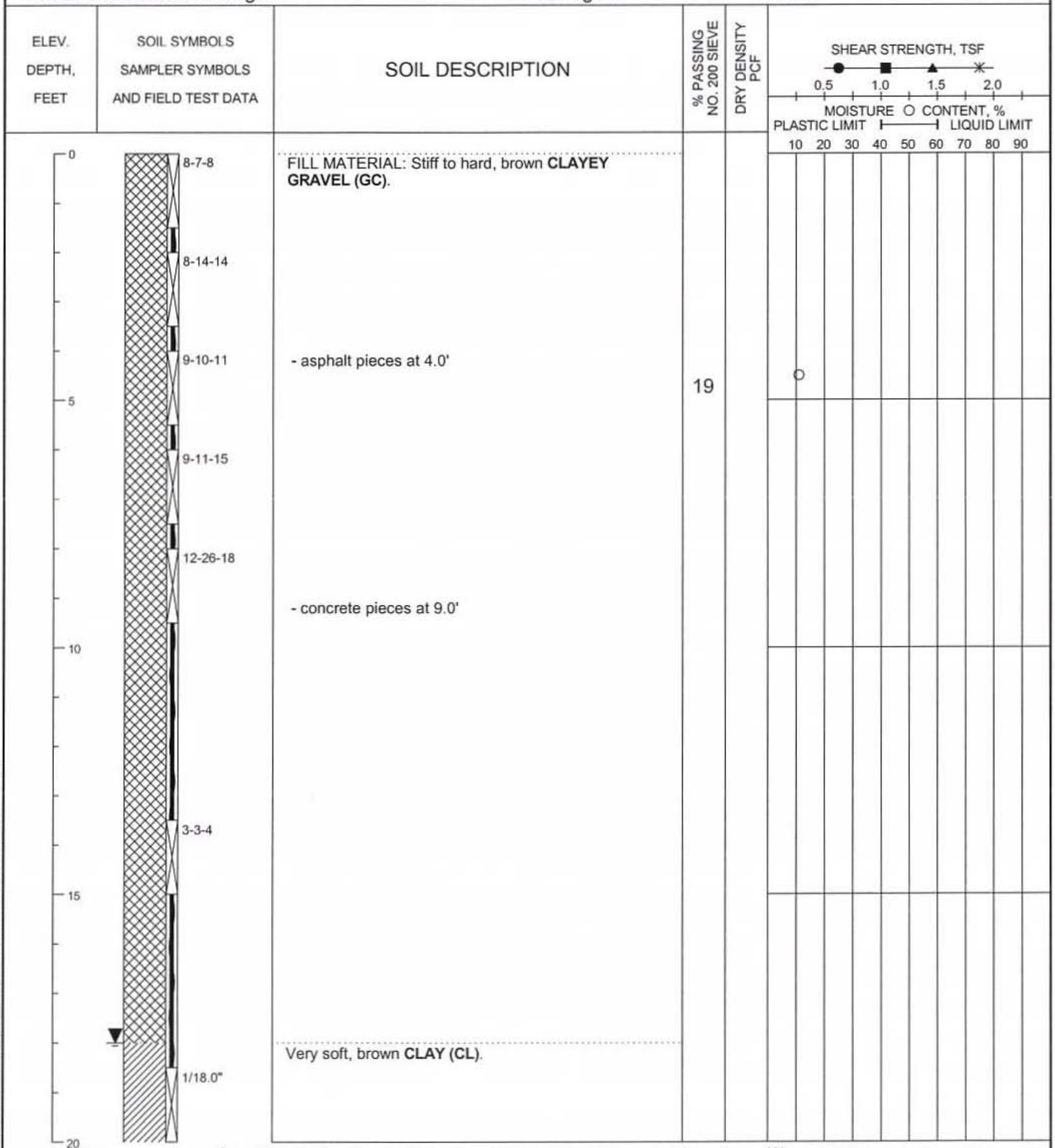
LOG OF SOIL BORING 02-155GA-0 KELLY FLOOD PROTECTION.GPJ HVJ.GDT 4/4/06

LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-7
Groundwater during drilling: 18.0 feet
Groundwater after drilling: ---

Date: 12-14-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL DESCRIPTION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
0	8-7-8	FILL MATERIAL: Stiff to hard, brown **CLAYEY GRAVEL (GC)**.		
	8-14-14			
	9-10-11	- asphalt pieces at 4.0'	19	
5	9-11-15			
	12-26-18			
		- concrete pieces at 9.0'		
10				
	3-3-4			
15				
		Very soft, brown **CLAY (CL)**.		
	1/18.0"			
20				

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

Plate 10a

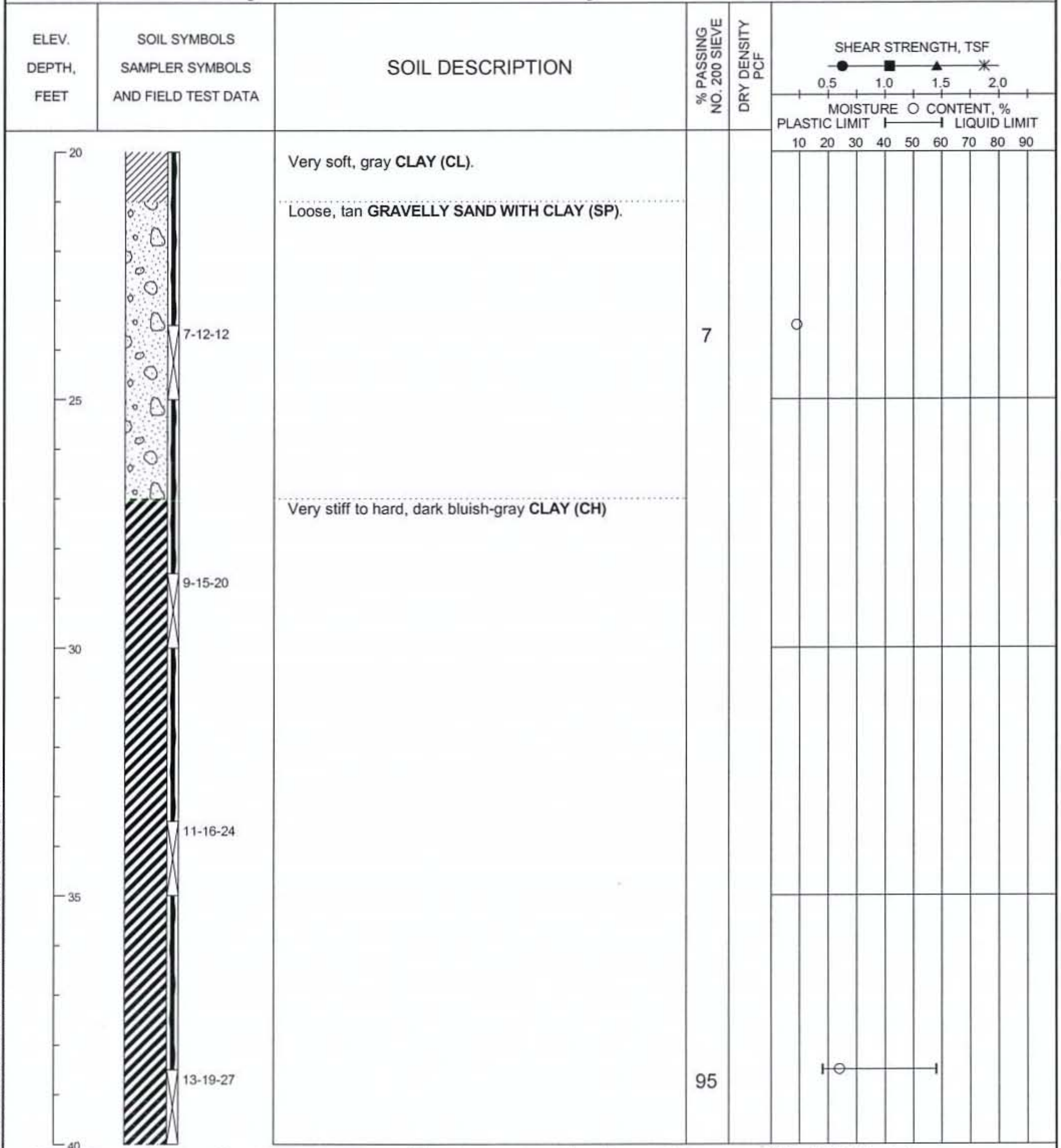
HVJ ASSOCIATES

LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-7
Groundwater during drilling: 18.0 feet
Groundwater after drilling: ---

Date: 12-14-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



Very soft, gray **CLAY (CL)**.

Loose, tan **GRAVELLY SAND WITH CLAY (SP)**.

Very stiff to hard, dark bluish-gray **CLAY (CH)**

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

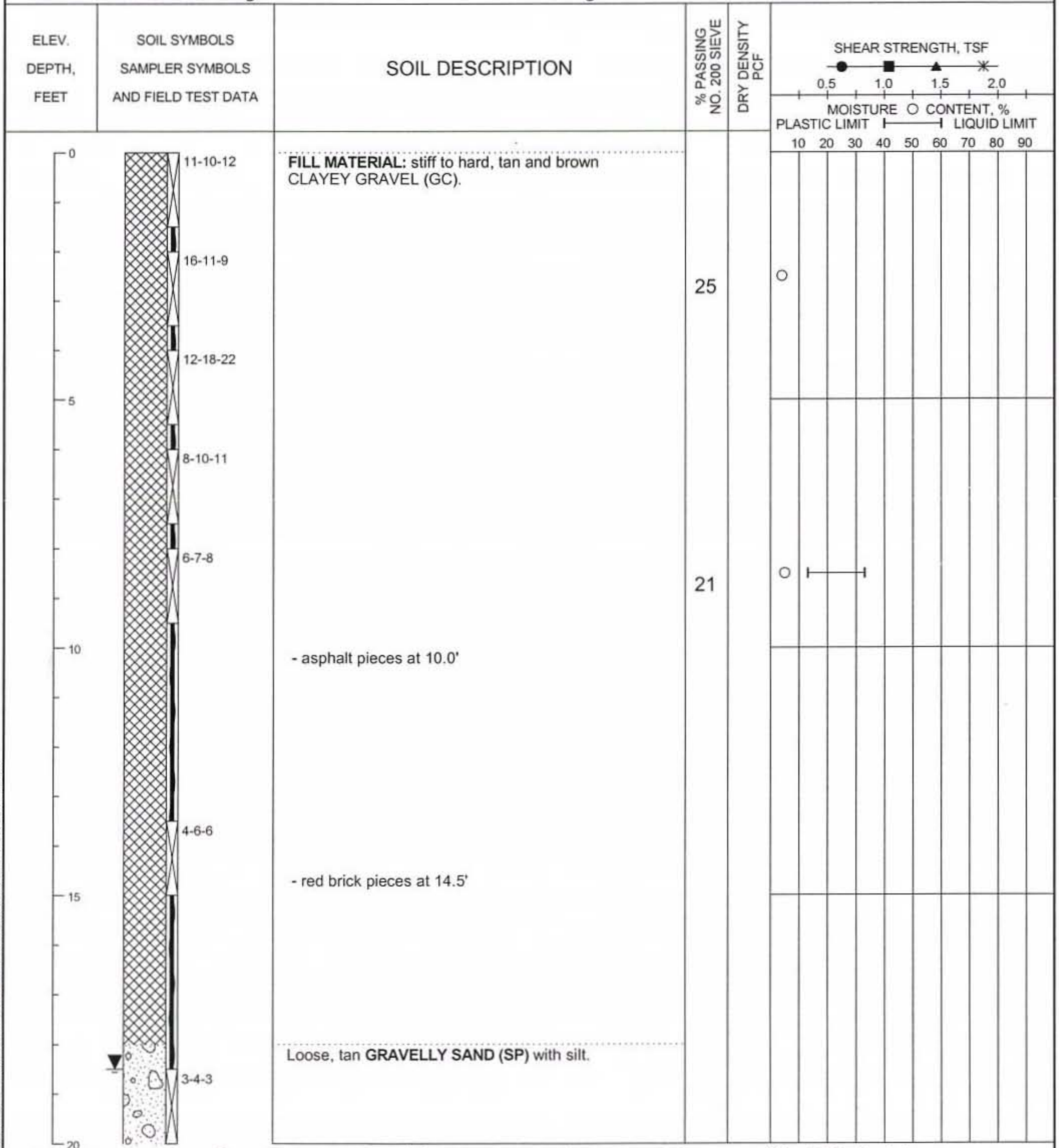
HVJ ASSOCIATES

LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-8
Groundwater during drilling: 18.5 feet
Groundwater after drilling: ---

Date: 12-15-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



FILL MATERIAL: stiff to hard, tan and brown CLAYEY GRAVEL (GC).

- asphalt pieces at 10.0'

- red brick pieces at 14.5'

Loose, tan **GRAVELLY SAND (SP)** with silt.

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

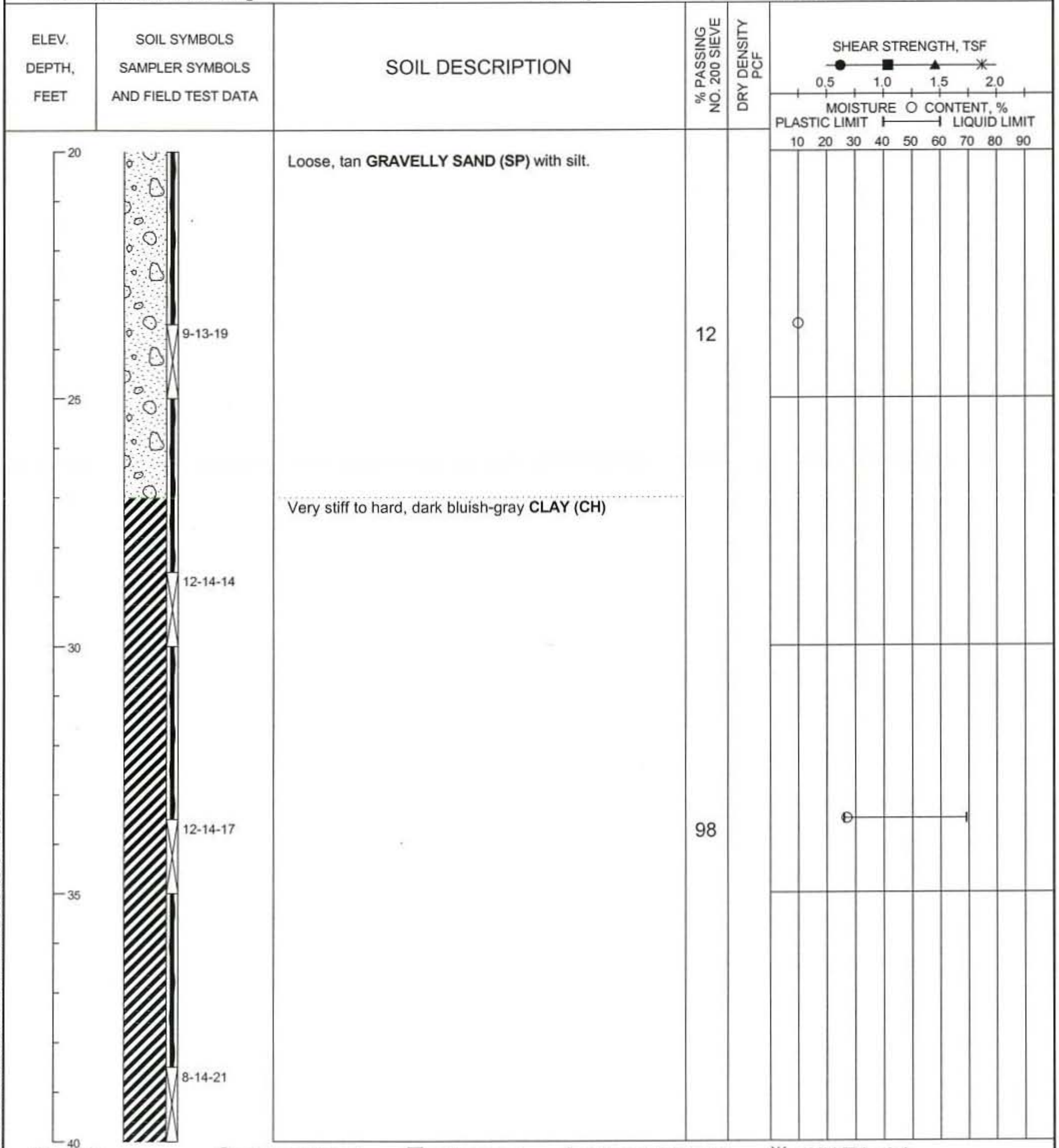
Plate 11a

LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-8
Groundwater during drilling: 18.5 feet
Groundwater after drilling: ---

Date: 12-15-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL DESCRIPTION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
	Loose, tan **GRAVELLY SAND (SP)** with silt.		
9-13-19		12	
	Very stiff to hard, dark bluish-gray **CLAY (CH)**		
12-14-14			
12-14-17		98	
8-14-21			

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

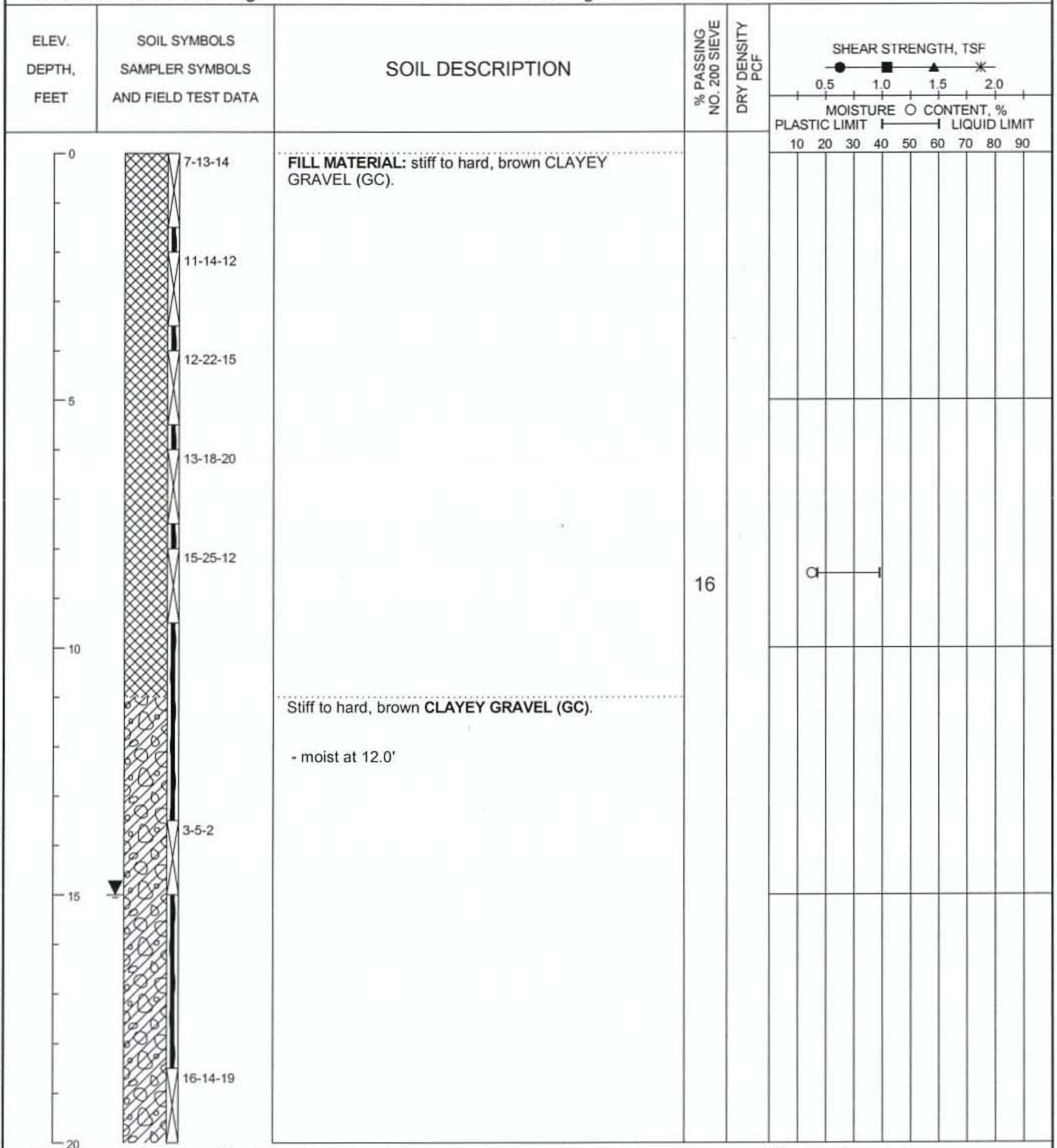
HVJ ASSOCIATES

LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-9
Groundwater during drilling: 15.0 feet
Groundwater after drilling: ---

Date: 12-15-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



FILL MATERIAL: stiff to hard, brown CLAYEY GRAVEL (GC).

Stiff to hard, brown **CLAYEY GRAVEL (GC)**.

- moist at 12.0'

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

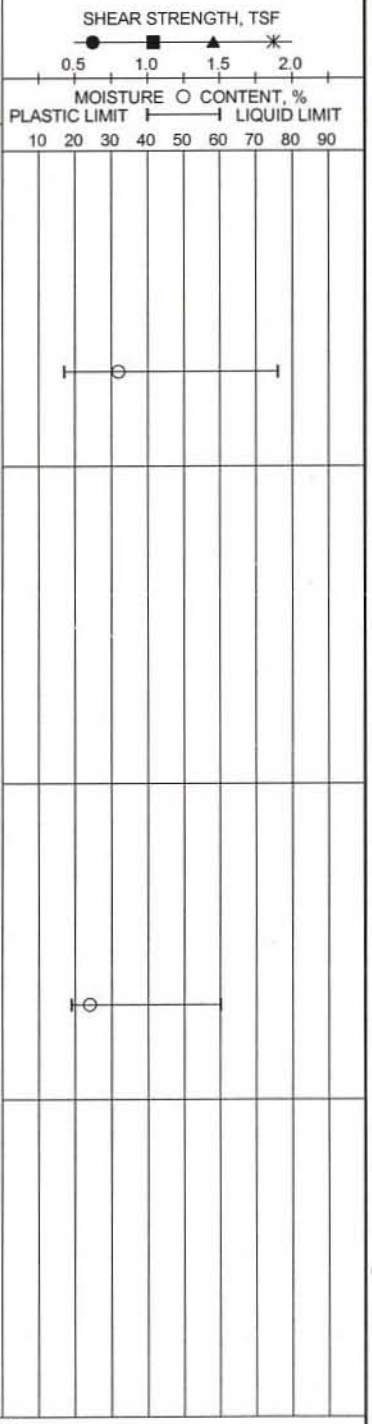
LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-9
Groundwater during drilling: 15.0 feet
Groundwater after drilling: ---

Date: 12-15-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL DESCRIPTION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
20		Stiff to hard, brown **CLAYEY GRAVEL (GC)**.		
		Stiff to hard, tan and gray **CLAY (CH)**		
	11-16-20		99	
25				
		Very stiff to hard, dark bluish-gray **CLAY (CH)**		
	14-17-25			
30				
	15-21-27		99	
35				
	13-19-21			
40				



Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

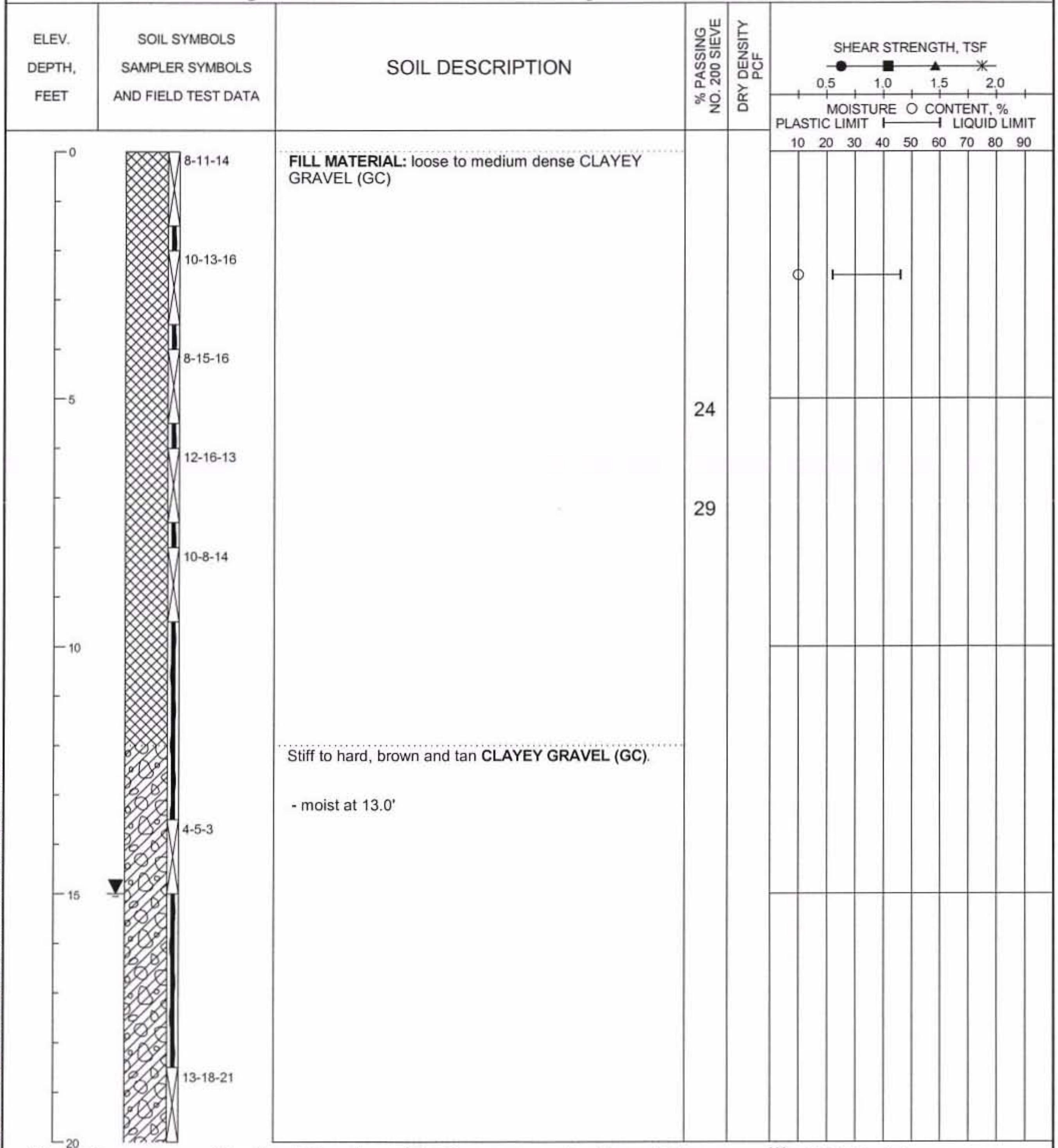
See Plate 3 for boring location.

LOG OF SOIL BORING

Project: Test Cell Levee Feasibility Analysis
Boring No.: B-10
Groundwater during drilling: 15.0 feet
Groundwater after drilling: ---

Date: 12-16-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --



FILL MATERIAL: loose to medium dense CLAYEY GRAVEL (GC)

Stiff to hard, brown and tan **CLAYEY GRAVEL (GC)**.

- moist at 13.0'

Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

Plate 13a

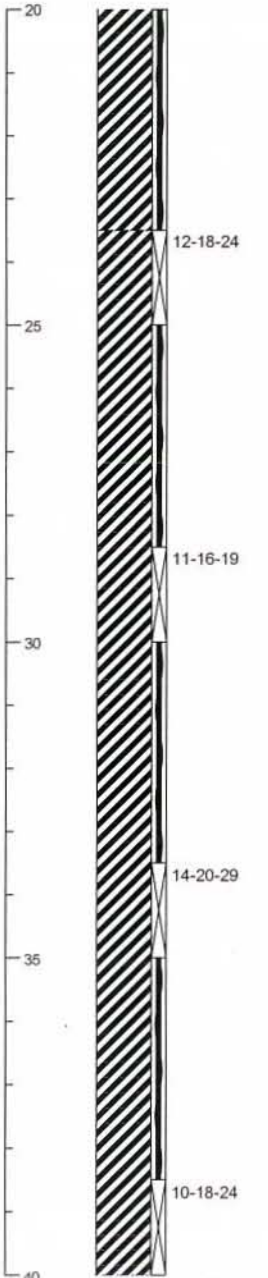
LOG OF SOIL BORING

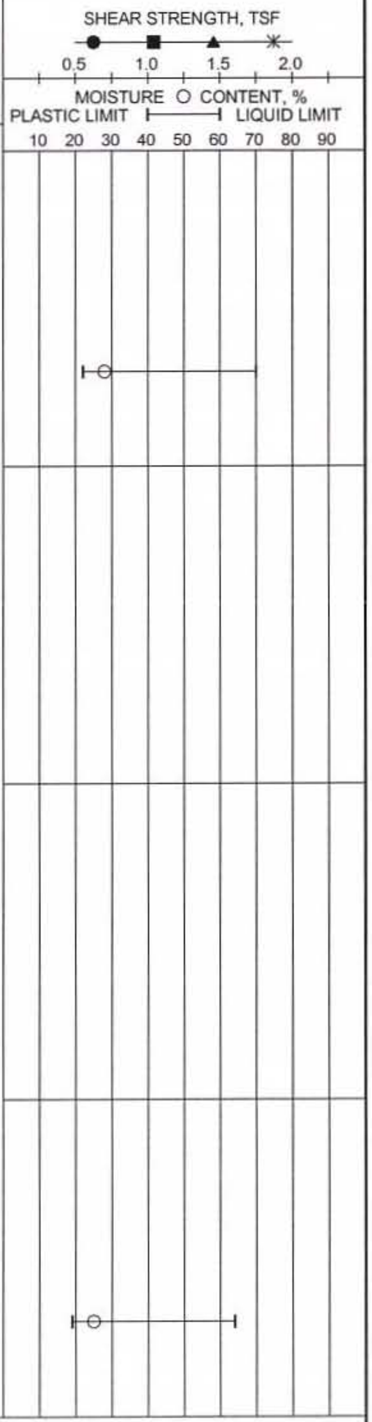
Project: Test Cell Levee Feasibility Analysis
Boring No.: B-10
Groundwater during drilling: 15.0 feet
Groundwater after drilling: ---

Date: 12-16-05
Northing: --
Easting: --

Project No.: 02-155GA-0
Elevation:
Station: --
Offset: --

ELEV. DEPTH, FEET	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	SOIL DESCRIPTION	% PASSING NO. 200 SIEVE	DRY DENSITY PCF
20		Stiff to hard, tan and gray **CLAY (CH)**		
	12-18-24	Very stiff to hard, dark bluish-gray **CLAY (CH)**	100	
25				
	11-16-19			
30				
	14-20-29			
35				
	10-18-24		99	
40				





Shear Types: ● = Hand Penet. ■ = Torvane ▲ = Unconf. Comp. ✳ = UU Triaxial

See Plate 3 for boring location.

HVJ
ASSOCIATES

ROCK TYPES

- ▦ Limestone
- ▨ Highly Weathered Limestone
- ▦ Weathered Limestone
- ▤ Shale
- ▨ Weathered Shale
- ▩ Dolomite
- ⛆ Sandstone
- ● Boulders
- ▩ Granite

SAMPLER TYPES

- ■ Thin-Walled Tube
- ☒ Standard Penetration Test
- ▤ THD Cone Penetration Test
- ◫ Rock Core
- § Auger
- ◧ Bag Sample

SOLUTION AND VOID CONDITIONS

Void	Interstice; a general term for pore space or other openings in rock.
Cavities	Small solutional concavities.
Vuggy	Containing small cavities, usually lined with a mineral of different composition from that of the surrounding rock.
Vesicular	Containing numerous small, unlined cavities, formed by expansion of gas bubbles or steam during solidification of the rock.
Porous	Containing pores, interstices, or other openings which may or may not interconnect.
Cavernous	Containing cavities or caverns, sometimes quite large. Most frequent in limestones and dolomites.

HARDNESS

Friable	Crumbles under hand pressure
Low Hardness	Can be carved with a knife
Moderately Hard	Can be scratched easily with a knife
Very Hard	Cannot be scratched with a knife

WEATHERING GRADES OF ROCKMASS$^{(1)}$

Slightly	Discoloration indicates weathering of rock material and discontinuity surfaces.
Moderately	Less than half of the rock material is decomposed or disintegrated to a soil.
Highly	More than half of the rock material is decomposed or disintegrated to a soil.
Completely	All rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	All rock material is converted to soil. The mass structure and material fabric are destroyed.

JOINT DESCRIPTION

SPACING

Very Close	<2"
Close	2"-12"
Medium Close	12"-3'
Wide	>3'

INCLINATION

Horizontal	0-5
Shallow	5-35
Moderate	35-65
Steep	65-85
Vertical	85-90

SURFACES

Slickensided	Polished, grooved
Smooth	Planar
Irregular	Undulating or granular
Rough	Jagged or pitted

REFERENCES:

(1) British Standard (1981) Code of Practice for Site Investigation, BS 5930.

(2) The Bridge Div., Tx. Highway Dept. Foundation Exploration & Design Manual, 2nd Division, revised June, 1974.

BEDDING THICKNESS$^{(2)}$

Very Thick	>4'
Thick	2'-4'
Thin	2"-2'
Very Thin	1/2"-2"
Laminated	0.08"-1/2"
Thinly Laminated	<0.08"

Information on each boring log is a compilation of subsurface conditions and soil and rock classifications obtained from the field as well as from laboratory testing of samples. Strata have been interpreted by commonly accepted procedures. The stratum lines on the logs may be transitional and approximate in nature. Water level measurements refer only to those observed at the times and places indicated, and may vary with time, geologic condition or construction activity.

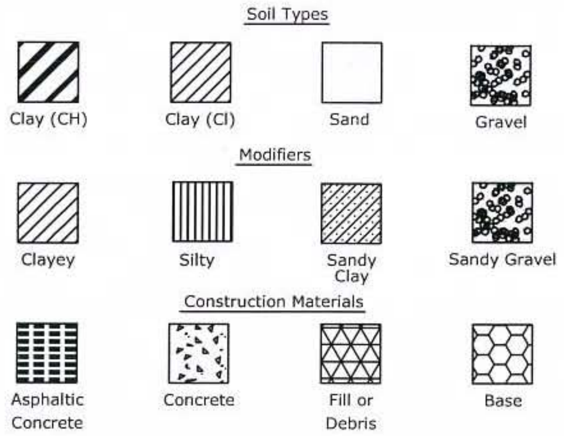
HVJ ASSOCIATES

PROJECT NO.: 02-155GA-0

DRAWING NO.: PLATE 14B

KEY TO TERMS AND SYMBOLS
USED ON BORING LOGS FOR ROCK

SOIL SYMBOLS



SAMPLER TYPES

■	Thin Walled Shelby Tube	⍁	No Recovery
☒	Split Barrel	≀	Auger
◧	Liner Tube	⧗	Jar Sample

WATER LEVEL SYMBOLS

▽	Groundwater level determined during drilling operations
▼	Groundwater level after drilling in open borehole or piezometer

SOIL GRAIN SIZE

Classification	Particle Size	Particle Size or Sieve No. (U.S. Standard)
Clay	< 0.002 mm	< 0.002 mm
Silt	0.002 - 0.075 mm	0.002 mm - #200 sieve
Sand	0.075 - 4.75 mm	#200 sieve - #4 sieve
Gravel	4.75 - 75 mm	#4 sieve - 3 in.
Cobble	75 - 200 mm	3 in. - 8 in.
Boulder	> 200 mm	> 8 in.

DENSITY OF COHESIONLESS SOILS

Descriptive Term	Penetration Resistance "N" * Blows/Foot
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

CONSISTENCY OF COHESIVE SOILS

Consistency	Undrained Shear Strength (tsf)
Very Soft	0 - 0.125
Soft	0.125 - 0.25
Firm	0.25 - 0.5
Stiff	0.5 - 1.0
Very Stiff	1.0 - 2.0
Hard	> 2.0

PENETRATION RESISTANCE

3/6	Blows required to penetrate each of three consecutive 6-inch increments per ASTM D-1586 *
50/4"	If more than 50 blows are required, driving is discontinued and penetration at 50 blows is noted
0/18"	Sampler penetrated full depth under weight of drill rods and hammer

* The N value is taken as the blows required to penetrate the final 12 inches

TERMS DESCRIBING SOIL STRUCTURE

Slickensided	Fracture planes appear polished or glossy, sometimes striated
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Inclusion	Small pockets of different soils, such as small lenses of sand scattered through a mass of clay
Parting	Inclusion less than 1/4 inch thick extending through the sample
Seam	Inclusion 1/4 inch to 3 inches thick extending through the sample
Layer	Inclusion greater than 3 inches thick extending through the sample
Laminated	Soil sample composed of alternating partings of different soil type
Stratified	Soil sample composed of alternating seams or layers of different soil type
Intermixed	Soil sample composed of pockets of different soil type and laminated or stratified structure is not evident
Calcareous	Having appreciable quantities of calcium carbonate
Ferrous	Having appreciable quantities of iron
Nodule	A small mass of irregular shape

HVJ ASSOCIATES

PROJECT NO.: 02-155GA-0

DRAWING NO.: PLATE 14A

KEY TO TERMS AND SYMBOLS
USED ON BORING LOGS FOR SOIL

LABORATORY TEST RESULTS SUMMARY

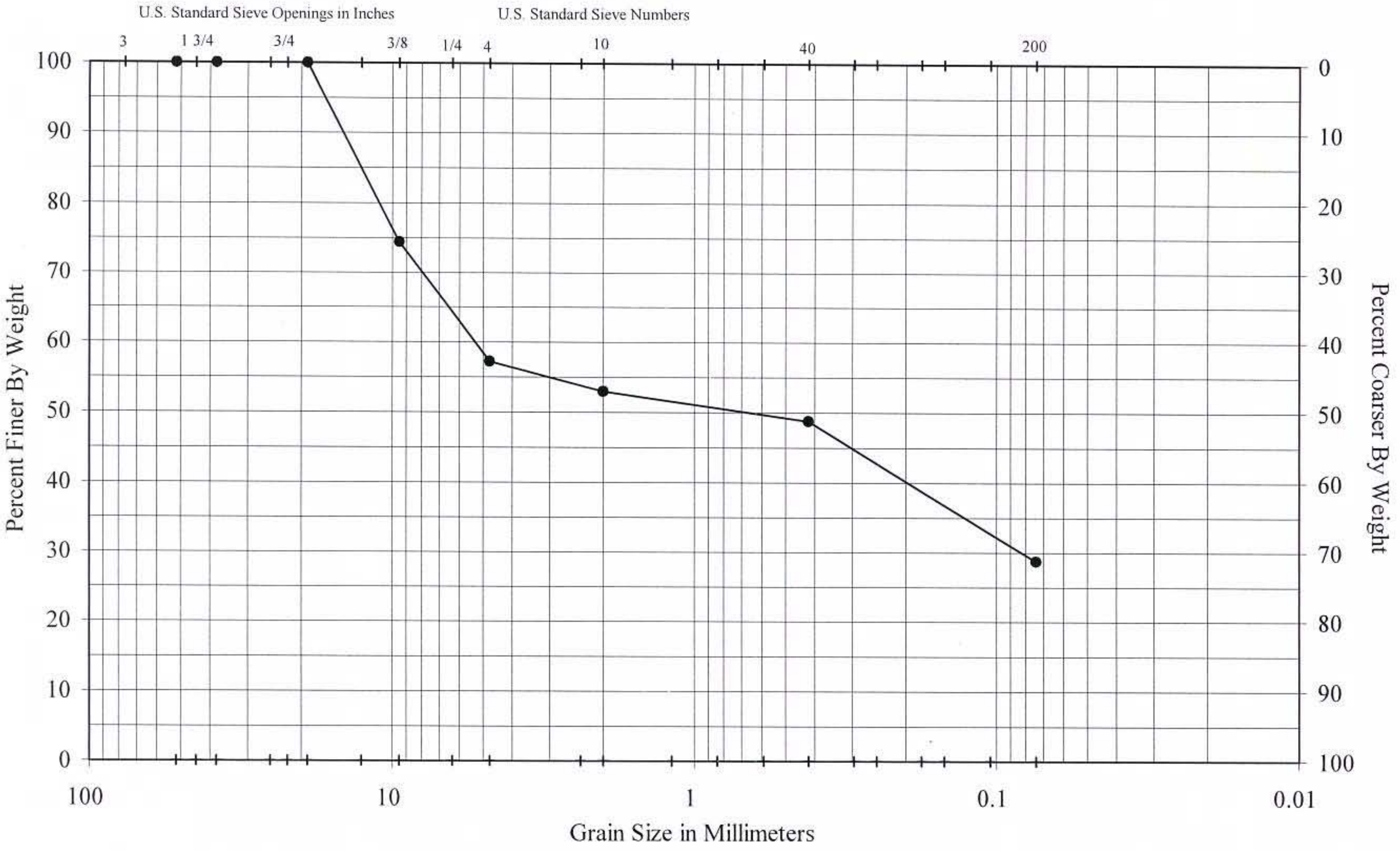
LABORATORY TEST RESULTS SUMMARY
Test Cell Levee Feasibility Analysis
02-155GA-0

Boring No.	Depth (ft)	% Passing No. 200 Sieve	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Wet Unit Wt. (pcf)	Dry Unit Wt. (pcf)	Strength Test	Compressive Strength (tsf)	Hand Penetrometer Reading (tsf)
B-1										
	1.0		43	26						
	4.5	35.0								
	15.0	57.1	31	16	25.0					
	30.0	98.9			19.1					
B-2										
	6.0	67.0	41	17	22.1					
	8.0				8.2	121.5	112.3	UC	1.0	
	10.0	21.0	36	20	8.2					
	30.0	84.1	49	31	1.6					
B-3										
	4.5	1.6			1.3					
	18.0	80.6	45	21	30.5					
	33.5	86.2	36	20	16.3					
B-4										
	2.5	8.6			1.8					
	8.5	61.2	45	27	19.6					
	28.5	77.9	58	38	24.8					
B-5										
	6.5	43.3	53	37	11.2					
	13.5	38.4	47	31	16.5					
	38.5	98.3	69	46	25.6					
B-6										
	4.5	39.4	34	21	10.9					
	8.5	50.9	46	27	15.0					
	18.5	59.8	46	29	18.6					
	33.5	96.4	68	49	29.8					
B-7										
	4.5	19.4			10.5					
	23.5	7.0			8.6					
	38.5	94.6	58	40	24.1					
B-8										
	2.5	25.2			4.3					
	8.5	21.1	33	20	4.8					
	23.5	11.7			10.0					
	33.5	98.4	69	43	27.1					

LABORATORY TEST RESULTS SUMMARY
Test Cell Levee Feasibility Analysis
02-155GA-0

Boring No.	Depth (ft)	% Passing No. 200 Sieve	Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Wet Unit Wt. (pcf)	Dry Unit Wt. (pcf)	Strength Test	Compressive Strength (tsf)	Hand Penetrometer Reading (tsf)
B-9										
	8.5	16.0	39	22	19.8					
	23.5	99.4	76	60	32.0					
	33.5	98.5	60	41	23.5					
B-10										
	2.5		46	24	9.9					
	4.5	24.0								
	6.5	29.0								
	23.5	99.6	69	47	27.7					
	38.5	99.0	64	45	25.0					

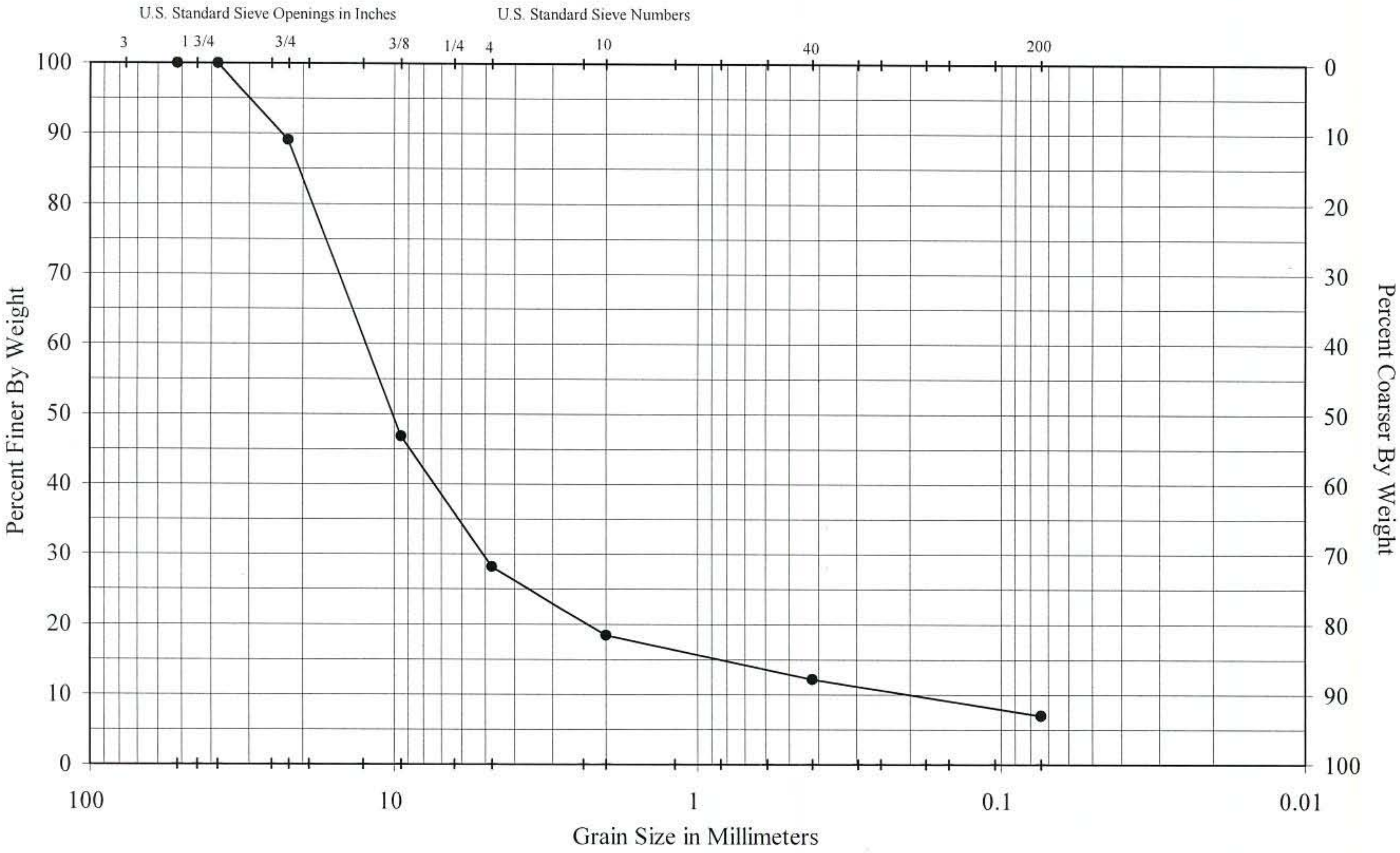
GRAIN SIZE ANALYSES



Sample No.
B-10
6.5'

Test Cell Levee Feasibility Analysis
Gradation Analysis
San Antonio, Texas

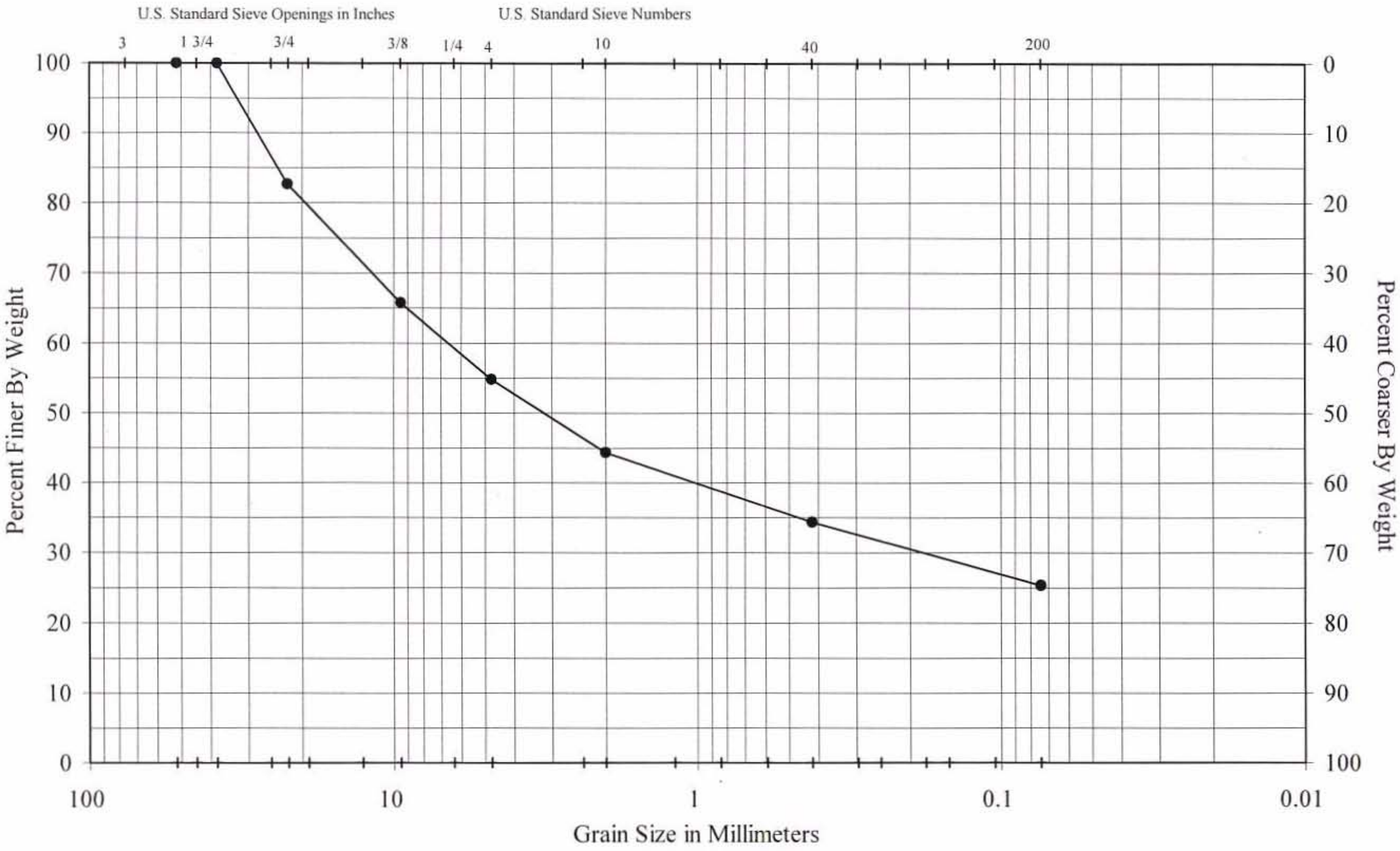
HVJ Project No. 02-155GA-0



Sample No.
B-7
23.5' - 25.0'

Test Cell Levee Feasibility Analysis
Gradation Analysis
San Antonio, Texas

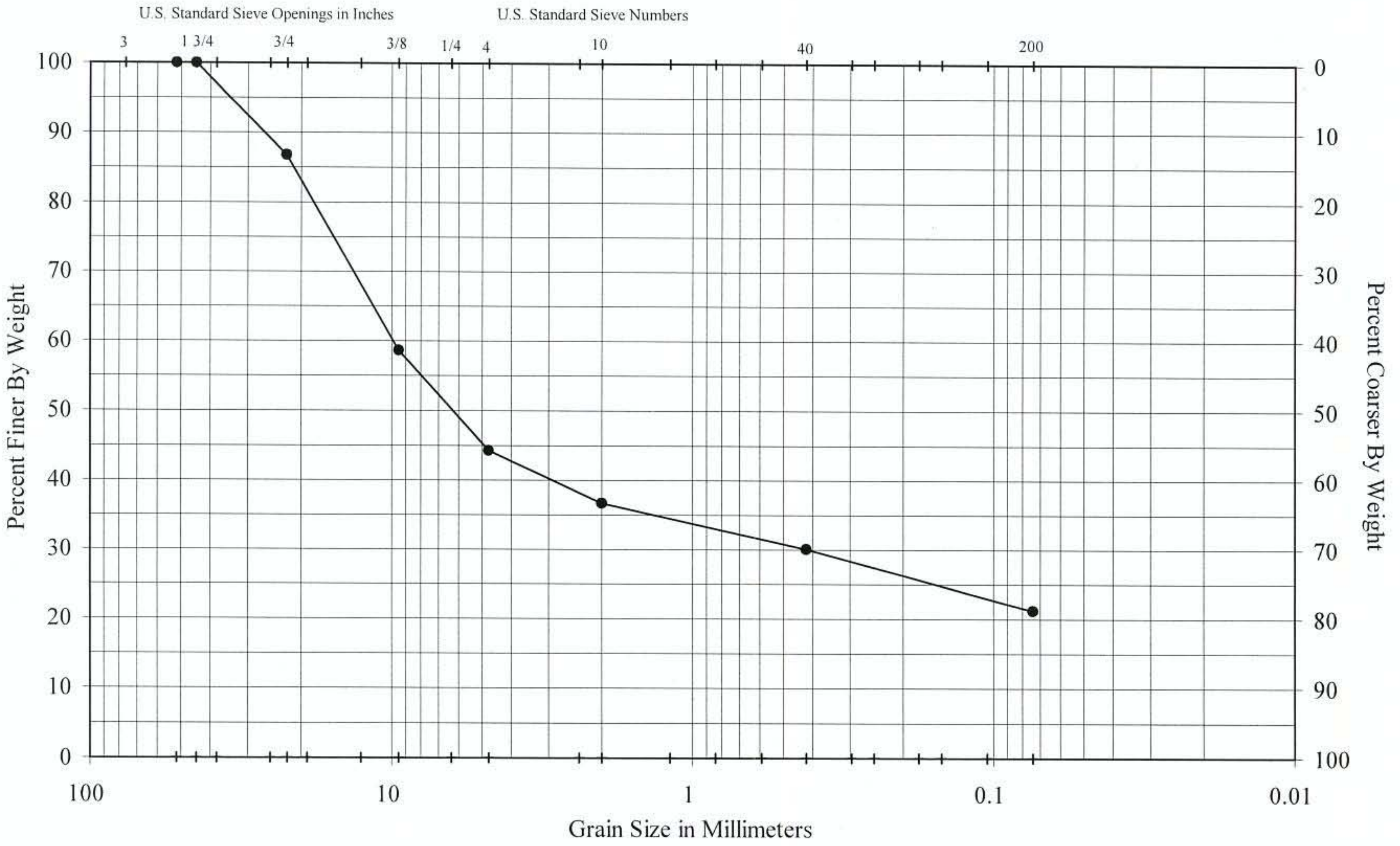
HVJ Project No. 02-155GA-0



Sample No.
B-8
2.5' - 4.0'

Test Cell Levee Feasibility Analysis
Gradation Analysis
San Antonio, Texas

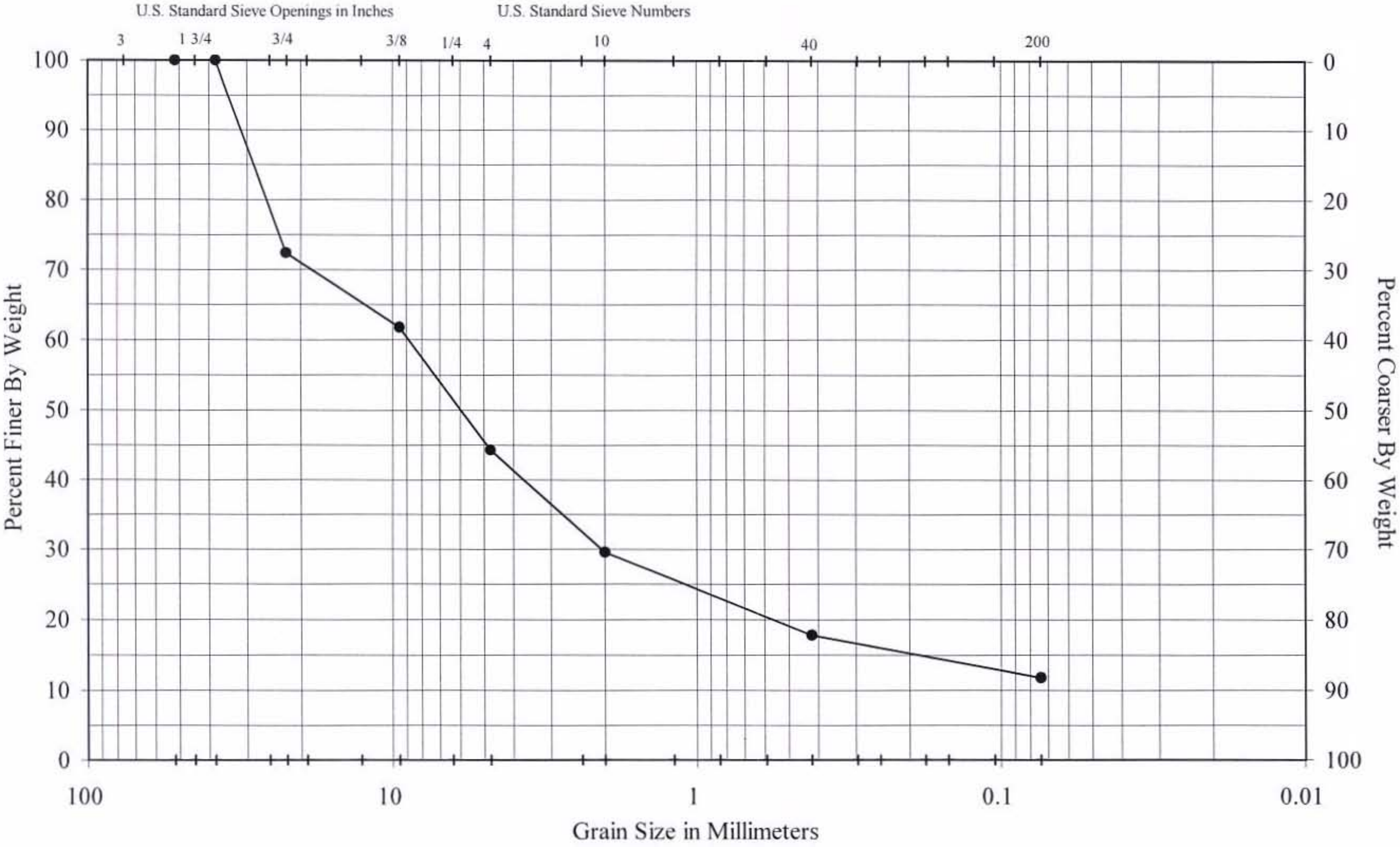
HVJ Project No. 02-155GA-0



Sample No.
B-8
8.5' - 10.0'

Test Cell Levee Feasibility Analysis
Gradation Analysis
San Antonio, Texas

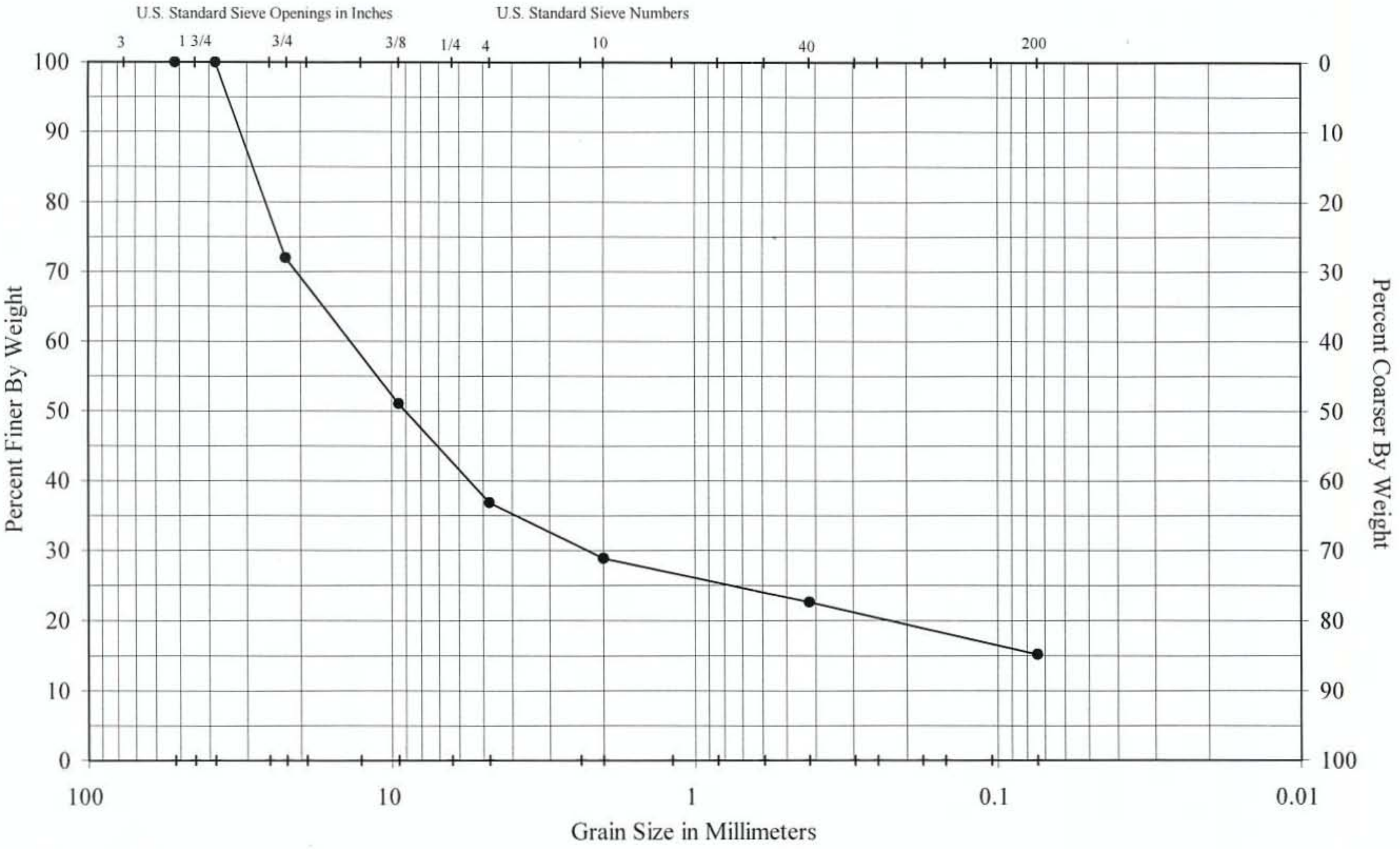
HVJ Project No. 02-155GA-0



Sample No.
B-8
23.5' - 25.0'

Test Cell Levee Feasibility Analysis
Gradation Analysis
San Antonio, Texas

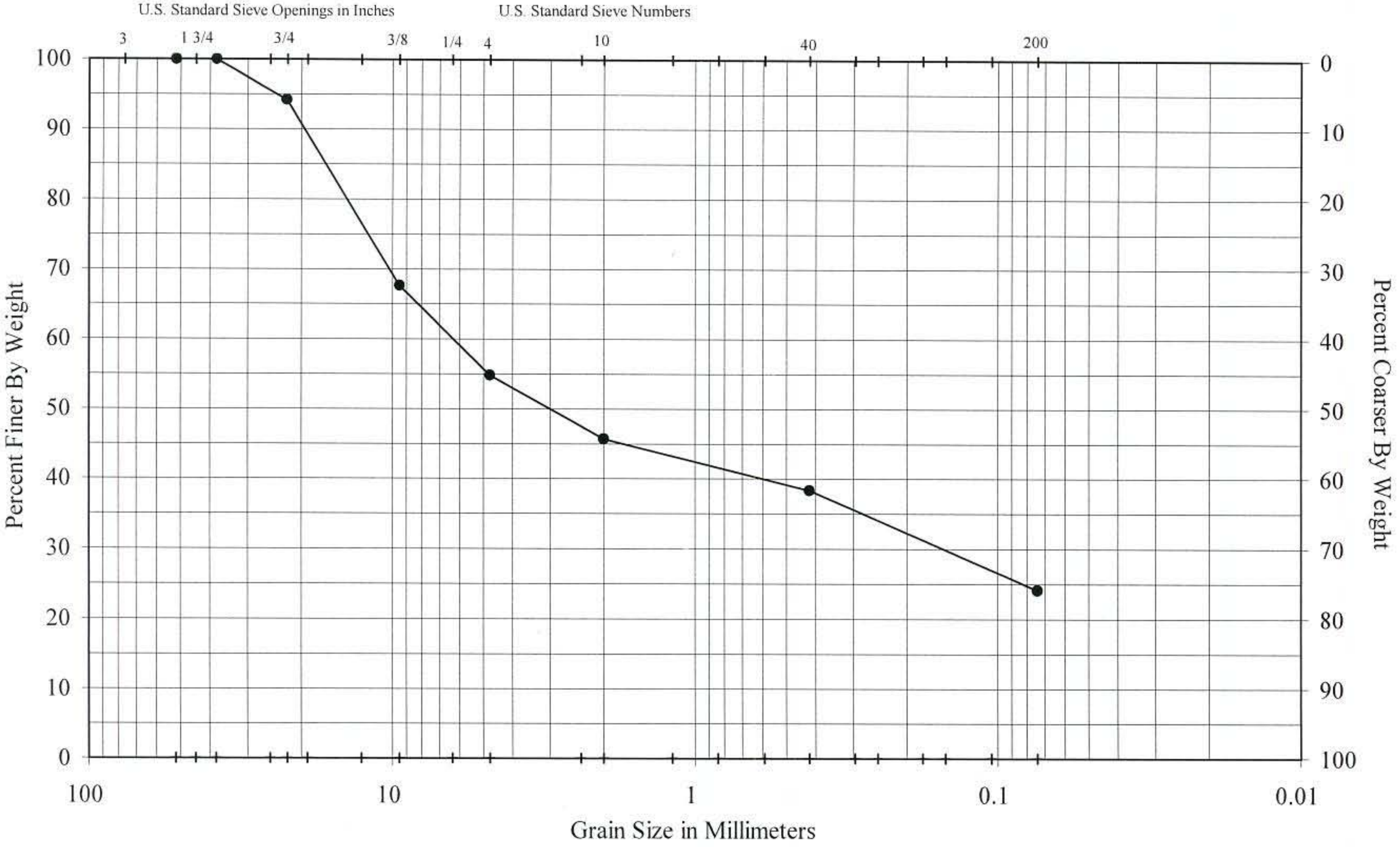
HVJ Project No. 02-155GA-0



Sample No.
B-9
6.5' - 8.0'

Test Cell Levee Feasibility Analysis
Gradation Analysis
San Antonio, Texas

HVJ Project No. 02-155GA-0



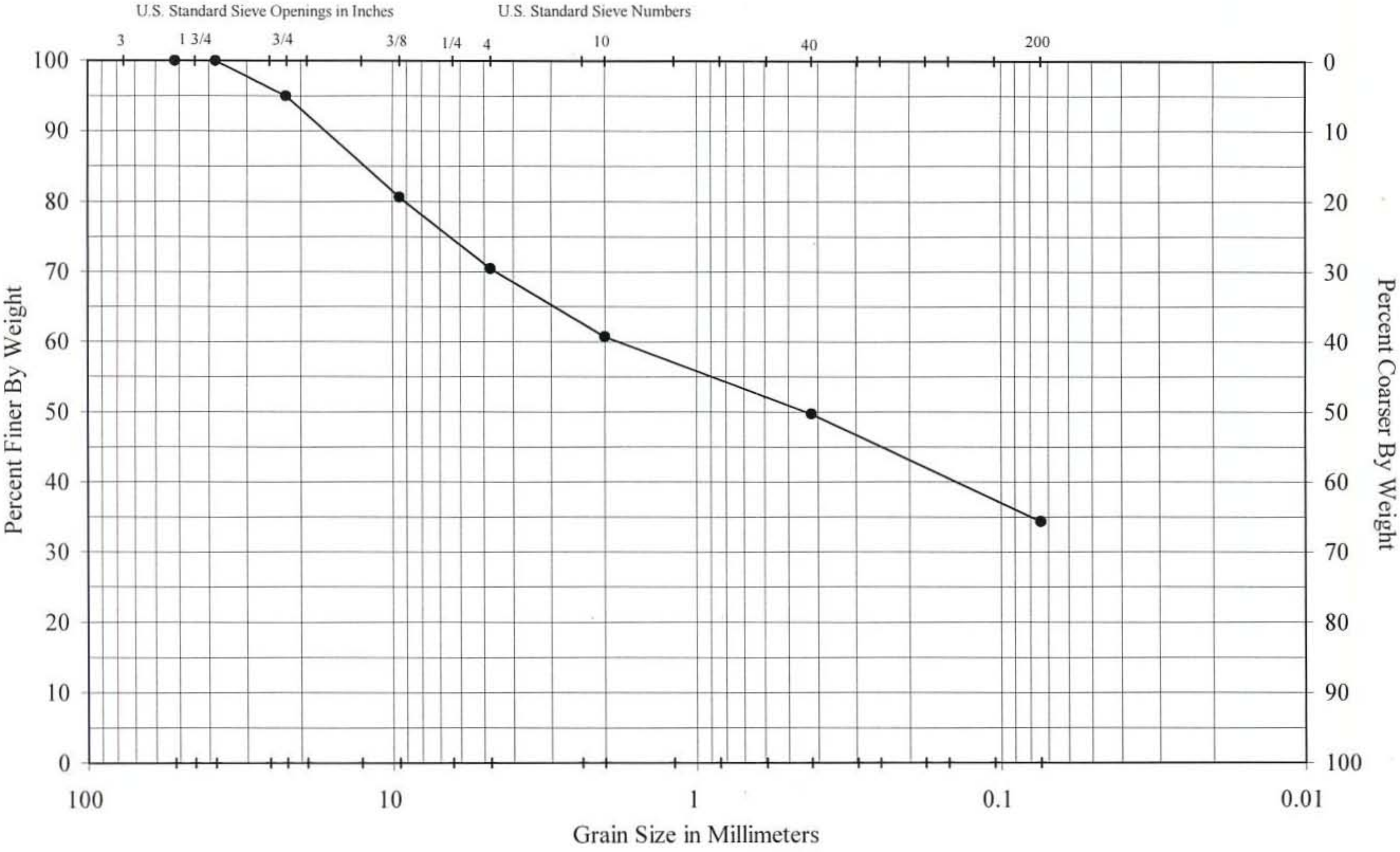
Sample No.

B-10

4.5' - 6.0'

Test Cell Levee Feasibility Analysis
Gradation Analysis
San Antonio, Texas

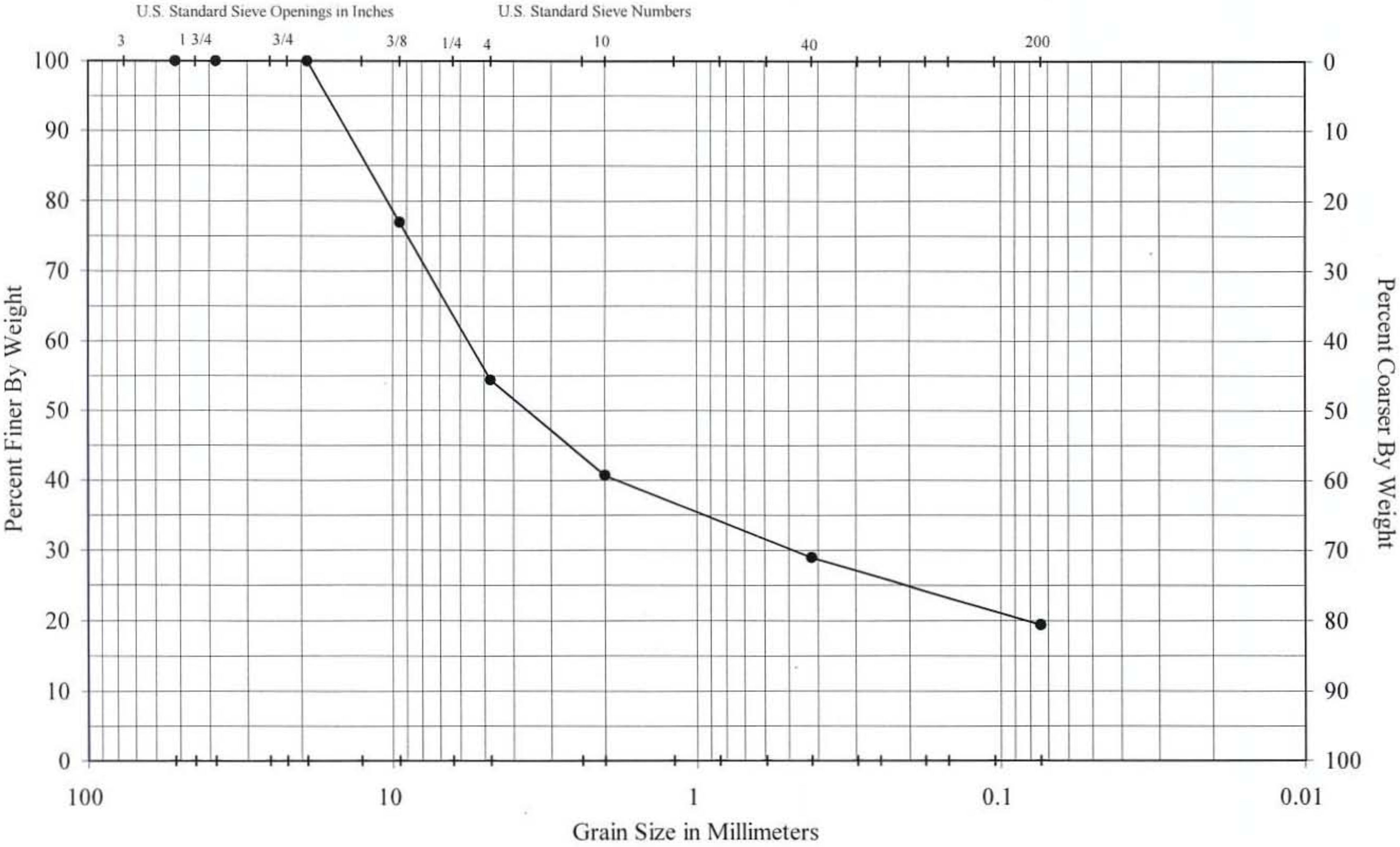
HVJ Project No. 02-155GA-0



Sample No.
B-1
4.0'

Test Cell Levee Feasibility Analysis
Gradation Analysis
San Antonio, Texas

HVJ Project No. 02-155GA-0



<u>Sample No.</u>
B-7
4.5'

Test Cell Levee Feasibility Analysis
Gradation Analysis
San Antonio, Texas

HVJ Project No. 02-155GA-0

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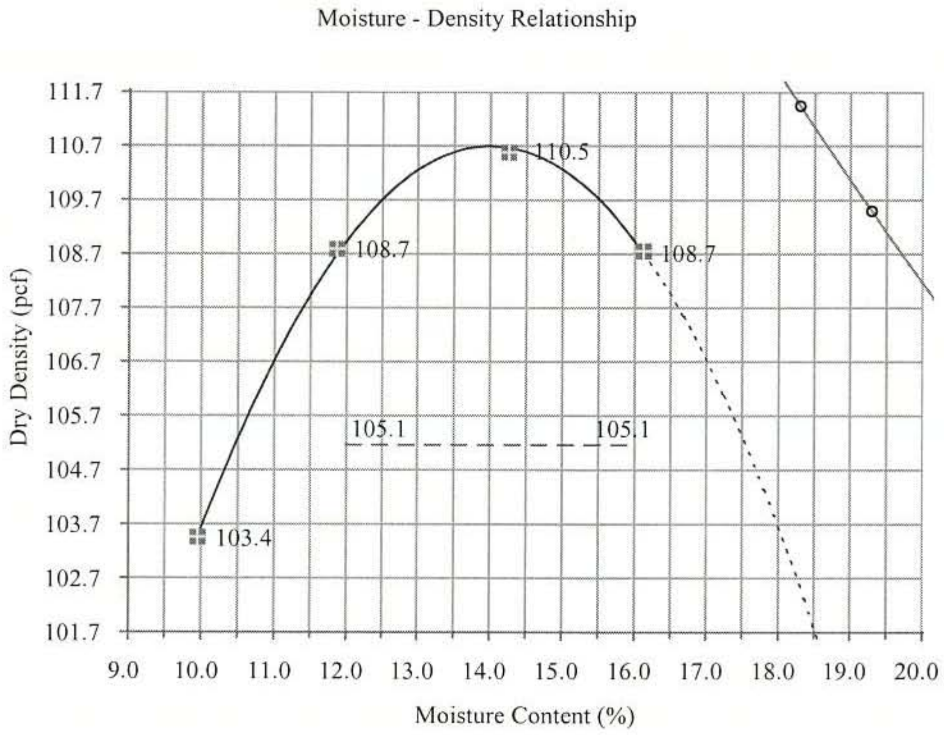
Report No	**B-1**	Date Sampled	12/20/05
Project Name	**Test Cell Levee Feasibility Analysis**	Project Number	**02-155GA-0**
Contractor Name		Work Order or CIP No.	
Lab. Technician	Jason Schwarz	Certification Type & No	NICET II 111079
City Inspector		Report of	Moisture/Demsity
Material Description	Tannish Brown Clayey SAND with gravel	Material use Type	Site Backfill
Material Source	Site Excavation	Date Tested	01/21/06



Sieve Analysis		
Size	% Passing	FAA adjusted
3"		
2"		
1 3/4"		
1 1/2"		
1"		
7/8"	100.0	
3/8"	86.8	
No. 4	73.8	
No. 10	64.0	100.0
No. 40	54.1	84.5
No. 200	38.5	60.1

Atterberg Limits		
LL	PL	PI
40	**14**	**26**

Soil Classification		
Unified:	SC	Group Index
AASHTO	A-6	4
FAA	E-7	

Test Method Used:	
Soil Sampling	TEX-100E
Soil Preparation	TEX-101E
Liquid Limit	TEX-104E
Plastic Limit	TEX-105E
Plasticity Index	TEX-106E
Sieve Analysis	TEX-110E
Compaction M/D Relatio	TEX-114E-II
Standard Classification	ASTM D2487

Estimated Specific Gravity: 2.65

Points on Graph: 4

Moisture Content in %	9.9	11.8	14.2	16.1
Dry Density (pcf)	103.4	108.7	110.5	108.7
Max Density (kg/m3)	1,772.6			
Maximum Density (pcf)	110.7			
Optimum Moisture(%)	14.0			

Std Error: 0.07070

Estimated Moisture: 12.9

* FAA classification with a * suffix indicates that it is possible to raise the classification if the coarse material is reasonably sound & fairly well graded.

LIZAN N. GILBERT
91796

P.E. Signature

P.E. Seal

Report Review by: Lizan N. Gilbert, P.E.
Company Name: HVJ Associates, Inc.

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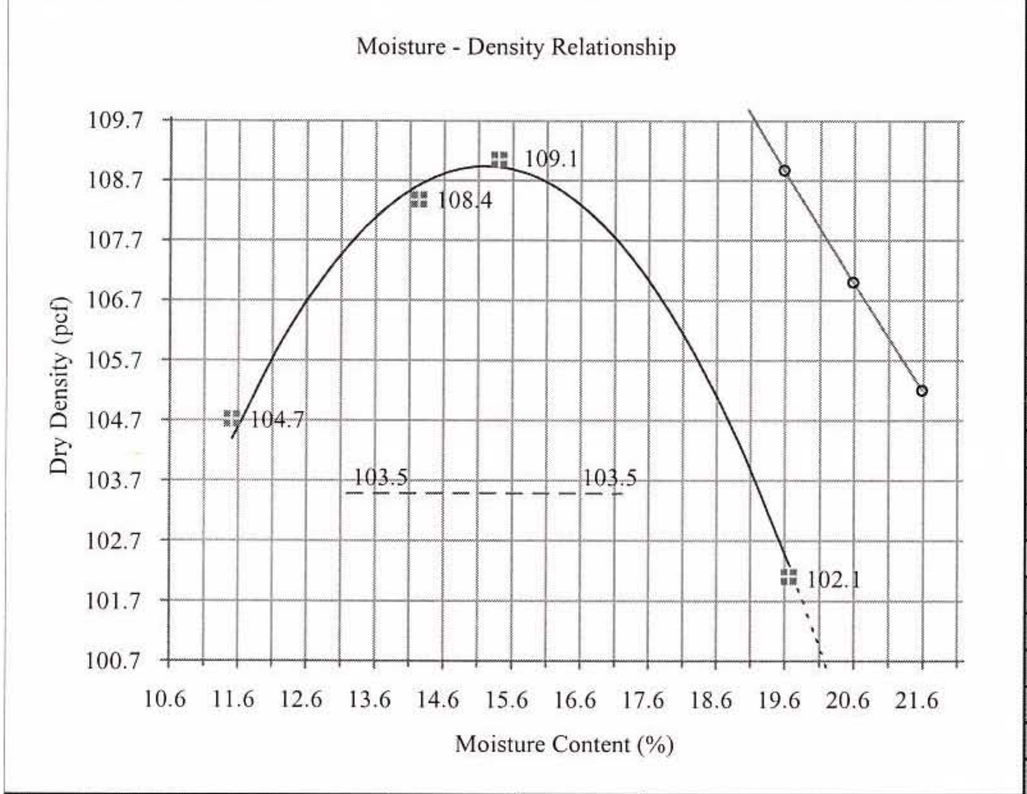
Report No	**B-6**	Date Sampled	12/20/05
Project Name	**Test Cell Levee Feasibility Analysis**	Project Number	**02-155GA-0**
Contractor Name		Work Order or CIP No.	
Lab. Technician	Jason Schwarz	Certification Type & No	NICET II 111079
City Inspector		Report of	Moisture/Demsity
Material Description	Brown Gravely Clay	Material use Type	Site Backfill
Material Source	Site Excavation	Date Tested	01/10/06



Sieve Analysis		
Size	% Passing	FAA adjusted
3"		
2"		
1 3/4"		
1 1/2"		
1"		
7/8"	#DIV/0!	
3/8"	#DIV/0!	
No. 4	#DIV/0!	
No. 10	#DIV/0!	100.0
No. 40	#DIV/0!	#DIV/0!
No. 200	#DIV/0!	#DIV/0!

Atterberg Limits		
LL	PL	PI
		#VALUE!

Soil Classification		
Unified:	**#DIV/0!**	Group Index
AASHTO	**#DIV/0!**	**#DIV/0!**
FAA	**#DIV/0!**	

Test Method Used:	
Soil Sampling	TEX-100E
Soil Preparation	TEX-101E
Liquid Limit	TEX-104E
Plastic Limit	TEX-105E
Plasticity Index	TEX-106E
Sieve Analysis	TEX-110E
Compaction M/D Relatio	TEX-114E-II
Standard Classification	ASTM D2487

Estimated Specific Gravity	2.65	Points on Graph: 4

Moisture Content in %	11.5	14.2	15.4	19.7
Dry Density (pcf)	104.7	108.4	109.1	102.1
Max Density (kg/m3)	1,745.0			
Maximum Density (pcf)	108.9			
Optimum Moisture(%)	15.2			

Std Error	0.23584

Estimated Moisture	15.1

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LIZAN N. GILBERT
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Lizan N. Gilbert

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P.E. Seal

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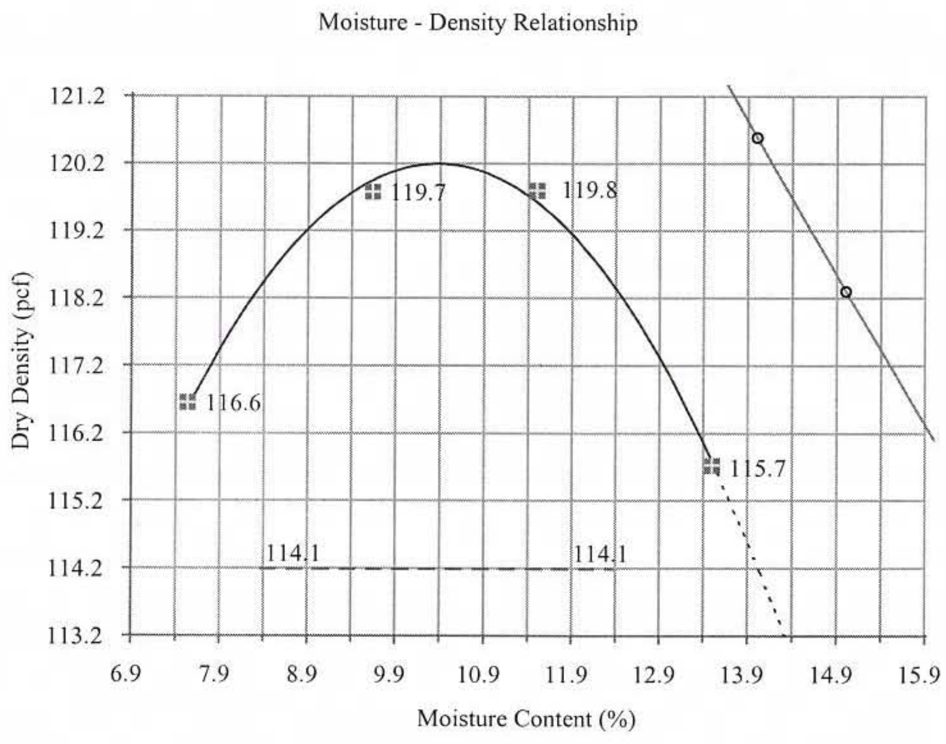
Report No	**B-8**	Date Sampled	12/20/05
Project Name	**Test Cell Levee Feasibility Analysis**	Project Number	**02-155GA-0**
Contractor Name		Work Order or CIP No.	
Lab. Technician	Jason Schwarz	Certification Type & No	NICET II 111079
City Inspector		Report of	Moisture/Density
Material Description	Brown Clayey Sand with Gravel	Material use Type	Site Backfill
Material Source	Site Excavation	Date Tested	01/10/06



Sieve Analysis		
Size	% Passing	FAA adjusted
3"		
2"		
1 3/4"		
1 1/2"		
1"	75.1	
7/8"	75.1	
3/8"	73.4	
No. 4	59.1	
No. 10	49.8	100.0
No. 40	41.8	83.9
No. 200	32.1	64.4

Atterberg Limits		
LL	PL	PI
39	**12**	**27**

Soil Classification		
Unified:	GC	Group Index
AASHTO	A-2-6	2
FAA	E-7	

Test Method Used:	
Soil Sampling	TEX-100E
Soil Preparation	TEX-101E
Liquid Limit	TEX-104E
Plastic Limit	TEX-105E
Plasticity Index	TEX-106E
Sieve Analysis	TEX-110E
Compaction M/D Relatio	TEX-114E-II
Standard Classification	ASTM D2487

Estimated Specific Gravity	2.65

Points on Graph: 4

Moisture Content in %	7.6	9.7	11.5	13.5
Dry Density (pcf)	116.6	119.7	119.8	115.7
Max Density (kg/m3)	1,924.6			
Maximum Density (pcf)	120.1			
Optimum Moisture(%)	10.4			

Std Error	0.12929
Estimated Moisture	10.7

* FAA classification with a * suffix indicates that it is possible to raise the classification if the coarse material is reasonably sound & fairly well graded.

STATE OF TEXAS
LIZAN N. GILBERT
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LICENSED PROFESSIONAL ENGINEER

P.E. Signature

P.E. Seal

Report Review by: Lizan Gilbert, P.E.
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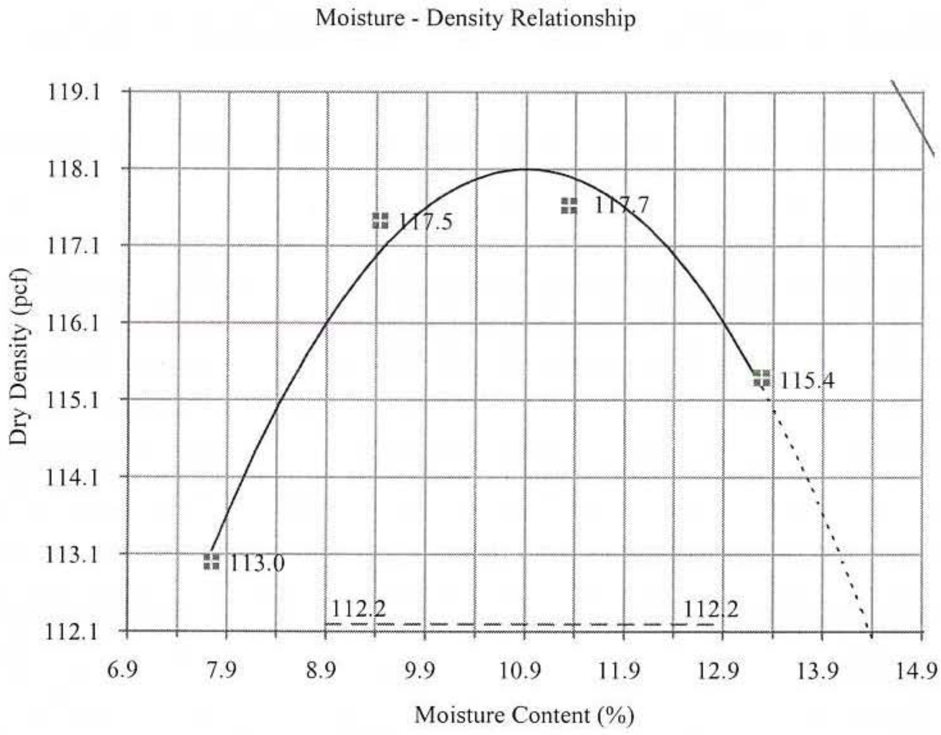
Report No	**B-3**	Date Sampled	12/20/05
Project Name	**Test Cell Levee Feasibility Analysis**	Project Number	**02-155GA-0**
Contractor Name		Work Order or CIP No.	
Lab. Technician	Jason Schwarz	Certification Type & No	NICET II 111079
City Inspector		Report of	Moisture/Demsity
Material Description	Tannish Brown Clayey SAND with gravel	Material use Type	Site Backfill
Material Source	Site Excavation	Date Tested	01/21/06



Sieve Analysis		
Size	% Passing	FAA adjusted
3"		
2"		
1 3/4"		
1 1/2"		
1"		
7/8"	100.0	
3/8"	86.8	
No. 4	73.8	
No. 10	64.0	100.0
No. 40	54.1	84.5
No. 200	38.5	60.1

Atterberg Limits		
LL	PL	PI
32	**12**	20

Soil Classification		
Unified:	SC	Group Index
AASHTO	A-6	2
FAA	E-7	

Test Method Used:	
Soil Sampling	TEX-100E
Soil Preparation	TEX-101E
Liquid Limit	TEX-104E
Plastic Limit	TEX-105E
Plasticity Index	TEX-106E
Sieve Analysis	TEX-110E
Compaction M/D Relatio	TEX-114E-II
Standard Classification	ASTM D2487

Estimated Specific Gravity: 2.65

Points on Graph: 4

Moisture Content in %	7.7	9.4	11.3	13.3
Dry Density (pcf)	113.0	117.5	117.7	115.4
Max Density (kg/m3)	1,892.1			
Maximum Density (pcf)	118.1		Std Error	
Optimum Moisture(%)	10.9		0.29154	

Estimated Moisture: 10.1

* FAA classification with a * suffix indicates that it is possible to raise the classification if the coarse material is reasonably sound & fairly well graded.

LIZAN N. GILBERT
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P.E. Signature

P.E. Seal

Report Review by: Lizan N. Gilbert, P.E.
Company Name: HVJ Associates, Inc.